

# Translating health economics research into public health action: Towards an economy of wellbeing

**Edited by**

Mariana Dyakova, Rebecca Masters and Timotej Jagric

**Coordinated by**

Rajendra Kadel and Kathryn Ashton

**Published in**

Frontiers in Public Health



## FRONTIERS EBOOK COPYRIGHT STATEMENT

The copyright in the text of individual articles in this ebook is the property of their respective authors or their respective institutions or funders. The copyright in graphics and images within each article may be subject to copyright of other parties. In both cases this is subject to a license granted to Frontiers.

The compilation of articles constituting this ebook is the property of Frontiers.

Each article within this ebook, and the ebook itself, are published under the most recent version of the Creative Commons CC-BY licence. The version current at the date of publication of this ebook is CC-BY 4.0. If the CC-BY licence is updated, the licence granted by Frontiers is automatically updated to the new version.

When exercising any right under the CC-BY licence, Frontiers must be attributed as the original publisher of the article or ebook, as applicable.

Authors have the responsibility of ensuring that any graphics or other materials which are the property of others may be included in the CC-BY licence, but this should be checked before relying on the CC-BY licence to reproduce those materials. Any copyright notices relating to those materials must be complied with.

Copyright and source acknowledgement notices may not be removed and must be displayed in any copy, derivative work or partial copy which includes the elements in question.

All copyright, and all rights therein, are protected by national and international copyright laws. The above represents a summary only. For further information please read Frontiers' Conditions for Website Use and Copyright Statement, and the applicable CC-BY licence.

ISSN 1664-8714  
ISBN 978-2-8325-4747-2  
DOI 10.3389/978-2-8325-4747-2

## About Frontiers

Frontiers is more than just an open access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

## Frontiers journal series

The Frontiers journal series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the *Frontiers journal series* operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

## Dedication to quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews. Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

## What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the *Frontiers journals series*: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area.

Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers editorial office: [frontiersin.org/about/contact](https://frontiersin.org/about/contact)

# Translating health economics research into public health action: Towards an economy of wellbeing

## Topic editors

Mariana Dyakova — Public Health Wales NHS Trust, United Kingdom  
Rebecca Masters — Public Health Wales NHS Trust, United Kingdom  
Timotej Jagric — University of Maribor, Slovenia

## Topic Coordinators

Rajendra Kadel — Public Health Wales NHS Trust, United Kingdom  
Kathryn Ashton — Public Health Wales NHS Trust, United Kingdom

## Citation

Dyakova, M., Masters, R., Jagric, T., Kadel, R., Ashton, K., eds. (2024). *Translating health economics research into public health action: Towards an economy of wellbeing*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-4747-2

# Table of contents

- 05 **Cost of health inequality to the NHS in Wales**  
Rajendra Kadel, James Allen, Oliver Darlington, Rebecca Masters, Brendan Collins, Joanna M. Charles, Miqdad Asaria, Mariana Dyakova, Mark Bellis and Richard Cookson
- 15 **Acceptability of prepayment, social solidarity and cross-subsidies in national health insurance: A mixed methods study in Western Kenya**  
Beryl Maritim, Adam D. Koon, Allan Kimaina and Jane Goudge
- 29 **Toward an economy of wellbeing: The economic impact of the Welsh healthcare sector**  
Timotej Jagrič, Christine Brown, Dušan Fister, Oliver Darlington, Kathryn Ashton, Mariana Dyakova, Mark A. Bellis and Vita Jagrič
- 43 **Health economics of health justice partnerships: A rapid review of the economic returns to society of promoting access to legal advice**  
Rachel Granger, Hazel Genn and Rhiannon Tudor Edwards
- 52 **Understanding health inequalities in Wales using the Blinder-Oaxaca decomposition method**  
James Allen, Andrew Cotter-Roberts, Oliver Darlington, Mariana Dyakova, Rebecca Masters and Luke Munford
- 64 **Well-being and well-becoming through the life-course in public health economics research and policy: A new infographic**  
Rhiannon Tudor Edwards
- 72 **Does self-medication reduce medical expenditure among the middle-aged and elderly population? A four-wave longitudinal study in China**  
Zehao Zheng, Zhanchun Feng, Donglan Zhang, Xiaobo Sun, Dong Dong, Youxi Luo and Da Feng
- 85 **Study on the evolutionary game of the three parties in the combined medical and health-care PPP project**  
Min Zhang and Ping Yao
- 97 **Long-term care insurance and multidimensional poverty of middle-aged and elderly: Evidence from China**  
Wenxiu Li, Jin Ke and Fei Sun
- 117 **Willingness to pay for a COVID-19 vaccine and its associated determinants in Iran**  
Moslem Soofi, Gerjo Kok, Shahin Soltani, Ali Kazemi-Karyani, Farid Najafi and Behzad Karamimatin



- 124 **Unconditional cash transfers for breastfeeding women in the Mexican informal workforce: Time for social justice**  
Sofía Barragán-Vázquez, Jocelyn Jaen and Sonia Collado-López
- 128 **Characteristics, risk management and GMP standards of pharmaceutical companies in China**  
Hong Chen, Lijian Qin, Cong Jiang, Mingshuai Qin, Yanming Sun and Jingjing Luo
- 142 **Two-stage dual-game model approach to view the difficulty of healthcare accessibility**  
Weiwei Wang, Futian Weng, Yusheng Chen and Miao Zhu
- 155 **Path analysis and empirical test of medical service enhancement for common prosperity under government participation**  
Baoqi Chen and Xigang Zhang
- 169 **The impacts of diagnosis-intervention packet payment on the providers' behavior of inpatient care—evidence from a national pilot city in China**  
Yi Ding, Jia Yin, Chao Zheng, Simon Dixon and Qiang Sun



## OPEN ACCESS

## EDITED BY

Dilaram Acharya,  
École de Santé Publique, Université de  
Montréal, Canada

## REVIEWED BY

Ak Narayan Poudel,  
University of Leicester,  
United Kingdom  
Amritpal Rehill,  
London School of Economics and  
Political Science, United Kingdom

## \*CORRESPONDENCE

Rajendra Kadel  
rajendra.kadel@wales.nhs.uk

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 01 June 2022

ACCEPTED 22 August 2022

PUBLISHED 16 September 2022

## CITATION

Kadel R, Allen J, Darlington O,  
Masters R, Collins B, Charles JM,  
Asaria M, Dyakova M, Bellis M and  
Cookson R (2022) Cost of health  
inequality to the NHS in Wales.  
*Front. Public Health* 10:959283.  
doi: 10.3389/fpubh.2022.959283

## COPYRIGHT

© 2022 Kadel, Allen, Darlington,  
Masters, Collins, Charles, Asaria,  
Dyakova, Bellis and Cookson. This is  
an open-access article distributed  
under the terms of the [Creative  
Commons Attribution License \(CC BY\)](#).  
The use, distribution or reproduction  
in other forums is permitted, provided  
the original author(s) and the copyright  
owner(s) are credited and that the  
original publication in this journal is  
cited, in accordance with accepted  
academic practice. No use, distribution  
or reproduction is permitted which  
does not comply with these terms.

# Cost of health inequality to the NHS in Wales

Rajendra Kadel<sup>1\*</sup>, James Allen<sup>1</sup>, Oliver Darlington<sup>1</sup>,  
Rebecca Masters<sup>1</sup>, Brendan Collins<sup>2</sup>, Joanna M. Charles<sup>2</sup>,  
Miqdad Asaria<sup>3</sup>, Mariana Dyakova<sup>1</sup>, Mark Bellis<sup>1</sup> and  
Richard Cookson<sup>4</sup>

<sup>1</sup>WHO CC on Investment for Health and Wellbeing, Public Health Wales, Cardiff, United Kingdom,

<sup>2</sup>Health and Social Services Group, Finance Directorate, Welsh Government, Cardiff,

United Kingdom, <sup>3</sup>Department of Health Policy, London School of Economics and Political Science,  
London, United Kingdom, <sup>4</sup>Centre for Health Economics, University of York, York, United Kingdom

**Background:** Forty years from the seminal work of Welsh GP Julian Tudor Hart on the Inverse Care Law, inequalities in health and healthcare remain deeply embedded in Wales. There is a wider gap (over 17 years) in healthy life expectancy between people living in the most and least deprived neighborhoods in Wales. This health inequality is reflected in additional healthcare use. In this study we estimate the cost of inequality associated with this additional healthcare use to the publicly funded National Health Service (NHS) in Wales.

**Methods:** We retrieved administrative data on all NHS inpatient admissions, outpatient and accident and emergency attendances in Wales between April 2018 and March 2019 from Digital Health and Care Wales (DHCW). Hospital service use data were translated to costs using Healthcare Resource Group (HRG) and health service specific unit cost data and linked with area level mid-year population and deprivation indices in order to calculate the healthcare costs associated with socioeconomic deprivation.

**Results:** Inequality in healthcare use between people from more and less deprived neighborhoods was associated with an additional cost of £322 million per year to the NHS in Wales, accounting for 8.7% of total NHS hospital expenditure in the country. Emergency inpatient admissions made up by far the largest component of this additional cost contributing £247.4 million, 77% of the total. There are also substantial costs of inequality for A&E attendances and outpatient visits, though not maternity services. Elective admissions overall have a negative cost of inequality, since among men aged 50–75 and women aged 60–70, elective utilization is actually negatively associated with deprivation.

**Conclusion:** There are wide inequalities in health and healthcare use between people living in more deprived neighborhoods and those living in less deprived neighborhoods in Wales. Tackling health inequality through a combination of

health promotion and early intervention policies targeted toward deprived communities could yield substantial improvement in health and wellbeing, as well as savings for the Welsh NHS through reduced use of emergency hospital care.

#### KEYWORDS

cost, inequality, health service use, NHS, Wales

## Introduction

Population health and wellbeing are substantially influenced by wider socio-economic (such as age, sex, income, education level etc.) and environmental factors (such as poor housing, poor working conditions etc.) (1). There are large inequalities in health and health service utilization between more and less socially advantaged groups (2). This results in different levels of healthcare needs which require relevant access to and provision of healthcare services. Health inequality has been a longstanding issue in Wales: people living in the most deprived neighborhoods (as measured by quintile groups) have a much higher probability of death from avoidable causes (3.7 times for males and 3.8 times for females) (3), and much worse health with fewer years of healthy life expectancy at birth (16.9 years for males and 18.3 years for females) compared to those living in the least deprived neighborhoods (4). People living in more deprived neighborhoods tend to consume more emergency healthcare resources at any given age, in terms of volume and cost, as they experience more adverse health conditions (5). However, although people living in more deprived neighborhoods are more likely to use emergency care [non-elective admissions, emergency GP appointments and accident and emergency (A&E) attendances] they are less likely to use specialist and preventative services, while the social patterning of elective inpatient care and primary care varies (6).

Disparities in healthcare service use can have a huge economic impact both in the short and the long-term. In EU, the annual cost of health inequality was estimated to be €980 billion or 9.4% of GDP (7). In UK, the cost of inequality in health service use was estimated to be £4.8 billion per year to the NHS in England (8) using data from 2011. The economic cost related to inequality in healthcare use has not been established for Wales specifically, or updated to recent years. This study aims to estimate the social gradient in different categories of hospital utilization and estimate the overall cost to the NHS in Wales of socioeconomic inequalities in health.

## Methods

We used whole-population hospital service data to estimate hospital utilization and cost by five deprivation groups for

different age groups, sex and hospital service types. The cost of health inequality to the NHS in Wales was defined as the excess hospital utilization costs among the most deprived four-fifths of the population compared with the least deprived fifth of the population.

## Population and data source

The resource use analysis was restricted to Welsh residents who visited either NHS hospitals or NHS funded private hospitals (including those who received hospital services in England) for inpatient admissions, outpatient appointments and accident and emergency attendances. The hospital service datasets included information about the patient's age, sex, area of residence, and their status of health service use, including diagnosis, procedures and frequencies.

Three different hospital service use datasets—hospital inpatient episodes, outpatient appointments and accident and emergency (A&E) attendances—were retrieved from the Patient Episodes Dataset for Wales (PEDW) managed by Digital Health and Care Wales (DHCW) for 1 year period between April 2018 and March 2019. In general, the data are regularly collected and coded at each hospital and then these records are electronically transferred to the DHCW, where data are validated and merged into the main database. Finished Consultant Episodes (FCE) were used to estimate the number of hospital inpatient episodes which are allocated to a Healthcare Resource Group (HRG) code. Healthcare Resource Groups (HRGs) are clinical groupings of treatment activities according to procedures and diagnoses, which consume similar healthcare resources (9). Cost information for the financial year 2018/19 was collected from the Finance Delivery Unit (FDU) hosted by Public Health Wales. The cost information consisted of HRG reference costs for inpatient episodes and unit cost per visit for outpatient appointments and A&E attendances. The population data required for the analysis at population level was drawn from the mid-year population estimates, supplied by the Office for National Statistics (10).

The researchers collected anonymized patient level data and do not have access to patient identifiable codes. The researchers fully comply with GDPR 2018 to handle such data.

## Measurement of outcomes and costs

We estimated the total cost of health inequality according to hospital service types, sex and different age groups. Moreover, we also included social patterns of hospital episodes and attendances, and average cost according to age, sex and levels of deprivation (quintiles) for different hospital service types. We classified patients' age to represent meaningful age groups: infants (<1 year old), under 5 children, under 16 children, working age group (16–64 year olds), older age group (65 year olds and above), and maternity age group (15–44 year olds).

The basic geographical unit of analysis in this study is the Lower-layer Super Output Area (LSOA). Wales is divided into 1,909 LSOAs, each consisted of around 1,500 individuals on average. Area-based deprivation for LSOAs are measured using the Welsh Index of Multiple Deprivation (WIMD) for 2019. WIMD comprised of seven domains: income, employment, health and disability, educational skills and training, barriers to housing and services, crime, and living environment. These domains are combined to produce an overall deprivation rank for each LSOA. In this study, we used LSOA grouping into quintiles based on deprivation ranks, ranging from Q1 (the least deprived fifth of LSOAs) to Q5 (the most deprived fifth of LSOAs) (11).

Hospital service categories were divided into inpatient admissions, outpatient and accident and emergency attendances. Hospital inpatient admission was further divided into elective, emergency and maternity admissions (12). In elective inpatient admission, a patient whose admission date is known in advance thus allowing arrangements to be made beforehand. However, patient's admission date and time is unpredictable and at a short notice due to its clinical need in case of emergency inpatient admission. If a hospital admission of a pregnant or recently pregnant woman to a maternity ward is done, except when the intention is to terminate pregnancy, this is called maternity inpatient admission. If an appointment is made at a hospital outpatient department or clinic for the purpose of consultation, examination or treatment by a doctor or independent nurse, this is called an outpatient appointment. Similarly, an accident and emergency (A&E) attendance is the one when a patient visits an accident and emergency department to receive advice and treatment for patients with urgent healthcare need.

The outcome measures in this study were the episodes and frequency of hospital service use (inpatient admissions, outpatient and A&E attendances) recorded in hospital administrative database. Cost of inpatient stays, outpatient, and A&E attendances were estimated using hospital episodes statistics and the Welsh reference cost data received from the FDU. The cost for the health service use was reported in 2018 pound sterling (£) from the NHS Wales perspective.

## Statistical analysis

Hospital service use data were grouped into age, sex and WIMD quintile categories. Then total costs for each age, sex and WIMD quintile group were computed using the HRGs and the relevant reference costs application to hospital inpatient, outpatient and A&E cases. This analysis used a simplified version of health service use and cost estimation, which was scaled up using patient population numbers and disaggregated the population-level results according to the social patterns observed in the health service use data. In brief, we estimated the average cost (per person) in each age, sex and levels of deprivation according to WIMD quintile by dividing the total costs by the mid-year population using ONS population estimates.

$$\text{Average Costs}_{\text{Age, Sex, WIMD}} = \frac{\sum \text{Hospital Costs}_{\text{Age, Sex, WIMD}}}{\sum \text{Population}_{\text{Age, Sex, WIMD}}}$$

The annual cost of health inequality was computed by multiplying the difference between total average annual cost and average annual cost of the least deprived group by mid-year population. The cost of health inequalities were also computed separately for specific age groups, sex and hospital service types.

$$\begin{aligned} \text{Cost of Inequality}_{\text{Age, Sex, WIMD}} &= \sum [\text{Population}_{\text{Age, Sex, WIMD}} \\ &\times (\text{Average Costs}_{\text{Age, Sex, WIMD} = \text{Q1-5}} \\ &- \text{Average Costs}_{\text{Age, Sex, WIMD} = \text{Q1}})] \end{aligned}$$

We used Microsoft SQL Server Management Studio 17 and Excel 2016 for data analysis.

## Results

Results are presented into three categories: social patterns of hospital service use, cost of health inequality, and average cost of hospital service use.

### Social patterns of hospital service use

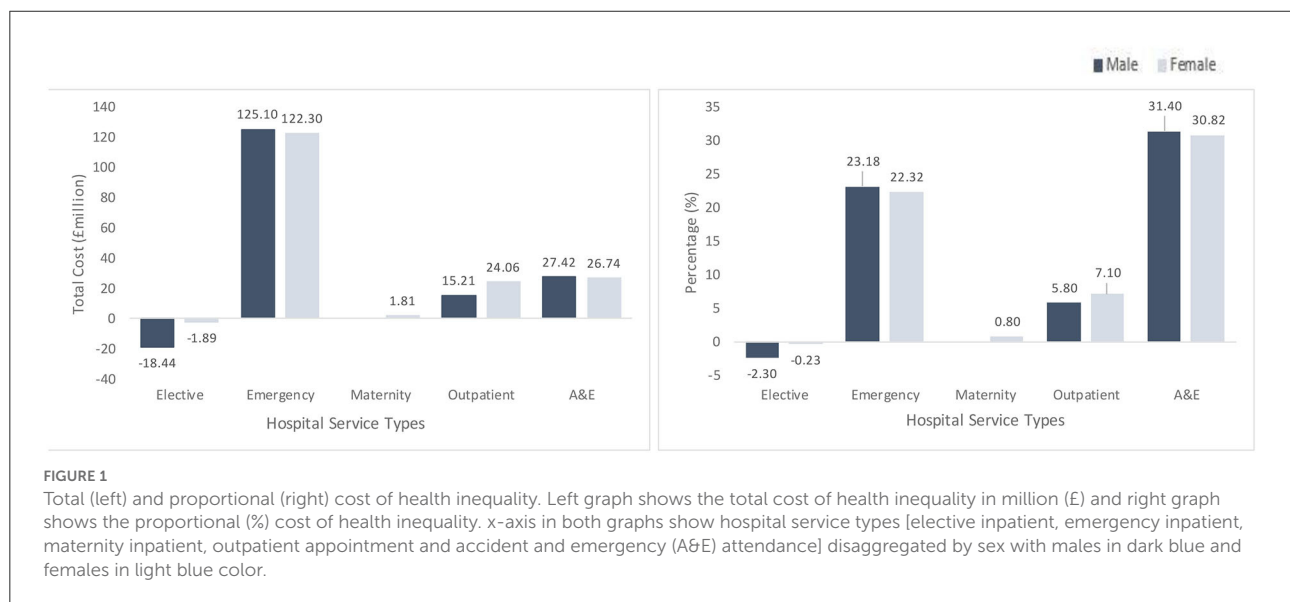
Table 1 presents the social patterns of hospital service use according to sex, levels of deprivation and hospital service types. A total of 1.22 million hospital inpatient episodes, 4.4 million outpatient appointments, and 0.87 million accident and emergency attendances were made between April 2018 and March 2019. The median age of patients receiving hospital service was the highest for elective admissions (63 years) followed by emergency admissions (62 years).

There was no substantial difference in percentage of hospital service use between males and females across different hospital

TABLE 1 Social pattern of hospital service use by age, sex and level of deprivation, Wales 2018/19.

Characteristics	Hospital inpatient episodes			Outpatient	A&E	Population (Mid-year 2018)
	Elective	Emergency	Maternity			
N	564,550	572,667	83,573	4,453,343	870,362	3,138,631
Age (median)	63 years	62 years	29 years	56 years	39 years	42.5 years
<b>Sex</b>						
Male	276,584 (49.0%)	276,043 (48.2%)	N/A	1,941,852 (43.6%)	436,591 (50.2%)	1,547,309 (49.3%)
Female	287,945 (51.0%)	296,607 (51.8%)	83,573 (100.0%)	2,511,491 (56.4%)	433,771 (49.8%)	1,591,322 (50.7%)
<b>Welsh index of multiple deprivation quintile (2019)</b>						
Q1 (Least deprived)	114,544 (20.3%)	90,525 (15.8%)	13,950 (16.7%)	860,237 (19.3%)	119,491 (13.7%)	623,358 (19.9%)
Q2	118,585 (21.0%)	105,046 (18.3%)	13,742 (16.5%)	894,317 (20.1%)	164,208 (18.9%)	638,695 (20.4%)
Q3	114,761 (20.3%)	112,173 (19.6%)	14,642 (17.5%)	866,161 (19.5%)	180,290 (20.7%)	643,563 (20.5%)
Q4	110,618 (19.6%)	125,844 (22.0%)	17,403 (20.8%)	910,571 (20.5%)	202,670 (23.3%)	618,030 (19.7%)
Q5 (Most deprived)	106,021 (18.8%)	139,062 (24.3%)	23,778 (28.5%)	922,057 (20.7%)	203,703 (23.4%)	614,985 (19.6%)

N/A, not applicable.



service categories. In terms of levels of deprivation, there were wider differences in service utilization between people living in the most deprived neighborhoods and those living in the least deprived neighborhoods for A&E attendances (23.4 vs. 13.7%), emergency admissions (24.3 vs. 15.8%), and maternity admissions (28.5 vs. 16.7%).

## Cost of health inequality

### Cost of health inequality by hospital service categories and sex

The total cost of health inequality in hospital service use is estimated to be £322 million in Wales, which is equivalent to 8.7% of the total hospital expenses. Emergency admissions are the largest contributor to the overall cost of

health inequality, with an additional cost of £247.4 million annually (Figure 1). Within service categories, A&E bear the highest proportional cost of health inequality (31%), followed by emergency admissions (23%).

Elective inpatient admissions have a negative overall and proportional cost of inequality, indicating that people from the least deprived neighborhoods have higher levels of elective inpatient utilization compared to those in more deprived neighborhoods.

### Average cost (per capita) of health inequality by hospital service categories, sex, and age group

For elective admissions, males aged 65 years and above incurred the highest negative cost per capita of health inequality

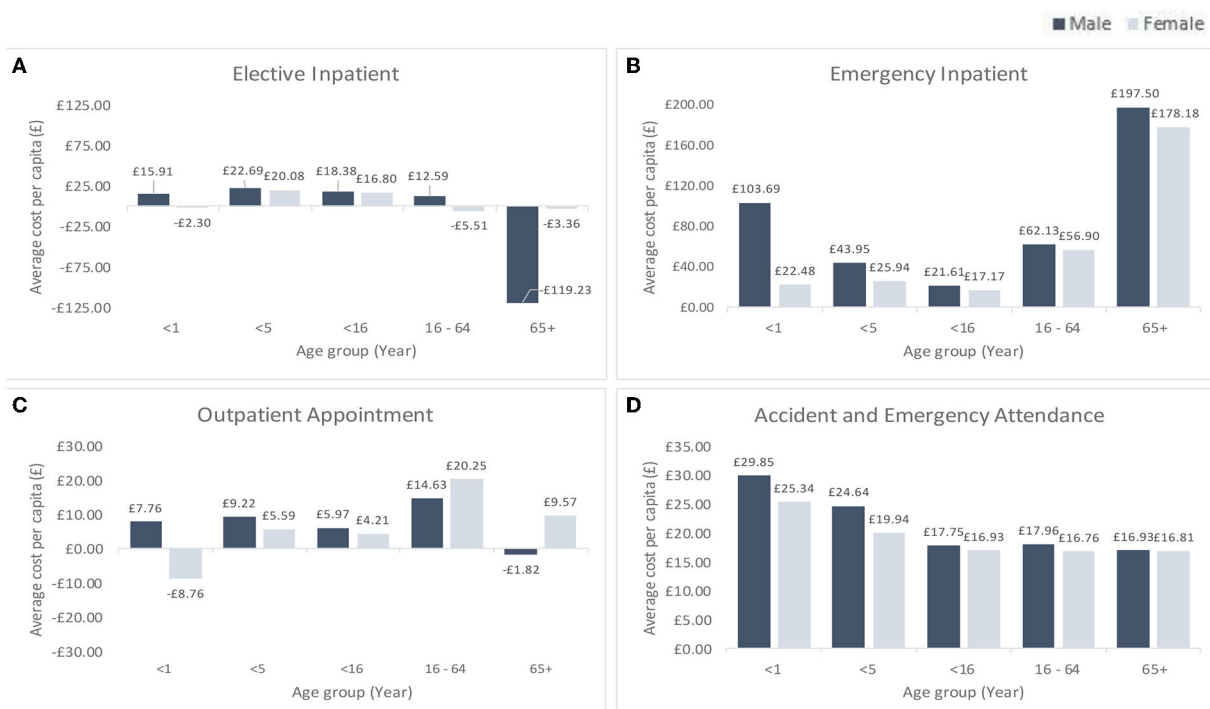


FIGURE 2

Cost of health inequality per capita by hospital service types, sex and age group. This figure is based on hospital episodes and attendance statistics for 2018/19 financial year in Wales. Results in the graphs are broken down by age groups—Infant (<1 year olds), under 5 year olds, under 16 year olds, 16–64 year olds (working age), 65 year olds and above (old age), by sex (Dark blue color bar charts are for males and light blue for females), and by hospital service types (A, Elective Inpatient; B, Emergency Inpatient; C, Outpatient Appointment; and D, Accident and Emergency Attendance).

(–£119 per person), resulting in an overall negative cost of health inequality attributed to the socioeconomic deprivation in this service category (Figure 2). There was also a substantial disparity in cost per capita of health inequality between males and females in this age category (–£119 vs. –£3.36). For emergency inpatient, the highest average cost per capita of health inequality were incurred by older age group (£197.50 for males, and £178.18 for females) and the lowest by under 16 age group (male: £21.61 and female: £17.17).

Average costs per capita of health inequality for outpatient appointments were the highest among working age people (male: £14.63 and female: £20.25). There were substantial differences in cost per capita of health inequality among infants (male: £7.76 and female: –£8.76) and older age group (male: –£1.82 and female: £9.57) in this service category. For A&E attendances, the average cost per capita of health inequality was the highest for infants (male: £29.85 and female: £25.34) and the lowest for older age group (male: £16.93 and female: £16.81).

## Average costs of hospital service use

### Elective inpatient admissions (upper charts)

The elective inpatient cost per person is higher for both males and females living in the most deprived neighborhoods

(16.0 and 18.0% higher, respectively) as compared to those in the least deprived neighborhoods (Figure 3). There is no clear social gradient across different age groups for both sexes.

### Emergency inpatient admissions (Figure 3 - lower charts)

The annual emergency inpatient cost per person is much higher for both males and females living in the most deprived neighborhoods (57.0 and 62.0% higher, respectively) compared to those living in the least deprived neighborhoods (including costs for all ages). There is a clear social gradient for those at the age of 40 and above for both sexes.

### Outpatient Appointments (upper charts)

The average outpatient cost is slightly higher for both males and females living in the most deprived neighborhoods (14.0 and 18.0% higher, respectively) compared to those living in the least deprived neighborhoods (Figure 4). There is a clear social gradient in the middle age groups for both sexes. There is a wider difference in cost between the most and the least deprived among younger females (18–28 years) compared to same age males.



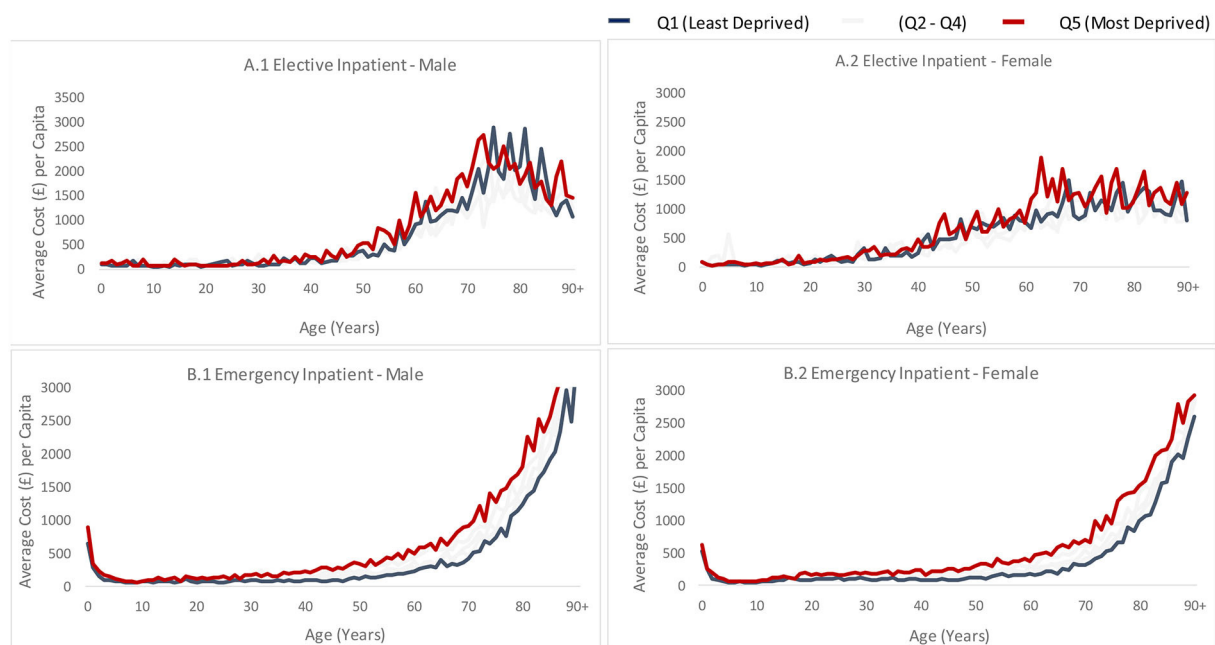


FIGURE 3

Average cost of inpatient service by age, sex and deprivation quintile. Graphs are based on Welsh' hospital episode statistics for 2018/19 financial year and are split by sex (male on the left and female on the right), deprivation quintile (different line colors) and are plotted against age (year). (A.1) Shows average elective inpatient cost for males, (A.2) shows average elective inpatient cost for females, (B.1) shows average emergency inpatient cost for males and (B.2) shows average emergency cost for females.

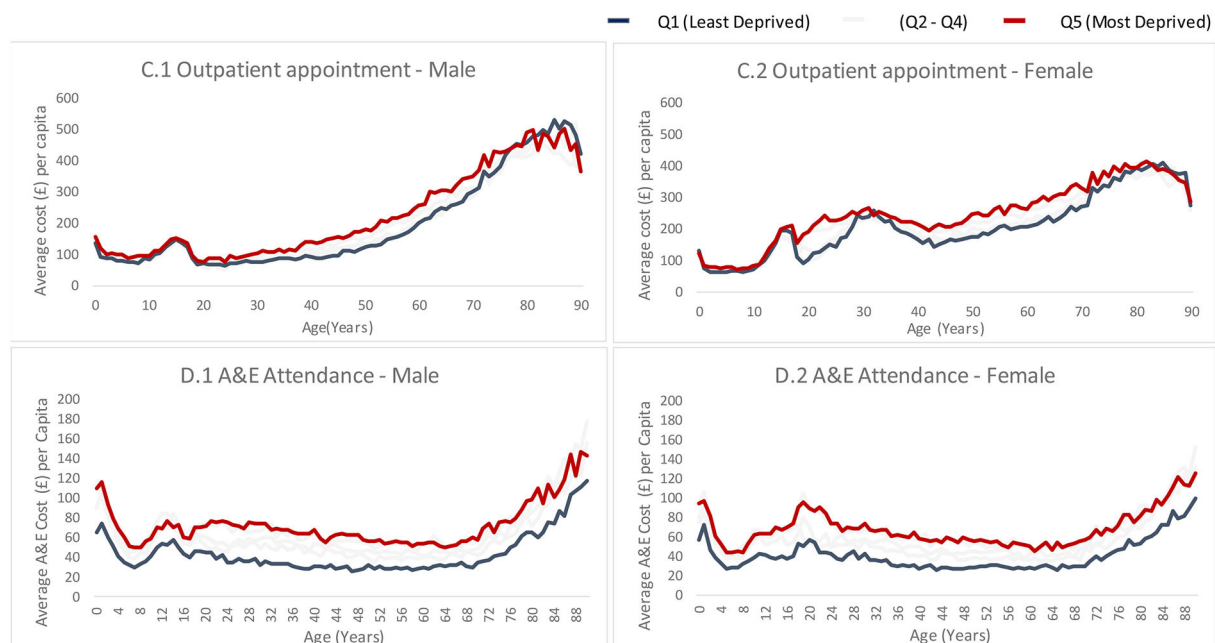


FIGURE 4

Average cost for outpatient and A&E attendances by age, sex and deprivation quintile. Graphs are based on Welsh' hospital attendance statistics for 2018/19 financial year and are broken down by sex (male on the left and female on the right) deprivation quintile (different line colors) and are plotted against age. (C.1) Shows average outpatient appointment cost for males, (C.2) shows average outpatient cost for females, (D.1) shows average accident and emergency (A&E) attendance cost for males and (D.2) shows average A&E attendance cost for females.



### A&E attendances (lower charts)

The annual A&E cost per person is much higher for both males and females living in the most deprived neighborhoods (67.0 and 68.0%, respectively) compared to those living in the least deprived neighborhoods (including costs for all ages) [Figure 3](#). There is a more prominent social gradient in the middle age groups for males, compared to same age females. There is a wider difference in cost between the most and the least deprived among younger females (18–28 years) compared to same age males.

## Discussion

### Summary of findings

The aim of the study was to estimate the cost of health inequality associated with socioeconomic deprivation in hospital service use to the NHS in Wales. The study findings showed that the total cost of health inequality to the NHS in Wales is estimated to be £322 million, equivalent to 8.7% of the total hospital service expenses, in 2018/19. Emergency inpatient admissions are the largest contributor to the overall cost of health inequality, with an additional cost of £247.4 million annually. Average cost per capita of health inequalities varies widely among different age groups, sexes and health service types. For emergency inpatient, the average cost per capita of health inequality among older people was substantial, but there was substantial average negative cost per capita of health inequality for elective inpatient among older males. We also found that there is wider gap in cost of health inequality between sexes among older age group, indicating older people from less deprived areas has been receiving more health services. One of the possible reason behind such gap may be due to poor health seeking behavior among older males living in more deprived areas compared to people living in less deprived areas for elective admissions. We also noted a wider gap in cost of health inequality among children under 1 year. This may partly be due to more health problems in male infants living in more deprived areas.

Average cost per capita of health inequality was higher among working age group for outpatient appointments, while the trends in average cost per capita of health inequality was decreased with age groups for A&E attendances. We also found that the levels of healthcare costs increased with age, and were higher among females in their reproductive years, and higher in males at most other ages. The average healthcare cost aggregated across all service categories is higher for both males and females living in the most deprived neighborhoods as compared to those in the least deprived in every age group. There is also a clear social gradient in average costs of health service use within each service category with the exception of elective admissions.

The concept of “Inverse Care Law” theorized by visionary Welsh GP Julian Tudor Hart in 1971 stated that “The availability

of good medical care tends to vary inversely with the need for it in the population served.” This study does not directly measure the inverse care law—it does not look at the quality of care, and it does not look at primary care (which is what Tudor Hart was mainly concerned about) [\(13\)](#). Rather, this study looks at the consequences of the inverse care law for the costs of secondary care (including emergency care), using hospital data not available in Tudor Hart’s time.

In England and other high income countries with universal healthcare systems, we only have a disproportional care law these days where people from socially disadvantaged communities receive more healthcare, but provision of such care are poor in quality and are inadequate to meet their healthcare needs [\(8, 14\)](#). Disproportional care law is also evident in Wales for emergency inpatients, outpatient appointments and A&E attendances, but that this is shocking evidence of an actual inverse care law emerging for elective hospital care whereby poorer people receive less care despite being less healthy and having greater needs for care. As a consequence of this, for these poor people are not accessing inpatient care to the same extent as similarly sick rich people, their health problems are therefore not tackled early on when they are relatively cheap and easy to deal with to the same extent as for similarly sick rich people. Instead these health problems in poor people are more likely to develop into more serious conditions that require more extensive treatment when they come in as more expensive emergency admissions.

We define the cost of health inequality in terms of disparities in hospital service utilization across deprivation quintiles, which in turn are driven by wider socioeconomic inequalities. The fact that health service utilization differs across social groups has been demonstrated consistently for over 70 years. Writing in 1968, the founding chair of the London School of Economics noted that “We have learnt from the 15 years’ experience of the health service that the higher income groups know how to make better use of service; they tend to receive more specialist attention; occupy more of the beds in better equipped and staffed hospitals; receive more elective surgery; have better maternal care, and are more likely to get psychiatric help and psychotherapy than low-income groups particularly the unskilled [\(15\)](#).”

### Strengths and limitations

This is the first study from Wales using whole population data to estimate the cost of health inequality associated with socioeconomic deprivation to the NHS in Wales. However, there are several limitations that should be considered. First, we only look at associations between healthcare costs and deprivation, and do not perform causal inference analysis. It is reasonable to assume that deprivation causes excess healthcare costs rather than the other way around, however, since the NHS provides universal care that is free at the point of delivery and the incidence of catastrophic health care costs in the UK is extremely

low by international standards. Second, we only look at the costs of health inequality not at the costs and effectiveness of interventions to tackle health inequality. Interventions to reduce health inequality would yield savings to the NHS from reduced emergency admissions, but they might also impose costs of various kinds and we cannot draw conclusions about the likely overall balance of costs and savings. Third, the population data used in this study were truncated at 90 years of age, assuming that the health service use remains constant at older age groups (90+). Fourth, this study uses the Welsh Index of Multiple Deprivation (WIMD) to categorize population into five quintile groups of small areas. The index is an area-based measure, which means that in this analysis, inferences about the nature of individuals are deduced from inferences about the area, e.g., an individual may live in a neighborhood that has a high level of deprivation, but that does not necessarily mean the individual has low income or education or other individual-level markers of social disadvantage. One of the domains of the WIMD is health but none of the data sources for this domain are around hospital admissions, however there may still be a small element of circularity with this analysis. Fifth, this study focuses on the cost of inequality in hospital service utilization, estimated according to service category and by age, sex and level of deprivation. Other services, such as primary and social care, and community health services might have an impact on the uses and economic costs of health services, as well as incur additional cost of health inequality. These might lead to under-estimation of the total cost of health inequality.

## Existing evidence to support this study

The current study results support and expand findings from the previous studies. Asaria, Doran (8) conducted a study based on comprehensive whole population data to explore the relationship between hospital costs and socioeconomic inequality in England. Their study found that inpatient hospital costs were 31% higher for people living in the most deprived neighborhoods compared with those living in the least deprived. We also used the similar approach, but our study was based on latest hospital service use data from Wales and estimated the cost of health inequality by including a broader group of hospital services, including outpatient and A&E attendances as well as inpatient admissions, and splitting out maternity admissions. Our study found wider differences in the excess cost of hospital service use for people living in the most deprived neighborhoods compared to those living in the least deprived neighborhoods: elective admissions (Female: 18% higher, Male: 16% higher), emergency admissions (Female: 62%, Male: 57%), maternity admissions (21%), outpatient appointments (Female: 18%, Male: 14%), and A&E attendances (Female: 68%, Male: 67%).

Another study from Kent, UK used individual patient level data aged 55 years and above to estimate the cost of inequality in

primary and secondary care service use (16). The study found the inequality in health and social care costs of £109 million, equivalent to 15% of the estimated total expenditure in this age group. Our study estimated the age group specific cost of inequality in hospital service use and found that it contributed to 5.54% of the total expenses in people aged 65 years and above. However, different hospital service categories contributed differently to the cost of health inequality: A&E attendances contributed 26% of the total expenses, emergency admissions contributed 18.31%, outpatient appointments contributed 1.26% of the total expenses, but people from the least deprived neighborhoods uses higher elective admission services which results in negative percentage cost of (−4.58%) health inequality.

## Policy implications

The study findings have implications for resource allocation and development of strategies to reduce the gaps in health service utilization associated with socioeconomic inequality. Inequality in hospital service utilization for people living in more deprived neighborhoods compared to those living in the least deprived neighborhoods incur substantial avoidable costs to the NHS in Wales. We found that the higher cost of health inequality in emergency admissions and A&E attendances as a result of higher health service utilization from people living in more deprived neighborhoods which were to some extent counterbalanced by higher elective inpatient service use by older people from the least deprived neighborhoods.

Future work could look at how much care is used in appropriate parts of the system, for instance looking at the cost of admissions for ambulatory care sensitive conditions. There is evidence of greater needs in deprived neighborhoods, but this need is not necessarily materializing in the right place and time in the treatment pathway.

Evidence suggest that people from more deprived neighborhoods tend to visit health facilities more frequently due to poor health and comorbidity, which may create more pressure on the emergency service departments and primary care/GP services and thereby receive worse quality healthcare by these people. In addition, people living in the least deprived neighborhoods could be healthier and tend to manage planned visit at hospital and specialist care (14, 17). The *inverse care law* propounded by Tudor Hart in 1971 appropriately explained this situation (13).

Several efforts have been made at global, regional and national level to improve health and reduce health inequalities. Reducing health inequality is an integral part of WHO's new strategy (Health 2020) for better health in Europe through promotion of multi-sectoral and whole-of-government approaches. The regional office delivers wide range of activities

and provides technical assistance to the member countries through various means to reduce such inequalities, including capacity building and learning exchanges, exploring evidence, promoting gender responsive policies, improving health of vulnerable groups, strengthening subnational and local governance (18). However, there is still a clear east-west gradient in health outcomes, with western countries performing relatively better compared to eastern counterpart in the WHO European Region (19). In Wales, There is also a wide equity gap in UK, including Wales, meaning that not much progress has been made since the “Inverse Care Law” was first coined in 1971 (4, 13). The equity gap in hospital service utilization resulting from existing healthcare arrangement could be addressed by more integrated healthcare, including better primary care (14). To address socio-economic inequality, the Welsh Government endorsed “A More Equal Wales” agenda, a statutory guidance based on Equality Act 2010 in March 2021, which aims to encourage public bodies for better decision making and to deliver better outcomes to the socio-economically disadvantaged groups (20).

Reducing the health equity gap is a complex multi-faceted multi-level challenge which requires tailored understanding and coherent action across different sectors, so we can (a) address the wider determinants of health inequalities; as well as (b) see what the healthcare service (NHS), social care and community services can do to tackle them (21, 22). A standardized case mix approach is an important consideration for the planning of healthcare resource use (23), as age, sex, and levels of deprivation have a significant impact on how and what services are used by the local community, which in turn impacts on the financial cost of delivering them (24). Community-based interventions targeted to those most in need could improve health outcomes (25), enable timely access to services (26), reduce hospital care need (27) and likely reduce inequalities (28) and thereby reducing healthcare costs, particularly associated with emergency and A&E contacts (27). Improving access/utilization of inpatient care by disadvantaged people which would have some cost could dramatically reduce costs of emergency admission in this population more than offsetting this additional investment in inpatient care. Above and beyond costs, this strategy would also unlock significant health benefits in this population. The COVID-19 pandemic has exacerbated existing health inequalities and created new vulnerabilities (29), which requires careful consideration to ensure inequalities in access to, delivery and quality of healthcare services are not amplified further, but reduced as part of the NHS and wider sustainable recovery (30). These findings will contribute to exploring further the relationship between health status, healthcare needs, health service access, provision and utilization, and the associated financial cost in order to help decision-makers to tailor services and prioritize investment toward reducing the health equity gap in Wales and beyond.

Our analyses estimated the cost of health inequality with area-based socioeconomic deprivation in Wales. We included whole population in the study, irrespective of their age, gender and socioeconomic status, so it may be reasonable to generalize the study results to other developed nations with similar type of health systems and population characteristics.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

RK has conceptualized and developed the manuscript and analyzed the data. JA and OD performed the quality check of the data and analysis work. RK, JA, OD, RM, BC, JC, MA, MD, MB, and RC subsequently revised the manuscript and approved the final draft. All authors contributed to the article and approved the submitted version.

## Funding

RC is supported by the Wellcome Trust (Grant No. 205427/Z/16/Z).

## Acknowledgments

We are thankful to the WHESri Joint Scientific and Advisory Group, the WHO CC Senior Leadership Team and the Public Health Wales Population Health Strategic Group for their helpful comments.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Braveman P, Gottlieb L. The social determinants of health: it's time to consider the causes of the causes. *Public Health Rep.* (2014) 129(Suppl. 2):19–31. doi: 10.1177/003335491412915206
- Marmot M, Bell R. Fair society, healthy lives. *Public Health.* (2012) 126(Suppl. 1):S4–S10. doi: 10.1016/j.puhe.2012.05.014
- Office for National Statistics. *Population Estimates for the UK, England and Wales, Scotland and Northern Ireland: Mid-2018.* (2019). Available online at: <https://www.ons.gov.uk/releases/populationestimatesfortheukenglandandwalesscotlandandnorthernirelandmid2018> (accessed May 15, 2022).
- Office for National Statistics. *Health State Life Expectancies by National Deprivation Deciles, Wales: 2017 to 2019.* (2021). Available online at: <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthinequalities/bulletins/healthstatelifeexpectanciesbynationaldeprivationdecileswales/2017to2019> (accessed May 15, 2022).
- Cookson R, Propper C, Asaria M, Raine R. Socio-economic inequalities in health care in England. *Fisc Stud.* (2016) 37:371–403. doi: 10.1111/j.1475-5890.2016.12109
- Dixon A, Le Grand J, Henderson J, Murray R, Poteliakhoff E. Is the British National Health Service equitable? The evidence on socioeconomic differences in utilization. *J Health Serv Res Policy.* (2007) 12:104–9. doi: 10.1258/135581907780279549
- Mackenbach JP, Meerdink WJ, Kunst AE. Economic costs of health inequalities in the European Union. *J Epidemiol Commun Health.* (2011) 65:412–9. doi: 10.1136/jech.2010.112680
- Asaria M, Doran T, Cookson R. The costs of inequality: whole-population modelling study of lifetime inpatient hospital costs in the English National Health Service by level of neighbourhood deprivation. *J Epidemiol Commun Health.* (2016) 70:990–6. doi: 10.1136/jech-2016-207447
- Gračić K, Mason AR, Street A. Paying for the quantity and quality of hospital care: the foundations and evolution of payment policy in England. *Health Econ Rev.* (2015) 5:15. doi: 10.1186/s13561-015-0050-x
- Population Estimates for the UK, England and Wales, Scotland and Northern Ireland: Mid-2018. (2019). Available online at: <https://www.ons.gov.uk/releases/populationestimatesfortheukenglandandwalesscotlandandnorthernirelandmid2018>
- Welsh Government. *Welsh Index of Multiple Deprivation (WIMD).* Cardiff: Welsh Government (2019). Available online at: <https://gov.wales/sites/default/files/statistics-and-research/2019-12/welsh-index-multiple-deprivation-2019-technical-report.pdf> (accessed May 15, 2022).
- NHS Wales. *NHS Wales Data Dictionary.* (2021). Available online at: <http://www.datadictionary.wales.nhs.uk/> (accessed May 15, 2022).
- Hart JT. The inverse care law. *Lancet.* (1971) 1:405–12. doi: 10.1016/S0140-6736(71)92410-X
- Cookson R, Doran T, Asaria M, Gupta I, Mujica FP. The inverse care law re-examined: a global perspective. *Lancet.* (2021) 397:828–38. doi: 10.1016/S0140-6736(21)00243-9
- Titmuss RM. *Commitment to Welfare.* 2nd ed. London: Allen & Unwin (1968).
- Jayatunga W, Asaria M, Belloni A, George A, Bourne T, Sadique Z. Social gradients in health and social care costs: analysis of linked electronic health records in Kent, UK. *Public Health.* (2019) 169:188–94. doi: 10.1016/j.puhe.2019.02.007
- Charlton J, Rudisill C, Bhattarai N, Gulliford M. Impact of deprivation on occurrence, outcomes and health care costs of people with multiple morbidity. *J Health Serv Res Policy.* (2013) 18:215–23. doi: 10.1177/1355819613493772
- World Health Organization. *Promoting Health and Reducing Health Inequities by Addressing the Social Determinants of Health.* Copenhagen: World Health Organization (2020). Available online at: [https://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0016/141226/Brochure\\_promoting\\_health.pdf](https://www.euro.who.int/__data/assets/pdf_file/0016/141226/Brochure_promoting_health.pdf) (accessed May 15, 2022).
- Zuidberg MRJ, Shriwise A, de Boer LM, Johansen AS. Assessing progress under health 2020 in the European region of the World Health Organization. *Eur J Public Health.* (2020) 30:1072–7. doi: 10.1093/eurpub/ckaa091
- Welsh Government. *A More Equal Wales: The Socio-economic Duty Equality Act 2010.* Cardiff: Welsh Government. (2021).
- Saunders M, Barr B, McHale P, Hamelmann C. *Key Policies for Addressing the Social Determinants of Health and Health Inequities.* Copenhagen: WHO Regional Office for Europe (2017). Contract No.: Health Evidence Network (HEN) synthesis report 52. Available online at: [https://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0009/345798/HEN52.pdf](https://www.euro.who.int/__data/assets/pdf_file/0009/345798/HEN52.pdf) (accessed May 15, 2022).
- World Health Organization. *Closing the Health Equity Gap: Policy Options and Opportunities for Action.* (2017). Available online at: <https://www.afro.who.int/sites/default/files/2017-06/SDH-closing-health-equity-gap-policy-opportunities-for-action-WHO2013.pdf> (accessed May 15, 2022).
- Hovenga EJS, Lowe C. Chapter 7 - Staffing resource allocation, budgets and management. In: Hovenga EJS, Lowe C, editors. *Measuring Capacity to Care Using Nursing Data.* London: Academic Press (2020). p. 181–235.
- Wiley MM. Hospital financing reform and case-mix measurement: an international review. *Health Care Financ Rev.* (1992) 13:119–33.
- Merzel C, D'Afflitti J. Reconsidering community-based health promotion: promise, performance, and potential. *Am J Public Health.* (2003) 93:557–74. doi: 10.2105/AJPH.93.4.557
- Khanassov V, Pluye P, Descoteaux S, Haggerty JL, Russell G, Gunn J, et al. Organizational interventions improving access to community-based primary health care for vulnerable populations: a scoping review. *Int J Equity Health.* (2016) 15:168. doi: 10.1186/s12939-016-0459-9
- Wallace E, Smith SM, Fahey T, Roland M. Reducing emergency admissions through community based interventions. *BMJ.* (2016) 352:h6817. doi: 10.1136/bmj.h6817
- Nickel S, von dem Knesebeck O. Do multiple community-based interventions on health promotion tackle health inequalities? *Int J Equity Health.* (2020) 19:157. doi: 10.1186/s12939-020-01271-8
- Paremoer L, Nandi S, Serag H, Baum F. Covid-19 pandemic and the social determinants of health. *BMJ.* (2021) 372:n129. doi: 10.1136/bmj.n129
- Propper C, Stockton I, Stoye G. *COVID-19 and Disruptions to the Health and Social Care of Older People in England Online.* Institute for Fiscal Studies (2020). Available online at: <https://ifs.org.uk/publications/15160> (accessed August 1, 2022).



## OPEN ACCESS

## EDITED BY

Enyi Ifeoma Etiaba,  
University of Nigeria, Nsukka, Nigeria

## REVIEWED BY

Guvenc Kockaya,  
Analysis and Consultancy Plc., Turkey  
Alec Morton,  
University of Strathclyde,  
United Kingdom

## \*CORRESPONDENCE

Beryl Maritim  
berylc.maritim@gmail.com

## SPECIALTY SECTION

This article was submitted to  
Public Health Policy,  
a section of the journal  
Frontiers in Public Health

RECEIVED 31 May 2022

ACCEPTED 20 September 2022

PUBLISHED 14 October 2022

## CITATION

Maritim B, Koon AD, Kimaina A and  
Goudge J (2022) Acceptability of  
prepayment, social solidarity and  
cross-subsidies in national health  
insurance: A mixed methods study in  
Western Kenya.  
*Front. Public Health* 10:957528.  
doi: 10.3389/fpubh.2022.957528

## COPYRIGHT

© 2022 Maritim, Koon, Kimaina and  
Goudge. This is an open-access article  
distributed under the terms of the  
[Creative Commons Attribution License  
\(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or  
reproduction in other forums is  
permitted, provided the original  
author(s) and the copyright owner(s)  
are credited and that the original  
publication in this journal is cited, in  
accordance with accepted academic  
practice. No use, distribution or  
reproduction is permitted which does  
not comply with these terms.

# Acceptability of prepayment, social solidarity and cross-subsidies in national health insurance: A mixed methods study in Western Kenya

Beryl Maritim<sup>1,2,3\*</sup>, Adam D. Koon<sup>4</sup>, Allan Kimaina<sup>3</sup> and  
Jane Goudge<sup>2</sup>

<sup>1</sup>Consortium for Advanced Research Training in Africa (CARTA), Nairobi, Kenya, <sup>2</sup>Centre for Health Policy, School of Public Health, University of the Witwatersrand, Johannesburg, South Africa, <sup>3</sup>Academic Model Providing Access to Healthcare (AMPATH), Eldoret, Kenya, <sup>4</sup>Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, United States

**Introduction:** Many low- and middle-income countries are attempting to finance healthcare through voluntary membership of insurance schemes. This study examined willingness to prepay for health care, social solidarity as well as the acceptability of subsidies for the poor as factors that determine enrolment in western Kenya.

**Methods:** This study employed a sequential mixed method design. We conducted a cross-sectional household survey ( $n = 1,746$ ), in-depth household interviews ( $n = 36$ ), 6 FGDs with community stakeholders and key informant interviews ( $n = 11$ ) with policy makers and implementers in a single county in western Kenya. Social solidarity was defined by willingness to make contributions that would benefit people who were sicker ("risk cross-subsidization") and poorer ("income cross-subsidization"). We also explored participants' preferences related to contribution cost structure – e.g., flat, proportional, progressive, and exemptions for the poor.

**Results:** Our study found high willingness to prepay for healthcare among those without insurance (87.1%) with competing priorities, low incomes, poor access, and quality of health services, lack of awareness of flexible payment options cited as barriers to enrolment. More than half of respondents expressed willingness to tolerate risk and income cross-subsidization suggesting strong social solidarity, which increased with socio-economic status (SES). Higher SES was also associated with preference for a proportional payment while lower SES with a progressive payment. Few participants, even the poor themselves, felt the poor should be exempt from any payment, due to stigma (being accused of laziness) and fear of losing power in the process of receiving care (having the right to demand care).



**Conclusion:** Although there was a high willingness to prepay for healthcare, numerous barriers hindered voluntary health insurance enrolment in Kenya. Our findings highlight the importance of fostering and leveraging existing social solidarity to move away from flat rate contributions to allow for fairer risk and income cross-subsidization. Finally, governments should invest in robust strategies to effectively identify subsidy beneficiaries.

#### KEYWORDS

social solidarity, health insurance, willingness to prepay, Kenya, informal workers, mixed methods

## Introduction

Many low- and middle-income countries (LMICs) struggle to provide adequate financial risk protection against high health care costs and are now experimenting with national social health insurance (SHI) schemes utilizing voluntary membership (1–6). These types of SHI schemes face challenges expanding membership to informal workers who have low and fluctuating incomes but constitute a large proportion of the population in many LMICs (7). The recommended path toward financial risk protection included prepayment and pooling systems where people pay before they are sick, by contributing to a pool from which they (and others contributing to the pool) can draw from in the event of sickness (5). Taking up voluntary membership of an insurance scheme requires a willingness to prepay for healthcare, and willingness to have your financial contribution to the pool benefit others who were sicker (“risk cross-subsidization”) and poorer (“income cross-subsidization”) than you, otherwise referred to as social solidarity (8).

There is growing focus on the role of solidarity in promoting participation in public health programs globally (8–11). Solidarity has been positively associated with participation in prepayment and growing financial risk pools in Europe, US and some sub-Saharan countries (8, 9, 11–16). It is founded on and influenced by trust in the scheme, and in the health systems’ ability to provide a promised benefit package (17–19). Research into social solidarity can provide insight into the barriers to increasing participation in prepayment and pooling mechanisms in LMICs. In this paper, we explore the willingness to prepay and social solidarity among informal worker households in western Kenya as part of broader efforts to understand participation in SHI in similar LMIC settings.

Kenya’s health sector is financed by a mix of methods with a significant contribution from private households in the form of out-of-pocket payments (OOP) (27% of the total health expenditure). Tax, donor funding, and health insurance account for 31, 25, 13% respectively (20). Kenya has averaged <9% of its annual government budget allocation toward health in the

2014–2020 budgets (21), despite signing the Abuja Declaration, committing to a 15% allocation (22). High poverty rates (almost 60% of the population live below the poverty line) (23) reduce the capacity to collect taxation and to expand SHI contributions (24). Health insurance enrolment rates in Kenya are currently below 20% (25). The result is an overreliance on out of pocket payment at the point of service.

The Kenyan government has prioritized universal health coverage (UHC) in its policy documents such as the ‘BIG Four Agenda’, Kenya’s Vision 2030 and the national health policy (26). The national UHC strategy intends to use the national insurer, NHIF, as a means to increase prepayment and pooling, and increase access to health care (23). NHIF is a Kenyan government state corporation and the national social health insurer founded in 1966. It provides both mandatory membership to formal sector employees and voluntary membership to informal workers. Recent policy and legal reforms have aimed at strengthening NHIF’s governance and increasing coverage especially among informal workers.

The Kenyan government has committed to gradually identifying and fully sponsoring the poorest households’ NHIF membership (27). These households are identified through a poverty list developed by the Ministry of Labor, Social Protection and Services and validated at community level to ensure the program benefits the poorest (23). An impact evaluation of the health insurance subsidy program revealed challenges providing adequate coverage and significant gaps in the inclusion of households. The program has been criticized for neither achieving desired financial risk protection nor increasing access to healthcare for poorer households.

Over 80% of the Kenyan population work are informal workers (7), many running small businesses in the agricultural, food, crafts and transportation industries (28). Those working in informal economy, defined as a “parallel unregulated economy,” are not subject to official labor laws” (28), making the levying of mandatory payments for health insurance on salaries impossible; as a result, health insurance payment, and membership, is voluntary. NHIF offers voluntary membership through a scheme known as *supa + cover* (29).

While voluntary health insurance offers an opportunity for the informal sector households to obtain the much-needed financial risk protection, the NHIF has however struggled to attract and retain new voluntary members (30). In 2017, 73% of voluntary NHIF members did not renew their health insurance (20). Low enrolment has slowed the growth of NHIF and threatens its viability. As Kenya attempts to increase health insurance coverage through NHIF, it is important to understand the population's willingness to participate in prepayment arrangements and their views on social solidarity (31).

For our study we developed a deductive conceptual framework (Figure 1) based on literature and the concepts we are focused on i.e., prepayment and tolerance of risk and income cross-subsidies. Household characteristics such as socioeconomic status, age, health and education influence views on willingness to prepay and social solidarity (13). Social solidarity and household characteristics are in turn hypothesized to influence voluntary health insurance uptake (8, 19). This paper is part of a larger PhD study exploring the role of affordability and citizen empowerment and other determinants on health insurance enrolment, the findings of which will be reported elsewhere.

## Methods

### Design

This was a mixed methods study with sequential qualitative and quantitative primary data collection (32). The study was part of a broader cross-sectional baseline household survey conducted by Academic Model Providing Access to Health care (AMPATH) between August and September 2021.

### Study site

The study was conducted in Bunyala sub-county, in Busia country, located on the western border with Uganda. Poverty levels are among the highest in the country with poor health indicators and low health insurance enrolment (33, 34).

### Study participants

We interviewed household respondents (>18 years) with adequate knowledge on households spending and healthcare utilization (Table 1) (35). Households were selected from an existing program database containing all households in Bunyala sub-County. The 6 locations in Bunyala sub-county formed the stratum for household sampling. A household list was prepared from the database and was used to randomly select households to participate in the survey under each stratum ( $n = 1,746$ ).

We asked all respondents whether they would be willing to participate in a subsequent qualitative interview.

For the in-depth interviews, we identified households who had participated in the quantitative phase, had been able to provide health care utilization and expenditure data, and had said they were willing to participate in a second interview. From this group, for each of the 6 administrative locations in the study site, we purposively selected two households from each of the following two groups: (a) currently enrolled in NHIF, (b) previously enrolled in NHIF, and (c) never been enrolled in NHIF.

For the FGDs, we purposively recruited 6–8 community stakeholders. These were mostly community opinion leaders, local administration, CSO members, community health volunteers (CHVs), ward administrators, youth representatives, teachers and religious leaders identified based on their active advocacy on health insurance related issues. We conducted 6 FGDs, one in each of the 6 sub-location with a total of 49 participants (30 males and 19 females). Key informant interview participants were also selected purposively from policymakers and implementers at facility, sub-county, county and national levels through snowballing methods ( $n = 11$ ).

## Data collection

### Quantitative

Trained interviewers collected the survey data using a structured questionnaire. With the help of local administration, data collectors with experience in national survey data collection were identified locally. The interviewers were trained on the use of tablet-based questionnaires and on the baseline survey concepts, procedures and guidelines (13, 36). Interviewers were paired with CHVs whose roles were to navigate the area and introduce the interviewers to the households. Interviews were confidential and CHVs did not take part in the interviewing session. The survey collected household information on household size, education level, health insurance status, health status, marital status, income level, household spending and healthcare utilization, health status, common illness, willingness to cross-subsidize and prepay for healthcare. Questions on social solidarity that were included in the questionnaire are adapted from the surveys previously carried out in Ghana, Tanzania and South Africa where they used show cards to assess income cross-subsidization and asked question on prepayment and social solidarity (13). Data collection tools were pretested in piloted and modifications made to address problems and potential errors. Potential challenges with the local interpretation of the show card led to some adjustments to fit the study setting context. In addition, we mitigated the effects of social desirability bias by triangulating data collection techniques to validate essential variables, using trained and skilled interviewers, and



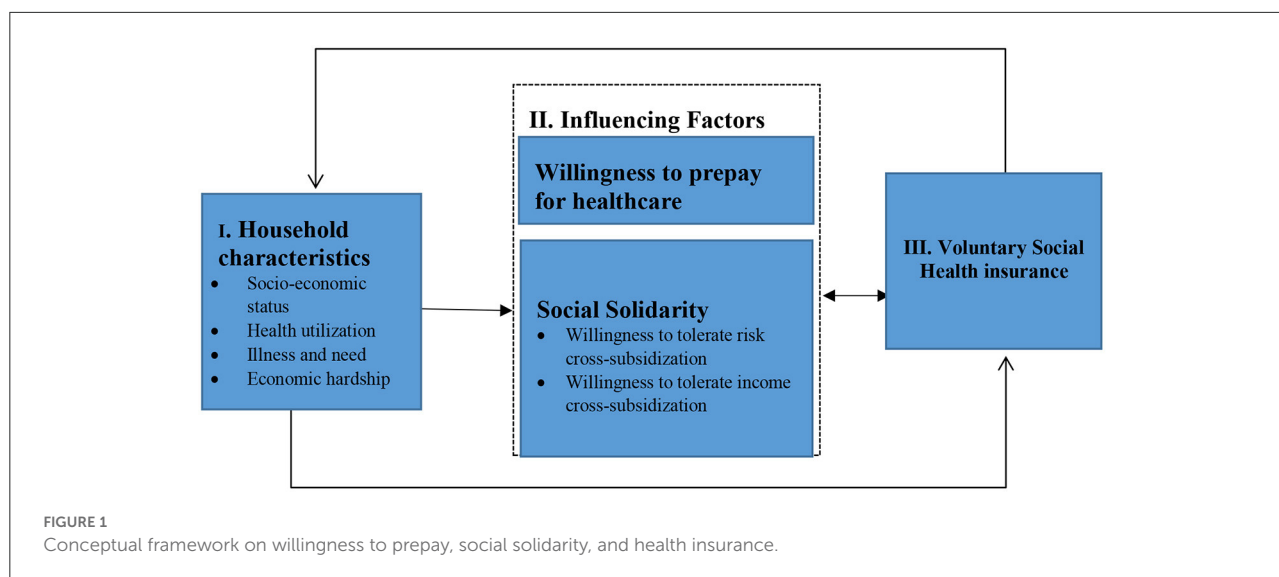


TABLE 1 Data collection method and study participants.

Interview method	Number of interviews	Participants
Household questionnaire	1,746	Household respondents (>18 years)
Household in depth interviews	36	Household respondents (>18 years)
Focus group discussions	6 groups with a total of 49 participants (30 male and 19 female)	Community stakeholders/representatives
Key informant interviews with policy makers and implementers	11	Sub-County, County and National policy makers, and implementers

pilot-testing the tools. Survey data collection was conducted between August and October 2021.

## Qualitative

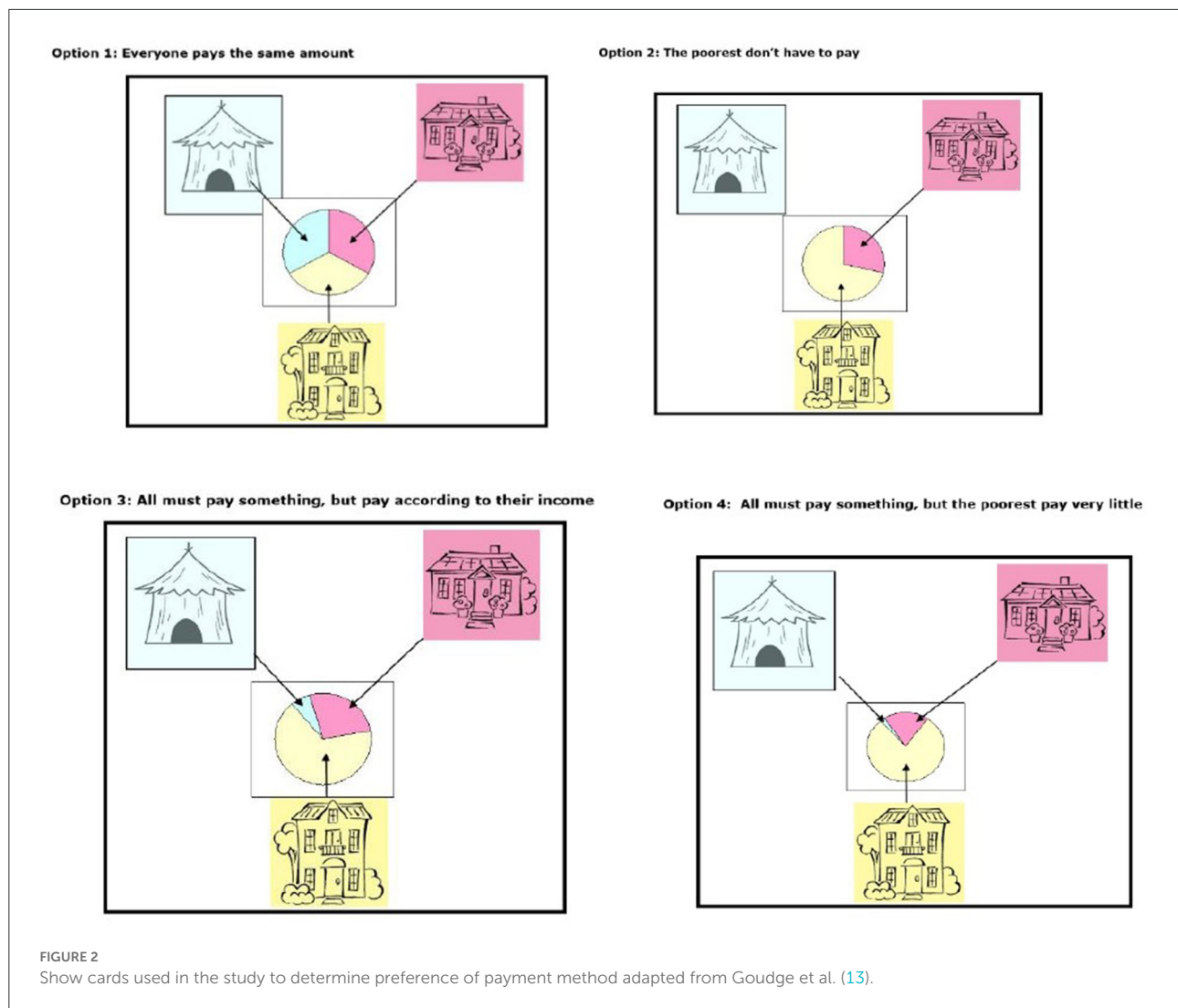
All interviews were conducted in person with KIIs with policymakers taking place in the respondent's choice of location, household interviews in respondent homesteads while FGDs were conducted at the nearest health facilities or community space. The researcher (BM) conducted interviews with the policymakers and facilitated half the FGDs. The rest of the interviews were facilitated by 3 trained research assistant. We explored respondents' views on social solidarity through semi-structured qualitative interviews using interview guides. BM, JG, and AK held debriefing sessions after a batch of interviews to identify areas of improvement in the exercise. KIIs and household IDI interviews took an average of 30–40 min while the FGDs were between 2 and 2.5 h. We conducted qualitative interviews between August and October 2021.

## Assessing willingness to prepay, social solidarity

We measured willingness to prepay among the respondents by asking whether they would agree to pay a small amount

each month so that if they got sick, health care will be free. To measure social solidarity, we assessed the respondent's tolerance of income and risk cross-subsidization, we asked whether they would be willing to contribute the same amount of money each month as everyone else, even though others who are more poor or sick than them will use the services more. This question was related to cross-subsidization that happens in financial risk pools.

To assess the determine their preference for different relative contributions that offers desired cross-subsidization, we presented household respondents with four healthcare contribution options in the form of pictorial diagrams (show cards) with housing type as the form as measure of socio-economic status (SES) (Figure 2). The four option were (1) everyone pays the same amount (flat contribution); (2) everyone must pay according to their income (proportional contributions e.g., everybody pays 5% of their income irrespective of their income level); (3) all must pay something, but the poorest pay very little (all pay progressive contributions, where the percentage increases with income); (4) progressive contributions but the poor do not pay. Respondents were then asked to select one that resonated with their belief of how healthcare contributions should be made.



## Analysis

In the quantitative analysis, we first conducted descriptive analysis to examine willingness to prepay, and tolerate income and risk cross-subsidization by the socio-demographic factors identified in literature (13). Secondly, we used bivariate logistic regression to examine the influence of population characteristics on the three outcomes of interest -willingness to prepay, and tolerate income and risk cross-subsidization. Odds ratio (OR) and corresponding confidence intervals were used to report the strength of influence of the socio-demographic factors on the 3 outcomes. The analysis was presented at 95% significance level at  $\alpha = 0.05$ . The analyses set the reference group for OR (odds ratio) as 1.0. Data analysis was done using R and relevant R packages.

The audio recordings from the IDIs with household heads, KIIs with policymakers and implementers, and FGDs were transcribed manually using Microsoft word and compared against their respective audio files for accuracy. Qualitative data was analyzed manually using a thematic framework analysis approach (37). BM read through the transcripts to familiarize with the data first. Second BM, JG, and AK began identifying key ideas and phrases from a few sampled transcripts and developing labels or codes. Once the team agreed on the labels or codes, BM went ahead and applied them to subsequent transcripts. A mind map was then used to categorize the codes based on the study objective and conceptual framework. The main categories were social solidarity and pooling, willingness to prepay, barriers to prepayment and views on preference of payment approaches. In an iterative process,

we drew relationships between the categories to identify and refine themes. Lastly, we interpreted the results and presented them under each theme and included supportive quotes from the interviews.

## Ethical consideration

Ethical approval was obtained from University of Witwatersrand (Certificate no. M210216) and the Moi University/Moi Teaching and Referral Hospital Institutional Research Ethics Committee (IREC)-(No. 0003935), before beginning the study. Additional approval was obtained from the National Commission for Science Technology and innovation (NACOSTI-P/21/12262) and Busia County Health Department. Written informed consent were also obtained from participants willing to participate in the study.

## Results

### Household survey findings

#### Willingness to prepay

Nearly all the respondents expressed willingness to prepay for their healthcare costs (88%) (Table 2). Respondents expressing willingness to prepay were 4.09 times likely to be aged 25–40 compared to those above 65 years. Higher likelihood of expressing willingness to prepay was recorded among respondents those who had attended school (OR2.82), those of higher SES (OR 4.07 and 3.12 for Q4 and Q5), and those with health insurance (OR 3.45). Interestingly, 87.1% of the respondents without health insurance expressed willingness to prepay. Also unexpectedly, lower likelihood of expressing willingness to prepay was recorded among respondents with chronic illness (OR 0.64). Lower likelihood was also reported among informal workers (OR 0.4). All these associations were statistically significant.

#### Social solidarity-tolerance of income and risk cross subsidization

Just over half of the sample (54.9%) were in favor of income cross-subsidies(IC) (Table 2) while nearly two thirds of the respondents (60.7%) were willing to tolerate risk cross-subsidization (RC). A higher likelihood of tolerating both income and risk cross-subsidies was expressed by the male respondents (IC: OR 1.4 and RC: 1.37). Higher likelihood of expressing tolerance for cross-subsidization was recorded among respondents those who had attended school (IC: OR 1.5, RC: 1.77), those of higher SES (IC: OR 2.19 and RC 2.03 for Q5) and those with health insurance (IC: OR 2.03 and RC: 2.76). All these associations were statistically significant. Seemingly,

tolerance of cross-subsidization increased with wealth. Lower likelihood was also reported among informal workers (OR 0.4) compared to those in formal employment and the divorced (OR 0.91, 0.84) compared to the married. Only 67.2% of those with health insurance were willing to cross-subsidize those who are poorer than themselves indicating a poor understanding of insurance.

#### Preferences for different relative contributions

Nearly half of the respondents (41.2%) were in favor of a progressive payment while only 4.9% of the respondents believed that everyone should pay the same amount (Table 3). The most popular options among the wealthy were the proportional payment (38.8%) and the progressive where the poor don't pay at all (23.1%). Surprisingly, among the poorest, progressive payments was the most popular option (54.2%) with option where the poor don't pay being much less popular (17.6%).

### Qualitative findings

#### Willingness to prepay and understanding of pooling

Respondents expressed a preference to make small regular contribution in advance to access free healthcare when they needed it. One of the perceived benefits of prepayment observed by participants is that it helped people access care without delays: *"Sometimes one is in a critical condition and the treatment is required urgent. At that point, there is no time to sit down as a community and fundraise and fundraise. That can take time."* (FGD F R4). Most of the respondents cited the rising cost of treatment as well as higher incidence and unpredictability of illness as the main reason to prepay: *"It is easier to put money in a pot every month, so you can get free services when you need it, than you pay when you are sick. Diseases come when there is no money."* (FGD C R2).

Despite the recognized importance of prepayment, many households were not enrolled into any health insurance scheme and paid for their healthcare at the point of service. Lack of awareness of available insurance mechanisms was cited as the reason for not enrolling. Community representatives and policy makers also noted that majority of the population comprised of low-income earners with many competing priorities and healthcare did not rank top of the priorities especially for the youth: *"We are all different and all have different priorities on how to spend our income. You can't pay for insurance and yet you do not have food."* (FGD F R4) Respondents expressed the desire to make smaller and flexible contributions toward premiums.

TABLE 2 Willingness to prepay and tolerance of risk cross-subsidies among the respondents.

Characteristic		% (n)	Willingness to prepay <sup>b</sup>			% (n)	Income cross-subsidies <sup>c</sup>			% (n)	Risk cross-subsidies <sup>d</sup>		
			OR <sup>a</sup>	95% CI <sup>a</sup>	p		OR <sup>a</sup>	95% CI <sup>a</sup>	p		OR <sup>a</sup>	95% CI <sup>a</sup>	p
Age	18–24	90.7 (714)	2.65	(1.43, 5.31)	<b>0.003</b>	55.4 (439)	0.91	(0.57, 1.44)	0.7	61.1 (483)	0.86	0.54, 1.37	0.5
	25–44	91.4 (551)	4.09	(2.94, 5.73)	<b>&lt;0.001</b>	57.5 (347)	1.3	(1.01, 1.68)	<b>0.039</b>	65.0 (392)	1.51	1.17, 1.94	<b>0.002</b>
	45–64	73.5 (202)	3.89	(2.75, 5.54)	<b>&lt;0.001</b>	49.5 (136)	1.47	(1.13, 1.91)	<b>0.004</b>	52.4 (144)	1.79	1.37, 2.34	<b>&lt;0.001</b>
	≥64	85.2 (69)	—			45.7 (37)	—			49.4 (40)	—	—	
Sex	Female	63.0 (967)	—			52.3 (581)	—			58.2 (647)	—	—	
	Male	89.6 (569)	1.1	(0.83, 1.46)	0.5	59.5 (378)	1.4	(1.16, 1.69)	<b>&lt;0.001</b>	64.9 (412)	1.37	1.13, 1.66	<b>0.001</b>
Marital status	Divorced/separated	90.5 (134)	—			54.1 (80)	—			60.8 (90)	—	—	
	Married/ living together	90.4 (989)	0.87	(0.47, 1.50)	0.6	56.1 (614)	1.12	(0.79, 1.58)	0.5	61.9 (677)	1.06	0.75, 1.50	0.7
	Never married/ never lived together	78.3 (90)	0.45	(0.22, 0.90)	<b>0.026</b>	54.8 (63)	1.32	(0.82, 2.13)	0.2	60 (69)	1.22	0.75, 1.99	0.4
	Widowed	83.0 (323)	0.49	(0.26, 0.88)	<b>0.022</b>	51.9 (202)	0.91	(0.63, 1.33)	0.6	57.3 (223)	0.84	0.57, 1.23	0.4
Ever attended school	No	79.7 (278)	—			49.0 (171)	—			52.1 (182)	—	—	
	Yes	90.1 (1,258)	2.82	(2.12, 3.75)	<b>&lt;0.001</b>	61.9 (788)	1.5	(1.20, 1.88)	<b>&lt;0.001</b>	99.6 (877)	1.77	1.42, 2.22	<b>&lt;0.001</b>
Occupation	Formal employment	95.3 (41)	—			76.7 (33)	—			81.4 (35)	—	—	
	Homemakers (Stay at home)	83.5 (232)	0.19	(0.03, 0.62)	<b>0.022</b>	46.4 (129)	0.26	(0.12, 0.52)	<b>&lt;0.001</b>	53.6 (149)	0.25	0.10, 0.52	<b>&lt;0.001</b>
	Students	57.1 (4)	0.06	(0.01, 0.46)	<b>0.008</b>	57.1 (4)	0.37	(0.07, 2.13)	0.2	42.9 (3)	0.16	0.03, 0.84	<b>0.031</b>
	Unemployed/Seeking work	78.5 (84)	0.17	(0.03, 0.60)	<b>0.018</b>	54.2 (58)	0.33	(0.14, 0.71)	<b>0.006</b>	59.8 (64)	0.33	0.13, 0.73	<b>0.01</b>
	Working in informal employment (e.g., farmers, artisans, juakali, business etc.)	89.8 (1,167)	0.4	(0.06, 1.30)	0.2	56.2 (731)	0.37	(0.17, 0.72)	<b>0.006</b>	61.7 (802)	0.35	0.15, 0.71	<b>0.007</b>
	Others (Specify)	72.7(8)	0.12	(0.01, 0.84)	<b>0.033</b>	36.4 (4)	0.16	(0.04, 0.63)	<b>0.011</b>	54.5 (6)	0.25	0.06, 1.06	0.056

(Continued)

TABLE 2 (Continued)

Characteristic		% (n)	Willingness to prepay <sup>b</sup>			% (n)	Income cross-subsidies <sup>c</sup>			% (n)	Risk cross-subsidies <sup>d</sup>		
			OR <sup>a</sup>	95% CI <sup>a</sup>	<i>p</i>		OR <sup>a</sup>	95% CI <sup>a</sup>	<i>p</i>		OR <sup>a</sup>	95% CI <sup>a</sup>	<i>p</i>
Have health insurance	No	87.1 (1,345)	—			53.3 (824)	—			58.5 (904)	—		
	Yes	95.0 (191)	3.45	(1.90, 7.06)	<b>&lt;0.001</b>	67.2%(135)	2.03	(1.51, 2.76)	<b>&lt;0.001</b>	77.1%(155)	2.76	1.99, 3.91	<b>&lt;0.001</b>
Wealth quintile	Q1	79.5 (276)	—			46.4 (161)	—			52.7 (183)	—		
	Q2	85.1 (298)	1.67	(1.16, 2.42)	<b>0.006</b>	56.9 (199)	1.74	(1.31, 2.30)	<b>&lt;0.001</b>	60.9 (213)	1.54	1.16, 2.05	<b>0.003</b>
	Q3	90.9 (311)	2.37	(1.58, 3.62)	<b>&lt;0.001</b>	51.5 (176)	1.25	(0.94, 1.67)	0.12	56.4 (193)	1.17	0.88, 1.57	0.3
	Q4	92.9 (326)	4.07	(2.58, 6.63)	<b>&lt;0.001</b>	53.8 (189)	1.47	(1.11, 1.95)	<b>0.007</b>	63.2 (222)	1.66	1.25, 2.22	<b>&lt;0.001</b>
	Q5	91.3 (325)	3.12	(2.03, 4.90)	<b>&lt;0.001</b>	65.7 (234)	2.19	(1.64, 2.94)	<b>&lt;0.001</b>	69.7 (248)	2.03	1.52, 2.74	<b>&lt;0.001</b>
Member financial group	No	86.0 (928)	—			52.5 (566)	—			58.5 (631)	—		
chama	Yes	91.2 (608)	1.84	(1.37, 2.51)	<b>&lt;0.001</b>	58.9 (393)	1.16	(0.97, 1.40)	0.11	64.2 (428)	1.16	0.96, 1.40	0.13
Admitted last 12 m	No	88.0 (1,435)	—			54.9 (895)	—			60.3 (983)	—		
	Yes	87.8 (101)	0.93	(0.56, 1.63)	0.8	55.7 (64)	1.06	(0.74, 1.54)	0.7	66.1 (76)	1.3	0.89, 1.92	0.2
Chronic ailment	No	89.9 (842)	—			53.3 (499)	—			60.0 (562)	—		
	Yes	85.5 (694)	0.64	(0.49, 0.83)	<b>0.001</b>	56.9 (460)	1.11	(0.93, 1.33)	0.3	61.4 (497)	1.01	0.84, 1.22	0.9
		<b>88.0 (1,536)</b>				54.9 (959)				60.7 (1,059)			

<sup>a</sup>OR, Odds Ratio; CI, Confidence Interval. The bold *P* values are statistically significant at  $\alpha = 0.05$ .

<sup>b</sup>I would agree to pay a small amount each month so that if I get sick, health care will be free, even if I am not sick now.

<sup>c</sup>I would be willing to pay the same amount of money each month as everyone else, even though others who are more sick than I am will use the services more than me.

<sup>d</sup>I would be willing to willingness to pay the same amount of money each month as everyone else, even though others who are more poor than I am will use the services more than me.

TABLE 3 Payment Preference and wealth quintiles of the respondents.

Wealth quintiles	Progressive but the poor don't pay <i>n</i> = 399 %(n)	Progressive <i>n</i> = 720 %(n)	Proportional <i>n</i> = 541 %(n)	Same flat amount <i>n</i> = 86 %(n)	<i>p</i> <sup>a</sup>
Q1 (Poorest)	17.6 (61)	54.2 (188)	19.9 (69)	8.4(29)	<0.001
Q2	26.0 (91)	41.4 (145)	27.7 (97)	4.9 (17)	
Q3	22.5 (77)	43.9 (150)	30.7 (105)	2.9 (10)	
Q4	22.2 (78)	36.5 (128)	37.6 (132)	3.7 (13)	
Q5 (wealthiest)	25.8 (92)	30.6 (109)	38.8 (138)	8 (17)	
Total (%)	22.9 (399)	41.2(720)	31.0 (541)	4.9 (86)	

## Trust

Trust in the health system was repeatedly mentioned by in the interviews. Reliability and quality of services was a key consideration for making decisions to enroll for insurance. Respondents expressed mistrust in the health care delivery system citing negative attitude and discrimination against the poor. There were complaints of unfair treatment and unreliable services often discouraging prepayment or causing many to default from making regular contributions: *“There are people with diabetes and blood pressure who are always contributing for health insurance but when they get unwell and come here for service, there are no drugs. Will they continue to contribute? They will decide they would rather give cash and get services.”* (FGD F R4) Geographical distribution of health facilities was also a concern. Participants felt that the pro-urban distribution of health facilities and the quality of services favored the urban dwellers and discouraged enrolment of rural populations.

## Social solidarity and risk and income related contributions

The sense of community was central to cultural identity and individuals felt bound together by this understanding: *“Within the African set up especially, we really tend to identify ourselves with our neighbors and our relatives. In as much as we will want to think about ourselves, most of the things we do in society usually involves others.”* (KII\_033) Harambees (fund raisings) were the commonest form of solidarity often relied on for both financial and social security in times of need: *“Even in common culture, fundraisings are part of our culture to raise money when people are unwell or sick. I think there is a common thread running through that people do support each other.”* (KII\_09) However, respondents observed weakening ties evidenced by declining participation in fundraisings: *“Actually when I look at the society now, it is like the issue of harambee is becoming very unpopular. There were years you used to call a harambee, and you would see*

*a crowd. Nowadays you don't see that. Maybe people are fatigued, and they have better ways of dealing with their issues.”* (KII\_11)

For many of the respondents, the health of the family formed the priority, with some participants expressing unwillingness to contribute to healthcare costs of people beyond their immediate family. *“If we said that we will pay for insurance that will cover the neighbors, we will have lied to ourselves”* (FGD F R6). Feelings of mistrust were expressed between members of the community with regards to their willingness to support others. Even when people declared good intent, they did not always honor them: *“Many times we hear someone saying at a burial, “These children belong to my brother. I will do this and this for them” but they never do it. When they leave, they are gone completely.”* (FGD F R2).

Tolerance for risk and income cross-subsidization varied across the respondents. Some respondents expressed regard for the plight of others in the community especially those who were sicker revealing a higher to tolerance of risk cross-subsidization: *“Maybe you are the kind who is blessed and you never get sick, yet you have a neighbor who is always sick; if you helped in this case, isn't that a good thing?”* (FGD F R1). Income cross-subsidization received relatively less support. The idea that contributions could benefit those who were poorer was viewed as burdensome by some respondents: *“If we say we carry each other on the back, we will not be helping each other. It is good for everyone to be self-reliant* (FGD C R6). Respondents expressed particularly higher distrust toward the rich who were otherwise viewed as having acquired their wealth by exploiting the poor. These were followed by concerns that they would not agree to cross-subsidize the poorer because of their “cruel” nature.

Policy makers expressed concern that there was limited awareness and understanding of how insurance pools and often, when people contribute to insurance, they are not aware of the cross-subsidization element: *“When they pay premiums, they won't really be thinking that it would pay for someone else, and they might actually be displeased to know that it happens in practice.”* (KII\_09) A representative of NHIF further elaborates on an expectation that the pool should cover all



medical cost revealing a lack of awareness on their entitlements and services covered in the benefit package. *“When most people contribute, they think we bank for them. When one has an accident and doesn’t get approval for the surgery, they will ask, ‘Why? I have been contributing all this time and I have not used this money. Who has been using it?’”* (KII\_02) There was need to sensitize the community on existing prepayment and pooling mechanisms as well as the benefit package to increase participation: *“Once people understand the importance of having a pool of resources to benefit the entire community, then it becomes cheaper for everybody.”* (KII\_04).

### Preferences for different relative contributions

The flat payment method option was the least preferred approach because it allowed the least level of cross-subsidization and denied access to the poor. This option used by NHIF was the main reason many people didn’t renew their membership: *“Today I may get Ksh 1,000 or Ksh 500 for this whole month; will I go to pay NHIF and my kids to sleep hungry? Of course not! So, I skip paying for that month. Once two months pass, I will become demotivated.”* (FGD D R3). Respondents felt that it was not fair to impose equal contributions across people of different socio-economic status: *“You see not everyone is equal because what you earn is not same as what I earn, so we cannot pay the same.”* (IDI\_A\_Never\_01). However, others objected to contributions based on ability to pay because the same principle was not applied outside the health sector: *“If you go to shops, they haven’t differentiated the price of items for the rich and the poor. If our wish is to be treated the same, I am for the opinion that the rates to be the same.”* (FGD B\_R4) Some participants believed that contributions be based on need not income but others believed that all should pay the same amount since sickness affected both the rich and the poor.

### Should the poor pay?

The idea of exempting the poor elicited mixed views. Most of the community respondents feared that exempting the poor from making contributions would create dependency or condone laziness. Ensuring everyone contributed enforced a culture of hard work and eliminated the culture of receiving handouts: *“Free things bring laziness. People don’t see a reason to work. They can be subsidized but it should not be completely free.”* (FGD D R4). (FGD D R6) Some said that contributing promoted a sense of ownership, arguing that it would give everyone, and especially the poor, the right to demand for quality services. There was a recognition that healthcare was expensive, and respondents held the view that it was important to mobilize contributions from everyone as one policy maker stated: *“You know financing health is very expensive. If we say we will pay for the poor, we may not sustain it.”* (KII\_01) Respondents also argued that the poor placed a higher burden on the health system

because they were a majority and often sicker, and therefore had to contribute.

In contrast, respondents who identified themselves as poor especially expressed the desire to be exempted and felt that the rich needed to contribute more in order to cross-subsidize the poor: *“I’d like them to pay for me, because if you tell me to pay from my income, I could not afford it.”* (IDI\_F\_Never\_01). A few respondents felt that the poor could not afford to pay for healthcare and should be exempted from contributing and therefore supported subsidizing the poor. However, government processes to determine subsidy recipients were often not transparent. Respondents expressed mistrust in the government institutions’ ability to objectively determine who to exempt: *“We see that we have government cash transfers. It has left out those people who have no means. And it has enrolled other people. Those with connections benefit while those people who have no means are left out.”* (FGD D R1)

## Discussion

Our study revealed that there was a high willingness to prepay for health care among those without insurance but competing priorities, low incomes, poor access and quality of health services, lack of awareness of flexible payment options were cited as barriers to enrolment. While more than just over half of the respondents expressed willingness to tolerate risk and income cross-subsidization, suggesting a strong sense of social solidarity, that increases with socio-economic status. However, the wealthy were more in favor of a proportional payment, and the poor, a progressive payment, although there seemed to be limited understanding of the importance of pooling funds. Despite many reporting they could not afford to pay the membership fee, only less than one fifth of the poor (17.1%) felt the poor should be exempt. This may be due to stigma (being accused of laziness) and fear of losing power in the process of receiving care (having the right to demand care). Our findings suggest the concept of social solidarity was consistent with the historical African culture of standing with one another but over time the level of social solidarity was observed to be diminishing.

Our findings on social solidarity reveal a higher willingness to tolerate risk cross-subsidization compared to income cross-subsidization and was observed across each wealth quintile. This demonstrates a higher consideration for the sick than for the poor. The observed difference may also be indicative of the population’s low tolerance of income cross-subsidies as poverty is perhaps thought to be a result of an individual’s efforts. Indeed, some participants felt that contributing to healthcare cost of others was burdensome, unrealistic and the reluctance to contribute was justified by the need to promote self-reliance among the poor. These findings could explain rising opposition to attempts in Kenya to revise premiums for formal sector



workers in order to cross-subsidize the poor. Such proposals were met with significant opposition by labor unions who preferred not to bear the responsibility of the poor (38). Similar views and opposition to policy reforms favoring the poor were recorded in a study in other LMIC settings and were found to limit social solidarity (39, 40). The objective of pooling prepaid contributions is to redistribute financial risk associated with healthcare among members of the society and therefore solidarity and support for risk income and risk cross-subsidization provide a conducive environment for pooling in the context of voluntary enrolment into health insurance (1, 13, 17, 30, 41).

Willingness to tolerate cross-subsidization increased with an increase in wealth and education implying a better understanding of pooling principles among the educated and those in higher SES groups. For example, likelihood of expressing willingness to tolerate income and risk cross-subsidization was higher among the highest quintile (richest) than the lowest quintile (poorest). Sixty-nine percent of respondents in the highest quintile (richest) expressed support for risk cross-subsidization compared to 52.7% of the lowest quintile (poorest). These findings are consistent to the results of the SHIELD Study in south Africa where greater support for risk cross-subsidization was reported among the higher income groups (65%) compared to the lower income groups (48%) (13). It is plausible that willingness to cross-subsidize was corresponded with the ability of the individuals to contribute and therefore lesser ability to contribute led to less willingness to cross-subsidize.

Kenyans have long been pooling their money to protect themselves against the financial risks arising from high medical expenses. The culture of fundraising, commonly referred to as “harambees” is a common form of solidarity and dates back to African cultural construct where solidarity among community and family formed part of individual identity. Similar findings are documented in other studies in South Africa where the African Ubuntu philosophy promoted communal relationships and mutual consideration for others (23). Despite operating on similar principles of contribution and pooling, the culture of raising funds through harambees seems more acceptable than health insurance. This could be explained by the fact that harambees, tend to happen among smaller social networks where the beneficiaries are identifiable and do not require long term financial commitment. Achieving the same level of solidarity among a much wider, diverse population nationwide, for social health insurance is harder. However, despite the popularity and reliance on harambees as an informal financial security, our findings reveal concerns that the tradition of fundraisings was declining due to modernization and socioeconomic changes. With the weakening of social ties and hard economic times globally, this form of solidarity can no longer be relied on to provide pooling and financial protection as it historically did, warranting the expansion of enrolment

into health insurance (19). Higher levels of cross-subsidization can be achieved with nationwide pooling systems like health insurance compared the cross-subsidization of a small group of poor rural people sharing their limited resources. Nationwide pooling draws the rural poor into the same pool as the wealthier urban population.

Our findings show that poverty is a significant barrier to increasing prepayment through health insurance. Despite a high willingness to prepay for healthcare, and the willingness to cross subsidize, the ability to pay for health insurance was a significant barrier to participation in schemes. This is evidenced by results from the recent Kenya Household Health Expenditure and Utilization Survey (KHHEUS) 2018 where 42% health insurance enrolment was reported among higher wealth quantiles while only 2.9% of the lowest wealth quantiles have insurance (30). Efforts to increase participation in health insurance schemes need to ensure the poorest are supported to access insurance through subsidy programs. Our study participants expressed concerns and fears of discriminatory treatment against the poor and the skewed distribution of resources, information and health facilities in favor of the wealthier populations. Health facilities were believed to discriminate against people of lower SES, offering them substandard care. Participants demanded equitable access and treatment across SES as a condition to enroll in prepayment schemes. Indeed, previous studies reveal that people of higher SES experience better healthcare than middle and lower SES (11, 42).

Our study also revealed the difficulty of exempting the poor from making contributions because of the difficulties of determining income levels among informal workers. Recent global and national UHC policy reforms are anchored on the need to prioritize the needs of the poorest and vulnerable in order to achieve truly “universal” coverage (43). This raises a pertinent question on the best way to determine SES to exempt the poor. Programs meant to benefit the poor have often failed to have the desired impact because of reported errors in inclusion inaccuracies (42, 44–46). The difficulties in measuring poverty among informal workers is a major interest in many program areas (47). The poor constitute a large proportion of the population in LMICs. According to the recent national household survey on, it is estimated that about 60% of Kenyans live below the poverty line making the issue of poverty especially important (23). Respondents in our study expressed concerns that the poor placed a high burden on the country’s health sector. There were also concerns about exempting the poor from making payment promoted laziness. This implies a reluctance to cross-subsidize the poor.

Various dimensions of trust were found to contribute to willingness to prepay and level of social solidarity as revealed by our study findings. These dimensions include trust in the public health system, trust among scheme members, and trust in the government institutions to objectively target vulnerable households to benefit from insurance subsidy program.

Respondents based decisions to participate in prepayment schemes on perceived trust in the health system. They expressed mistrust in the formal public health system citing unreliability of services, poor services offered in facilities, negative staff attitudes, discrimination of the poor in healthcare delivery and pro-urban distribution of facilities. These views are validated by findings of previous studies that found that trust in the health system influenced participation in insurance schemes (14, 18, 19). Perceived mistrust of government systems used in means testing to exempt the poor from contributing had failed in other programs. This is confirmed by other studies that found that 65% of the national health insurance subsidy recipients meant for the poor belonged to wealthier quintiles (42). This is indicative of a targeting challenge that had led to mistrust of government systems used to establish vulnerability among community members—a common problem in many LMICs. Similar targeting challenges are reported in Ghana's National Health Insurance Scheme (NHIS) (13, 48). Efforts to increase coverage must therefore be accompanied by strategies to address trust and reliability of health services and systems.

## Recommendations for policy

Our findings have a number of policy implications in Kenya and similar LMIC settings. First, social health insurance schemes have the opportunity to foster and leverage existing solidarity to increase participation in health insurance programs. Solidarity in insurance can be strengthened by ensuring better understanding of the concept of risk pooling. For instance, messaging about NHIF should deliberately frame the scheme as a central pot that all members benefit from and the premium contributions to the risk pool as individual contributions to the good of the community.

Second, trust in the health system and NHIF should be strengthened through improving communication and relationships between the community, healthcare providers, and NHIF. Citizen involvement and engagement is a key element in building trust. Policies that facilitate community engagement should be adopted and forums for citizen engagement by NHIF and the ministries of health should be established. To curb the low awareness on prepayment that persists, NHIF should focus efforts in creating awareness on NHIF processes, and health services covered by NHIF. There is also need for continuous monitoring of service delivery by NHIF accredited providers to improve quality of services. Lastly, there is need to build trust and transparency in the identification of beneficiaries for national social assistance programs including the national health insurance subsidy program. An important step to this is community verification of vulnerability as part of the identification process.

## Limitation of the study

A key limitation of previous inquiries into the subject of social solidarity in health insurance is that they have been mostly quantitative and therefore did not describe the respondents reasoning underlying their responses on social solidarity. The mixed method study approach assumed in our paper attempts to bridge this limitation. This study took part in a small geographical area made up of a relatively ethnically homogenous population that is predominantly poor and should be interpreted with this consideration in mind. The results of our study can be generalized to other rural areas with low SES and informal workers. Further researcher would be required among urban population and among individuals of higher SES. We also acknowledge that other health economics methods have been used to explore willingness to pay. The goal of our paper was to get a broad understating on the risk and income distribution preference in the society. We did not take the willingness to pay approach on willingness to prepay and tolerance of cross-subsidization because we wanted to focus respondents' acceptance of the principle of prepayment and pooling. This is an important consideration for insurance coverage and presents preliminary work that further research can build off.

We therefore caution that these proportions may not translate to decisions to prepay for healthcare as they may be influenced by hypothetical bias. Hypothetical bias occurs when participants overstate hypothetical preference different from actual preference. Despite our best efforts to minimize their effect, social desirability and hypothetical bias may have led respondents to overstate willingness to prepay or cross-subsidize. Nonetheless we believe, our study is a novel exploration into the social solidarity, prepayment of healthcare and health insurance among informal workers. We presented findings that help us understand the role of health insurance related factors in determining health insurance enrolment. Further research is needed to the role of social solidarity on health insurance enrolment.

## Conclusion

This paper assessed the level of social solidarity and willingness to prepay as a key consideration in gaining broader understanding of participation in social health insurance programs. We explored how individual socio-economic and health status influenced their views on willingness to prepay and social solidarity. Although there is a high willingness to prepay for healthcare, low incomes, inadequate awareness of prepayment mechanisms and poor service delivery at health facilities hinder voluntary enrolment into existing SHI schemes. Efforts to increase awareness would need to be coupled with similar efforts to improve health service delivery so as to build

trust in the formal health system. Our findings suggest the importance of fostering and leveraging existing social solidarity to increase health insurance enrolment. NHIF can leverage existing solidarity and willingness to prepay for healthcare to increase enrolment into health insurance. However, there is an urgent need to revise payment approaches away from flat rate contributions currently employed in Kenya for the informal sector to allow for adequate risk and income cross-subsidization. Finally, the government should consider revising or ensuring proper implementation of targeting policies to ensure subsidy programs benefit intended beneficiaries. In this way, we propose that a stronger NHIF will help Kenya more fully realize its UHC ambitions.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving human participants were reviewed and approved by Ethical approval was obtained from University of Witwatersrand (Certificate no. M210216) and the Moi University/Moi Teaching and Referral Hospital Institutional Research Ethics Committee (IREC)-(No. 0003935), before beginning the study. Additional approval was obtained from the National Commission for Science Technology and Innovation (NACOSTI-P/21/12262) and Busia County Health Department. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

BM, JG, and AKi contributed to the conceptualization of the project and drafted the manuscript. BM, JG, AKi, and AKo contributed to the development of data collection materials. BM contributed to the recruitment of participants and data collection. All authors edited and approved the final draft. All authors contributed to the article and approved the submitted version.

## References

1. Mathauer I, Torres LV, Kutzin J, Jakab M, Hanson K. Pooling financial resources for universal health coverage: options for reform. *Bull World Health Organ.* (2020) 98:132–9. doi: 10.2471/BLT.19.234153
2. Maarse H, Paulus A. Has solidarity survived? A comparative analysis of the effect of social health insurance reform in four European countries. *J Health Polit Policy Law.* (2003) 28:585–614. doi: 10.1215/03616878-28-4-585

## Funding

This work was funded by CARTA and AbbVie Foundation (Grant 341). BM was supported by the Consortium for Advanced Research Training in Africa (CARTA). CARTA is jointly led by the African Population and Health Research Center and the University of the Witwatersrand and funded by the Carnegie Corporation of New York (Grant No. G-19-57145), Sida (Grant No. 54100113), Uppsala Monitoring Center, Norwegian Agency for Development Cooperation (Norad), and by the Wellcome Trust [reference no. 107768/Z/15/Z] and the UK Foreign, Commonwealth and Development Office, with support from the Developing Excellence in Leadership, Training and Science in Africa (DELTAS Africa) programme. The statements made and views expressed are solely the responsibility of the Fellow. For the purpose of Open Access, the author has applied a CC BY public copyright license to any Author Accepted Manuscript version arising from this submission.

The Population Health Program in AMPATH under which this research was nested was supported by ABBVIE Foundation (Grant 341).

## Acknowledgments

We would like to thank AMPATH Population Health Program under which the research was conducted.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

3. Cotlear D, Nagpal S, Smith O, Tandon A, Cortez R. *Going Universal: How 24 Developing Countries Are Implementing Universal Health Coverage Reforms from the Bottom Up.* (2015). doi: 10.1596/978-1-4648-0610-0

4. Kutzin J. Health financing for universal coverage and health system performance: concepts and implications for policy. *Bull World Health Organ.* (2013) 91:602–11. doi: 10.2471/BLT.12.113985

5. World Health Organization. *Health System Financing: The Path to Universal Coverage* (2010).
6. The World Bank. Financing health in low-income countries. *Heal Financ Revisit*. (2005) 209–48. doi: 10.1596/978-0-8213-0900-1
7. World Bank. *Informal Enterprises in Kenya* [Internet]. Washington, DC (2016). Available online at: <https://openknowledge.worldbank.org/handle/10986/24973>
8. Douwes R, Stuttard M, London L. Social solidarity, human rights, and collective action: considerations in the implementation of the National Health Insurance in South Africa. *Heal Hum Rights J*. (2018) 20:185–96.
9. Davies B, Savulescu J. Solidarity and responsibility in health care. *Public Health Ethics*. (2019) 12:133–44. doi: 10.1093/phe/phz008
10. Gualda E. Altruism, solidarity and responsibility from a committed sociology: contributions to society. *Am Sociol*. (2022) 53:29–43. doi: 10.1007/s12108-021-09504-1
11. Mbogo BA, McGill D. Perspectives on financing population- based health care towards Universal Health Coverage among employed individuals in Ghanzi district, Botswana: A qualitative study. *BMC Health Serv Res*. (2016) 1–14. doi: 10.1186/s12913-016-1657-2
12. Snell K, Tarkkala H, Tupasela A. A solidarity paradox – welfare state data in global health data economy. *Heal*. (2021) 0. doi: 10.1177/13634593211069320
13. Goudge J, Akazili J, Ataguba J, Kuwawenaruwa A, Borghi J, Harris B, et al. Social solidarity and willingness to tolerate risk- and income-related cross-subsidies within health insurance: experiences from Ghana, Tanzania and South Africa. *Health Policy Plan*. (2012) 27(Suppl.1):i55–63. doi: 10.1093/heapol/czs008
14. Dror DM, Shahed Hossain SA, Majumdar A, Koehlmoos TLP, John D, Panda PK. What factors affect voluntary uptake of community-based health insurance schemes in low- and middle-income countries? A systematic review and meta-analysis. *PLoS ONE*. (2016) 11:160479. doi: 10.1371/journal.pone.0160479
15. Zang L, Wang H, Wang L, Hsiao W. Social capital and farmer's willingness-to-join a newly established community-based health insurance in rural China. *Health Policy*. (2006) 76:233–42. doi: 10.1016/j.healthpol.2005.06.001
16. Jost T. NHealth care access in the United States. Conflicting concepts of justice and little solidarity title. *Med Law*. (2008) 27:605–16.
17. Mathauer I, Schmidt JO, Wenyaa M. Extending social health insurance to the informal sector in Kenya. An assessment of factors affecting demand. *Int J Health Plann Manage*. (2008) 23:51–68. doi: 10.1002/hpm.914
18. Fusheini A. The politico-economic challenges of Ghana's national health insurance scheme implementation. *Int J Heal Policy Manag*. (2016) 5:543–52. doi: 10.15171/ijhpm.2016.47
19. Fenenga CJ, Nketiah-Amponsah E, Ogink A, Arhinful DK, Poortinga W, Hutter I. Social capital and active membership in the Ghana National Health insurance scheme - a mixed method study. *Int J Equity Health*. (2015) 14:1–12. doi: 10.1186/s12939-015-0239-y
20. Barasa E, Rogo K, Mwaura N, Chuma J, Barasa E, Rogo K, et al. Kenya national hospital insurance fund reforms: implications and lessons for universal health coverage Kenya national hospital insurance fund reforms: implications and lessons for universal health coverage. *Heal Syst Reform*. (2018) 4:346–61. doi: 10.1080/23288604.2018.1513267
21. Health Policy Plus. *Is Kenya Allocating Enough Funds for Healthcare?* (2021). Available online at: [http://www.healthpolicyplus.com/ns/pubs/18441-18879\\_KenyaNCBAbrief.pdf](http://www.healthpolicyplus.com/ns/pubs/18441-18879_KenyaNCBAbrief.pdf)
22. WHO. *The Abuja Declaration: Ten Years On*. Heal (San Fr (2011) (2000):1–4.
23. Government of Kenya (GoK). *Road to Universal Health Coverage*. Kenya Yearbook Editorial Board Chief (2020).
24. Chuma J, Mulupi S, McIntyre D. *Providing Financial Protection and Funding Health Service Benefits for the Informal Sector: Evidence From Sub-Saharan Africa* (2013).
25. World Bank Group. *Kenya Poverty and Equity Brief* (2020).
26. Government of Kenya (GoK). *Kenya Vision 2030* (2006).
27. Ministry of Health G of K. *Kenya Health Financing Strategy Ministry of Health Overview of the Kenya Health Financing Strategy* (2020).
28. Okungu VR, McIntyre D. Does the informal sector in Kenya have financial potential to sustainably prepay for health care? Implications for financing universal health coverage in low-income settings. *Heal Syst Reform*. (2019) 5:145–57. doi: 10.1080/23288604.2019.1583492
29. Barasa EW, Mwaura N, Rogo K, Andrawes L. Extending voluntary health insurance to the informal sector: experiences and expectations of the informal sector in Kenya. *Wellcome Open Res*. (2017) 2:1–13. doi: 10.12688/wellcomeopenres.12656.1
30. Ministry of Health G of K. *Kenya Household Health Expenditure and Utilization Survey* (2018).
31. WHO. *Strategic Purchasing for Universal Health Coverage: Key Policy Issues and Questions* (2017).
32. Creswell J. *Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications, Inc (2014).
33. County Government of Busia. *County Integrated Development Plan* [Internet]. (2018). Available online at: <https://www.devolutionhub.or.ke/resource/county-government-of-busia-health-sector-strategic-and-investment-plan-2018-2023>
34. Mercer T, Gardner A, Andama B, Chesoli C, Christoffersen-deb A, Dick J, et al. *Leveraging the Power of Partnerships: Spreading the Vision for a Population Health Care Delivery Model in Western Kenya*. (2018). p. 1–11. doi: 10.1186/s12992-018-0366-5
35. World Health Organization. *World Health Survey: Guide to Administration and Question by Question* (2002).
36. Ministry of Health G of K. (2013). *Kenya Household Health Expenditure And Utilization Survey* (2014).
37. Gale, K N, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC, Med Res Methodol* [Internet]. (2013) 7:260–1. Available online at: <http://www.biomedcentral.com/1471-2288/13/117>
38. Koon AD. *Framing Universal Health Coverage in Kenya: An Interpretive Analysis of Health Financing Politics*. (2017). p. 25–44. Available online at: [http://researchonline.lshrm.ac.uk/4398421/1/2017\\_PHP\\_PhD\\_Koon\\_AD.pdf](http://researchonline.lshrm.ac.uk/4398421/1/2017_PHP_PhD_Koon_AD.pdf)
39. Paugam S, Cousin B, Giorgetti C, Naudet J. *What do the Rich Think of the Poor?* Seuil (2017). Available online at: <https://www.sciencespo.fr/en/news/what-do-the-rich-think-of-the-poor> (accessed Sep 1, 2022).
40. Künzler D. The Politics of Health Care Reforms in Kenya and their Failure. *Sozialpolitik Ch*. (2016) 2016:1–20. doi: 10.18753/2297-8224-64
41. Munguti Dennis. *Perceptions of Households Towards Health Insurance and Their Implication to Enrolment, Kenya* (2020).
42. Kabia E, Mbau R, Muraya KW, Morgan R, Molyneux S, Barasa E. How do gender and disability influence the ability of the poor to benefit from pro-poor health financing policies in Kenya? An intersectional analysis. *Int J Equity Health*. (2018) 17:1–12. doi: 10.1186/s12939-018-0853-6
43. Hanson K, Brikci N, Erlangga D, Alebachew A, De Allegri M, Balabanova D, et al. The Lancet Global Health Commission on financing primary health care: putting people at the centre. *Lancet Glob Heal*. (2022) 10:e715–72. doi: 10.1016/S2214-109X(22)00005-5
44. Kabia E, Mbau R, Oyando R, Oduor C, Bigogo G, Khagayi S, et al. “We are called the et cetera”: Experiences of the poor with health financing reforms that target them in Kenya. *Int J Equity Health*. (2019). 18:1–14. doi: 10.1186/s12939-019-1006-2
45. Chuma J, Maina T, Ataguba J. Does the distribution of health care benefits in Kenya meet the principles of universal coverage? *BMC Public Health*. (2012) 12:20. Available online at: <http://www.biomedcentral.com/1471-2458/12/20> doi: 10.1186/1471-2458-12-20
46. Buigut S, Ettarh R, Amendah DD, McGuire F, Vijayasingham L, Vassall A, et al. Extending social health insurance to the informal sector in Kenya. An assessment of factors affecting demand. *Int J Equity Health*. (2019) 18:1–12. Available online at: <http://www.biomedcentral.com/1472-6963/12/66>
47. Falkingham J, Namazie C. *Measuring Health and Poverty: A Review of Approaches to Identifying the Poor*. (2002). p. 44. Available online at: <http://eprints.soton.ac.uk/35016/>
48. Nsiah-boateng E, Aikins M. Trends and characteristics of enrolment in the National Health Insurance Scheme in Ghana: a quantitative analysis of longitudinal data. *Global Health Res Policy*. (2018). 6:1–10. doi: 10.1186/s41256-018-0087-6





## OPEN ACCESS

## EDITED BY

Fares Al-Shargie,  
American University of Sharjah, United  
Arab Emirates

## REVIEWED BY

Monica Violeta Achim,  
Babeş-Bolyai University, Romania  
Štefan Bojnec,  
University of Primorska, Slovenia

## \*CORRESPONDENCE

Vita Jagrič  
vita.jagric@um.si

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 26 May 2022

ACCEPTED 05 October 2022

PUBLISHED 26 October 2022

## CITATION

Jagrič T, Brown C, Fister D,  
Darlington O, Ashton K, Dyakova M,  
Bellis MA and Jagrič V (2022) Toward  
an economy of wellbeing: The  
economic impact of the Welsh  
healthcare sector.  
*Front. Public Health* 10:953752.  
doi: 10.3389/fpubh.2022.953752

## COPYRIGHT

© 2022 Jagrič, Brown, Fister,  
Darlington, Ashton, Dyakova, Bellis and  
Jagrič. This is an open-access article  
distributed under the terms of the  
[Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/)  
(CC BY). The use, distribution or  
reproduction in other forums is  
permitted, provided the original  
author(s) and the copyright owner(s)  
are credited and that the original  
publication in this journal is cited, in  
accordance with accepted academic  
practice. No use, distribution or  
reproduction is permitted which does  
not comply with these terms.

# Toward an economy of wellbeing: The economic impact of the Welsh healthcare sector

Timotej Jagrič<sup>1</sup>, Christine Brown<sup>2</sup>, Dušan Fister<sup>1</sup>,  
Oliver Darlington<sup>3</sup>, Kathryn Ashton<sup>3</sup>, Mariana Dyakova<sup>3</sup>,  
Mark A. Bellis<sup>3</sup> and Vita Jagrič<sup>1\*</sup>

<sup>1</sup>Institute of Finance and Artificial Intelligence, Faculty of Economics and Business, University of Maribor, Maribor, Slovenia, <sup>2</sup>European Office for Investment and Health and Development, World Health Organization, Venice, Italy, <sup>3</sup>Public Health Wales, WHO Collaborating Centre on Investment for Health and Well-being, Capital Quarter 2, Cardiff, United Kingdom

Population health and wellbeing is both a result, as well as a driver, of economic development and prosperity on global, European, national and sub-national (local) levels. Wales, one of the four United Kingdom (UK) nations, has shown a long-term commitment to sustainable development and achieving prosperity for all, providing a good example of both national and sub-national level, which can be useful for other European countries and regions. In this paper, the economic importance of the healthcare sector to the Welsh economy is explored. We use a large number of data sources for the UK and Welsh economy to derive an economic model for 2017. We estimate output, income, employment, value-added, and import multipliers of the healthcare sector. Results suggest that the healthcare sector has an above average contribution in four explored economic aspects of the Welsh economy (output, income, employment, value-added), according to its impact on the surrounding economic ecosystem. Also, it is below average regarding leaking through imports. The multipliers' values offer empirical evidence when deciding on alternative policy actions. Such actions can be used as a stimulus for encouraging regional development and post-COVID economic recovery. Our study refers to the Welsh healthcare sector's economic impact as a whole. Therefore, we suggest investigating the economic impact of individual healthcare providers in the future.

## KEYWORDS

input-output analysis, healthcare sector, Wales, impact analysis, economy of wellbeing

## Introduction

The uncertain and dynamic time we live in, facing challenges of epidemics, climate change, economic instability, societal disruption and escalating inequalities, requires an urgent and explicit recognition of the value and wider economic benefits of protecting, improving and caring for the health and wellbeing of people and communities. Population health is both a result of, as well as a driver of, economic development and prosperity on a global, European, national and sub-national (local) level.

Wales, one of the four United Kingdom (UK) nations, has shown a long-term commitment to sustainable development and achieving prosperity for all through relevant legislation (Well-being of Future Generations Act - WFGA<sup>1</sup>, Socio-economic Duty - SED<sup>2</sup>) and policy levers (Programme for Gov<sup>3</sup>, A Healthier Wales<sup>4</sup>) to ensure the health and wellbeing of current and future generations. It provides a good example of both national (devolved nation with autonomous health and social care sector) and sub-national level (as part of the wider UK system), which can be useful for other European countries and regions. Wales has an explicit commitment to improving population health through its health related legislation, policies and programmes of work. However, the Welsh National Health Service (NHS) is still struggling to cope with demand and the needs of the population, with health inequalities and waiting lists exacerbated by the COVID-19 pandemic, as well as the direct and indirect implications of climate change, rising cost of living and the UK departure from the European Union (Brexit) [see e.g., (1)].

The economic ecosystem is an interconnected supply and demand system of different industries. One of these is the healthcare sector. Due to its economic linkages to other sectors, changes in the demand for its services cause a knock-on effect on the whole economic ecosystem having direct, indirect, and induced effects. One way of monitoring the impact is by measuring the change in the economy's output, value-added, income, employment, and import as input-output (IO) multipliers. The impact and economic importance of the healthcare sector in the economic ecosystem are being broadly studied in the literature from different perspectives, naming some (2–10).

From the economic point of view, the COVID-19 pandemic is a health-triggered economic crisis. Its economic consequences are immense and have immediately called for policy actions (11–14). Health policy is primarily devoted to achieving public health goals. However, we argue that it is also justified to consider the economic effects of public health expenditures and the healthcare sector's activity when designing policy actions. These actions can simultaneously support multiple societal priorities, one of them being the economic recovery in the post-COVID-19 period.

Further, health policy actions can support policies from other fields. Due to trends like deindustrialization,

the weakening of social infrastructure, loss of employment opportunities, or population decrease, growing disparities between the capitals and the rural regions can be observed widely in Europe and elsewhere (15). Addressing development disparities with new job opportunities and more robust healthcare infrastructure can also result from health policy action. Not to forget that providing healthcare services results in first place in non-economic effects, namely, improved population health outcomes. Illness costs suppress the economic ecosystem, thus improved health is favorable from the economic perspective (16–20) as it results in a healthier and more productive workforce, less absenteeism and less lost working days due to illness.

In developed economies, the size of the healthcare sector is generally large, however its economic importance differs by country due to the particular economic interrelation to the local economy. Further, due to structural changes, it also varies over time. Therefore, empirical evidence for each individual country is needed to estimate the extent of the economic footprint of the healthcare sector. In this paper we have chosen to study an example of a small, high-income country, namely, Wales. This case study aims to quantify the economic importance of the Welsh healthcare sector to the Welsh economy. The studies' results bring novelty to the international literature body. To evaluate the obtained empirical results and its robustness, we are benchmarking them to the previous empirical studies from other countries (8, 10, 21) and most importantly, compare them to the forecasted value of econometric models developed in an international study (21).

The rest of the analysis is structured as follows. First, data is described and where it was gathered from. Next, methodological note is provided. After it, results are presented and interpreted. Finally, we give our conclusions and discuss the policy implications.

## Materials and methods

### Data on the Welsh and the UK economy

In this research, we used input-output (IO) tables. The economic ecosystem consists of a group of industries, which both produce goods and consume goods produced by other industries. IO analysis thus reflects the flow of products from producers to consumers, where each industry is considered in both positions starting from an interindustry transactions table (22). For our research an IO table was needed at the Welsh level. The most recent IO table for Wales was published in 2007 (23). In this analysis, multiple data sources presented in Table 1 were used to create a more recent IO table. We used the 2017 United Kingdom IO analytical table as a general benchmark, alongside the 2007 Welsh IO table. Further, additional data variables from different

1 For more see <https://www.futuregenerations.wales/about-us/future-generations-act/>.

2 For more see <https://gov.wales/more-equal-wales-socio-economic-duty#:~:text=The%20Socio%20Deconomic%20Duty%20came,do%20things%20differently%20in%20Wales.>

3 For more see <https://gov.wales/programme-government>.

4 For more see <https://gov.wales/healthier-wales-long-term-plan-health-and-social-care>.

TABLE 1 Data description and sources.

Data	Year	No. of sectors	Source	Classification, and details
UK IO analytical table	2017	105	ONS <sup>a</sup>	CPA, Domestic use, basic prices, product-by-product, £ million
Welsh IO table	2007	88	(23) <sup>b</sup>	SIC2003, Domestic use, basic prices, £ million
Employment by industry (UK, Wales)	2017	88	Nomis <sup>c</sup>	SIC2007, No. of employees
Final consumption expenditure by government (UK, Wales)	2017–2018	10 (16)	ONS <sup>d</sup>	Business Register and Employment Survey COFOG, £ million, EU transactions recorded on net basis, as they include: (1) GNI and VAT-based EU contributions, (2) EU foreign aid contributions, (3) EU receipts from Common Agricultural Policy and Structural Funds.
National household final consumption expenditure NUTS1 (UK, Wales)	2017	12 (42)	ONS <sup>e</sup>	COICOP commodities, UKL NUTS code, £ million, in current market prices, experimental statistics.
Regional Gross fixed capital formation, NUTS1	2017	10 (11)	ONS <sup>f</sup>	SIC2007, UKL NUTS code, £ million. Production sector (sectors BCDE) further divided into manufacturing (C).
Exports of goods (Regional trade statistics)	2017	10	HMRC <sup>g</sup>	SITC, £ million
Total value of service exports from the UK by NUTS1 area, industry, and destination	2017	13	ONS <sup>h</sup>	SIC2007, £ million, UK Balance of Payments - The Pink Book
Taxes less subsidies on products	2017	Total	ONS <sup>i</sup>	TLL ITL code, £ million
Compensation of employees by industry	2017	31	ONS <sup>j</sup>	SIC2007, TLL ITL code, £ million Estimates of workplace based GVA.
Gross operating surplus and mixed income	2017	31	ONS <sup>k</sup>	SIC2007, TLL ITL code, £ million
Taxes less subsidies on production by industry at current basic prices	2017	31	ONS <sup>l</sup>	SIC2007, TLL ITL code, £ million Estimates of workplace based GVA.
Regional gross value added (ITL1 current price estimates)	2017	81	ONS <sup>m</sup>	TLL ITL code, £ million
Regional gross value added in Wales by industry	2017	81	StatsWales <sup>n</sup>	SIC2007, £ million, current prices.
Approximate gross value added at basic prices (aGVA)	2017	73	ONS <sup>o</sup>	SIC2007, £ million, Data source from Annual Business Survey (ABS).
Total output (total turnover) at basic prices (Non-financial business economy, UK regional results: Sections A to S)	2017	19 (77)	ONS <sup>p</sup>	SIC2007, £ million, Data source from Annual Business Survey (ABS).
UK and Wales Gross domestic product (GDP) at current market prices	2017	Total	ONS <sup>q</sup>	TLL ITL code, £ million
UK and Wales Gross domestic product (GDP) per head at current market prices	2017	Total	ONS <sup>r</sup>	TLL ITL code, £ million
UK and Wales Total GDHI at current basic prices	2017	Total	ONS <sup>s</sup>	UKL NUTS code, £ million
ITL1 implied deflators	2017	81	ONS <sup>t</sup>	SIC2007, TLL ITL code

<sup>a</sup><https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/ukinputoutputanalyticaltables-detailed>.

<sup>b</sup>[https://www.cardiff.ac.uk/\\_data/assets/pdf\\_file/0010/698869/input-output-tables-2007-final-30-6.pdf](https://www.cardiff.ac.uk/_data/assets/pdf_file/0010/698869/input-output-tables-2007-final-30-6.pdf).

<sup>c</sup><https://www.nomisweb.co.uk/query/construct/components/stdListComponent.asp?menuopt=12&subcomp=100>.

<sup>d</sup><https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/datasets/countryandregionalpublicsectorfinances-expendituretables>.

<sup>e</sup><https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/datasets/regionalhouseholdfinalconsumptionexpenditure>.

<sup>f</sup><https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/adhocs/10949regionalgrossfixedcapitalformationn1andn22000to2018>.

<sup>g</sup><https://www.uktradeinfo.com/trade-data/regional/2020/uk-regional-trade-in-goods-statistics-fourth-quarter-2020/>.

<sup>h</sup><https://www.ons.gov.uk/businessindustryandtrade/internationaltrade/datasets/internationalexportsofservicesfromsubnationalareasoftheuk>.

<sup>i</sup><https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnutslevelregions>.

<sup>j</sup><https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalregionalgrossvalueaddedbalancedperheadandincomecomponents>.

<sup>k</sup><https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalregionalgrossvalueaddedbalancedperheadandincomecomponents>.

<sup>l</sup><https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalregionalgrossvalueaddedbalancedperheadandincomecomponents>.

<sup>m</sup><https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalandrealregionalgrossvalueaddedbalancedbyindustry>.

<sup>n</sup><https://stats.wales.gov.wales/Catalogue/Business-Economy-and-Labour-Market/Regional-Accounts/Gross-Value-Added-GDP/gvainwales-by-industry>.

<sup>o</sup><https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/datasets/uknonfinancialbusinesseconomyannualbusinesssurveyregionalresultssectionsas>.

<sup>p</sup><https://www.ons.gov.uk/businessindustryandtrade/business/businessservices/datasets/uknonfinancialbusinesseconomyannualbusinesssurveyregionalresultssectionsas>.

<sup>q</sup><https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnutslevelregions>.

<sup>r</sup><https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/regionalgrossdomesticproductallnutslevelregions>.

<sup>s</sup><https://www.ons.gov.uk/economy/regionalaccounts/grossdisposablehouseholdincome/datasets/regionalgrossdisposablehouseholdincomegdhi>.

<sup>t</sup><https://www.ons.gov.uk/economy/grossvalueaddedgva/datasets/nominalandrealregionalgrossvalueaddedbalancedbyindustry>.



TABLE 2 Final demand matrix for both UK and Wales IO tables.

Final demand matrix		Final payments matrix	
IO table UK	IO table Wales	IO table UK	IO table Wales
Final consumption expenditure	–	Use of imported products, cif	Imports RUK
Final consumption expenditure by government	Government	–	Imports ROW
Final consumption expenditure by households	Consumers	Compensation of employees	Disposable Income (Employees & Self emp)
Final consumption expenditure by NPISH	NPISH	Gross operating surplus and mixed income	Gross Operating Surplus (excluding mixed income)
–	Daytrippers	–	Income & Self employment Tax & NIC
–	Stock200	Taxes less subsidies on production	Taxes less subsidies on production
Gross fixed capital formation	GFCF	Taxes less subsidies on products	Taxes on Products
–	Tour 1–3	Gross value added	–
–	Tour 4+		
–	Tour Intl		
–	Tour Bus		
Changes in inventories	–		
Acquisitions less disposals of valuables	–		
Export of goods to EU	–		
Exports of goods to rest of the world	Exports ROW		
Exports of services	–		
–	Exports RUK		

Sources: ONS and (23). RUK, Rest of UK; ROW, Rest of World.

sources were used for the database creation, as described in Table 1.

Two UK IO tables are published by Office for National Statistics (ONS), the (1) product by industry, and the (2) product by product IO table (the latter was considered in this study). The product by product table follows the statistical Classification of Products by Activity (CPA). Monetary terms are specified in the current basic prices (£ million); the intermediate demand is symbolized by a symmetric 105x105 matrix and two additional matrices, i.e., the final demand (FD) and final payments (FP) are attached on the right and lower borders (elements of these are outlined in Table 2).

The 2007 Welsh IO table differs slightly from the UK's, as it incorporates 88 sectors, as outlined in the report by Jones et al. (23). FD and FP differences between the UK and Welsh IO table are denoted in Table 2. For regionalization of an IO table, standardized employment data are required on both levels (24). Therefore, in the Welsh case, data is needed, on the UK and Wales level. Standardization is crucial for the test of the tables as well, these were, prior to use, first adjusted at our best efforts among different standards, such as Standard Industrial Classification (SIC 2003 and SIC 2007), Classification of the Functions of Government (COFOG), Classification of Individual Consumption by Purpose (COICOP), Standard international trade classification (SITC).

The element of final consumption expenditure was further divided by (1) government, by (2) households, and by (3) non-profit organizations serving households (NPISHs). In the

Welsh case, the third element was missing. Final consumption by government was ranked into three different categories: (1) total, (2) current and (3) capital expenditure. There were 10 individual industry sectors, some of which were further divided into sub-sectors. Altogether, data for 16 industry sectors on government consumption were available. Data on final consumption expenditure by households was also available at the exceptional sectoral division. Although the statistics were experimental, ONS have published the regional household final consumption expenditure by COICOP commodities. There were 12 large groups of products and further 42 sub-groups of products outlined by the COICOP commodities division. Finally, consumption for 20 basic commodities was outlined as well.

Regional Gross Fixed Capital Formation (GFCF) is an aggregate measure for Wales, as there are only 11 SIC2007 industry groups available. Consequently, aggregation is applied, i.e., health sector is aggregated with public administration and education sectors; export/import of goods are no different. The HMRC web portal for regional trade statistics publishes data for 10 different SITC sections, total export of services is available for 13 highly aggregated groups. Unfortunately, no interregional trade by industry data was found that could act as a superior information.

Regional taxes less subsidies on products for Wales is available at total aggregate level (a single value); these are calculated as the sum of VAT and other taxes on products, subtracted by subsidies on products. Taxes less subsidies in

TABLE 3 Types of multipliers.

Type of multiplier	Multiplier	Equation
Output	Simple	$\mathbf{m}(o) = m(o)_j = \mathbf{i}' \cdot \mathbf{L}_1 = \sum_{i=1}^n l_{ij}$
	Total	$\bar{\mathbf{m}}(o) = \bar{m}(o)_j = \mathbf{i}' \cdot \mathbf{L}_2 = \sum_{i=1}^{n+1} \bar{l}_{ij}$
	Truncated	$\bar{\mathbf{m}}[o(t)] = \bar{m}[o(t)]_j = \mathbf{i}' \cdot \mathbf{L}_{2(11)} = \sum_{i=1}^n \bar{l}_{ij}$
Income	Simple	$\mathbf{m}(h) = m(h)_j = \mathbf{h}'_c \cdot \mathbf{L}_1 = \sum_{i=1}^n h_i \cdot l_{ij}$
	Total	$\bar{\mathbf{m}}(h) = \bar{m}(h)_j = \bar{\mathbf{h}}'_c \cdot \begin{bmatrix} \mathbf{L}_{2(11)} \\ \mathbf{L}_{2(21)} \end{bmatrix} = \sum_{i=1}^{n+1} h_i \cdot \bar{l}_{ij}$
	Truncated	$\bar{\mathbf{m}}[h(t)] = \bar{m}[h(t)]_j = \mathbf{h}'_c \cdot \mathbf{L}_{2(11)} = \sum_{i=1}^n h_i \cdot \bar{l}_{ij}$
	Type I	$\mathbf{m}(h)^I = m(h)^I_j = \mathbf{m}(h) \cdot (\hat{\mathbf{h}}'_c)^{-1} = \frac{m(h)_j}{h_j}$
	Type II	$\mathbf{m}(h)^{II} = m(h)^{II}_j = \mathbf{L}_{2(21)} \cdot (\hat{\mathbf{h}}'_c)^{-1} = \frac{\bar{m}(h)_j}{h_j}$
Employment	Simple	$\mathbf{m}(e) = m(e)_j = \mathbf{e}'_c \cdot \mathbf{L}_1 = \sum_{i=1}^n e_i \cdot l_{ij}$
	Total	$\bar{\mathbf{m}}(e) = \bar{m}(e)_j = \bar{\mathbf{e}}'_c \cdot \begin{bmatrix} \mathbf{L}_{2(11)} \\ \mathbf{L}_{2(21)} \end{bmatrix} = \sum_{i=1}^{n+1} e_i \cdot \bar{l}_{ij}$
	Truncated	$\bar{\mathbf{m}}[e(t)] = \bar{m}[e(t)]_j = \mathbf{e}'_c \cdot \mathbf{L}_{2(11)} = \sum_{i=1}^n e_i \cdot \bar{l}_{ij}$
	Type I	$\mathbf{m}(e)^I = m(e)^I_j = \mathbf{m}(e) \cdot (\hat{\mathbf{e}}'_c)^{-1} = \frac{m(e)_j}{e_j}$
	Type II	$\mathbf{m}(e)^{II} = m(e)^{II}_j = \mathbf{L}_{2(21)} \cdot (\hat{\mathbf{e}}'_c)^{-1} = \frac{\bar{m}(e)_j}{e_j}$
Value-added	Simple	$\mathbf{m}(d) = m(d)_j = \mathbf{d}'_c \cdot \mathbf{L}_1 = \sum_{i=1}^n d_i \cdot l_{ij}$
	Total	$\bar{\mathbf{m}}(d) = \bar{m}(d)_j = \bar{\mathbf{d}}'_c \cdot \begin{bmatrix} \mathbf{L}_{2(11)} \\ \mathbf{L}_{2(21)} \end{bmatrix} = \sum_{i=1}^{n+1} d_i \cdot \bar{l}_{ij}$
	Truncated	$\bar{\mathbf{m}}[d(t)] = \bar{m}[d(t)]_j = \mathbf{d}'_c \cdot \mathbf{L}_{2(11)} = \sum_{i=1}^n d_i \cdot \bar{l}_{ij}$
	Type I	$\mathbf{m}(d)^I = m(d)^I_j = \mathbf{m}(d) \cdot (\hat{\mathbf{d}}'_c)^{-1} = \frac{m(d)_j}{d_j}$
	Type II	$\mathbf{m}(d)^{II} = m(d)^{II}_j = \mathbf{L}_{2(21)} \cdot (\hat{\mathbf{d}}'_c)^{-1} = \frac{\bar{m}(d)_j}{d_j}$
Import	Simple	$\mathbf{m}(m) = m(m)_j = \mathbf{m}'_c \cdot \mathbf{L}_1 = \sum_{i=1}^n m_i \cdot l_{ij}$
	Total	$\bar{\mathbf{m}}(m) = \bar{m}(m)_j = \bar{\mathbf{m}}'_c \cdot \begin{bmatrix} \mathbf{L}_{2(11)} \\ \mathbf{L}_{2(21)} \end{bmatrix} = \sum_{i=1}^{n+1} m_i \cdot \bar{l}_{ij}$
	Truncated	$\bar{\mathbf{m}}[m(t)] = \bar{m}[m(t)]_j = \mathbf{m}'_c \cdot \mathbf{L}_{2(11)} = \sum_{i=1}^n m_i \cdot \bar{l}_{ij}$
	Type I	$\mathbf{m}(m)^I = m(m)^I_j = \mathbf{m}(m) \cdot (\mathbf{m}'_c)^{-1} = \frac{m(m)_j}{m_j}$
	Type II	$\mathbf{m}(m)^{II} = m(m)^{II}_j = \mathbf{L}_{2(21)} \cdot (\mathbf{m}'_c)^{-1} = \frac{\bar{m}(m)_j}{m_j}$

Source: Beko et al. (35) and Jagrić et al. (21).

production are calculated similarly, but are readily available at much more detailed level, i.e., 31 industry sectors. After all, these carry an important information value, by representing the difference between Welsh Gross Value Added (GVA) (B) and Welsh GDP. Gross operating surplus and mixed income are calculated as a sum of seven elements.

International Territorial Levels—Level 1 (ITL1) current price estimates by ONS and regional GVA in Wales by industry by StatsWales are identical figures, but differentiate from approximate gross value added (aGVA) obtained from ONS. For the majority of sectors aGVA deviates from GVA. The total output at basic prices (which is equal to total use, i.e., the first is sum of rows and the second sum of columns) is found to be available on the level of 19 SIC2007 industry groups, which can

be parceled into 77 industry sectors. The regional data by Annual Business Survey (ABS) covers the non-financial industry sectors only. As well, some other industries, such as mining, electricity, public administration and defense, and education are omitted or given an information on higher aggregated group.

Regional and national GDPs are calculated as GVA + VAT on products + other taxes on products - subsidies on products; also, GDP per head is calculated to compare economies between the regions and a nation themselves; here, implied sectoral deflators provide a fair comparison between 2007 and 2017 prices.

## Generation of Welsh IO table and multipliers calculation

For this study, the greatest methodological challenge was to derive a Welsh IO table. Some of the standard procedure's steps from the literature had to be adjusted to the Welsh individual case. The IO table was generated using the mechanical manipulation and insertion of superior data. We employed a modified GRIT methodology to derive Welsh IO table from the single UK IO table by implementing the following steps:

- adjustment to the UK table,
- adjustment to the Welsh import data,
- definition of Welsh sectors,
- definition of prototype transactions tables,
- GRAS optimization,
- definition of final transactions tables.

In the case of Queensland in 1979, a process regionalizing a national IO table, later known as Generation of Regional Input-Output Tables (GRIT method) was developed (24). It has been applied for many cases, for example Greece (25), Germany and the Czech Republic (26), and the Mediterranean region (27). Additionally, the purpose of GRIT regionalization has been verified using the Monte Carlo simulation (28). Although the classic GRIT methodology is a 15-step process (24), the methodology has been often tailored to the needs of researchers.

Mattas et al. (25, 29) outlined the complete (customized) methodology of GRIT regionalization along with the programming code. GRIT starts from the national IO table **T**. The national table **T** has three elements: (1) the central interindustry matrix **Z** ( $n \times n$ ), (2) the matrix of final demand **fd** ( $n \times h$ ), and (3) the vector of final payments **fp** ( $l \times n$ ). The sum of interindustry matrix and final demand **fd** can be denoted as follows (29):

$$\mathbf{x} = \mathbf{Z} \cdot \mathbf{i} + \mathbf{fd},$$

where the sum **x** is of dimension ( $1 \times n$ ) and **i** is a ones vector. The sum **x** is identical to the sum of

interindustry matrix and final payments (except transposed), as follows:

$$\mathbf{x}' = \mathbf{i}^T \cdot \mathbf{Z} + \mathbf{fp}.$$

Hence, the IO table is balanced. The step 1 of the GRIT procedure is to ensure that the national technical coefficients are calculated as follows:

$$\mathbf{A}_{n \times n}^{(0)} = \mathbf{Z} \cdot \hat{\mathbf{x}}^{-1},$$

where the  $\mathbf{A}_{n \times n}^{(0)}$  depicts the initial datum technical coefficients. Similarly, the initial datum matrix of primary inputs is denoted as  $\mathbf{fp}_{l \times n}^{(0)}$ , withholding the  $l$ -elements of the primary inputs. Since Jensen et al. (24) denote the original matrix of primary inputs as  $\mathbf{B}_{l \times n}^{(0)}$  and this causes confusion with Leontief inverse matrix, we renamed it to  $\mathbf{fp}_{l \times n}^{(0)}$ . Additionally, as suggested by Mattas et al. (29), the calculation of technical coefficients is postponed from the step 1 to the step 4. Hence, step 2 and 3 were implemented on the original (interindustry) matrix.

Step 2 is devoted to the prices adjustments (24). For constant prices this process is conducted using the sectoral implied deflators. We have not employed any specific corrections to the obtained national IO table. Step 3 is organized to first identify and outline the primary (P), secondary (S) and tertiary (T) industry sectors, and hence primary, secondary and tertiary sub-matrices of national technical coefficients matrix  $\mathbf{A}_{n \times n}^{(0)}$ . Next, partitioning of the so-called competitive and non-competitive imports within the secondary sub-matrix  $\mathbf{S}_{s \times n}^{(0)}$  follows, where the  $s$  denotes number of secondary industry sectors. Finally, a row vector of imports denoted as  $\mathbf{m}_{1 \times n}$ , i.e., an extraction of the matrix of primary inputs  $\mathbf{fp}_{l \times n}^{(0)}$ , is allocated and next distributed over the secondary sectors as follows:

$$\mathbf{d}_1 = \mathbf{i}^T \cdot \mathbf{S}^{(0)},$$

where the identity vector is of dimension  $\mathbf{i}^T (1 \times s)$  and the  $\mathbf{d}_1 (1 \times n)$  represents the sum of column elements of the secondary sub-matrix  $\mathbf{S}^{(0)}$ . On the other hand, Mattas et al. (29) treat the  $\mathbf{m}_{1 \times n}$  to include only the secondary sectors and thus designate it as  $\mathbf{m}_{1 \times n}^{(S)}$ . We employed the original scenario by Jensen et al. (24) and defined the sum of secondary sub-matrix and imports vector as follows:

$$\mathbf{d}_2 = \mathbf{d}_1 + \mathbf{m},$$

where  $\mathbf{d}_2$  is again of dimension  $(1 \times n)$ . The two sums, i.e.,  $\mathbf{d}_1$  and  $\mathbf{d}_2$  are used to formalize the corrected secondary sub-matrix  $\mathbf{S}^{(1)}$  as follows:

$$\mathbf{S}^{(1)} = \hat{\mathbf{d}}_2 \cdot \hat{\mathbf{d}}_1^{-1} \cdot \mathbf{S}^{(0)},$$

where the superscript denotes diagonalized matrices of dimensions  $(n \times n)$ . By replacing the original sub-matrix  $\mathbf{S}^{(0)}$  with the corrected sub-matrix  $\mathbf{S}^{(1)}$ , one obtains:

$$\mathbf{A}_{n \times n}^{(1)}.$$

In our case, instead of Jensen's original method, we employed a similar scenario described by Mattas et al. (29), as follows:

$$\mathbf{S}^{(1)} = \mathbf{S}^{(0)} \cdot \hat{\mathbf{d}}_2 \cdot \hat{\mathbf{d}}_1^{-1}.$$

One must note that we have not been operating with the national technical coefficients matrix (relative numbers)  $\mathbf{A}_{n \times n}^{(0)}$  and  $\mathbf{A}_{n \times n}^{(1)}$ , but instead with the national I-O table (nominal numbers)  $\mathbf{Z}_{n \times n}^{(0)}$  and  $\mathbf{Z}_{n \times n}^{(1)}$ . Hence, the update of  $\mathbf{A}_{n \times n}^{(1)}$  with corrected sub-matrix  $\mathbf{S}^{(1)}$  is meant to be  $\mathbf{Z}_{n \times n}^{(1)}$ . Simultaneously, the primary inputs  $\mathbf{fp}_{l \times n}^{(0)}$  were updated to the  $\mathbf{fp}_{l \times n}^{(1)}$ .

Step 4 are adjustments for non-competitive regional imports. Sectors that are non-existent in the region, i.e., sectors with zero regional employment, are zeroized; consequently, a transformation of  $\mathbf{A}_{n \times n}^{(1)} \rightarrow \mathbf{A}_{n \times n}^{(2)}$  is carried out (for our case  $\mathbf{Z}_{n \times n}^{(1)} \rightarrow \mathbf{Z}_{n \times n}^{(2)}$ ). Simultaneously, intermediate input coefficients of such sectors are summed column-wise and added to the import row of  $\mathbf{fp}_{l \times n}^{(1)}$ , thus becoming  $\mathbf{fp}_{l \times n}^{(2)}$ . No such sectors were found to be existing in our case. As suggested by Mattas et al. (29), we have zeroized the main diagonal to avoid the existence of intra-sectoral flows, i.e., interregional trade:

$$\mathbf{Z}^* = \mathbf{Z} - \mathbf{Z} \cdot \hat{\mathbf{i}},$$

where the  $\mathbf{Z}^*$  represents the national interindustry matrix with the diagonal deleted. Additionally, we have calculated the national technical coefficients matrix as follows:

$$\mathbf{A} = \mathbf{Z}^* \cdot \hat{\mathbf{x}}^{-1}.$$

Step 5 is the actual regionalization procedure, in technical terms called scaling. Scaling is performed using the so-called location quotients (24). Authors denote the location quotients with a common symbol  $\mathbf{q}_{n \times n}$ , where the  $\mathbf{q}_{n \times n}$  can be calculated alternatively in any means, also by diagonalizing the vector  $\mathbf{q}_{(1 \times n)}$ . This is then used to update the technical coefficients as follows:

$$\mathbf{A}^{(3)} = \mathbf{q} \cdot \mathbf{A}^{(2)},$$

where the dimension of  $\mathbf{A}^{(3)}$  remains the  $(n \times n)$ . We employed the cross-industry location quotients (CILQ), as follows:

$$CILQ_{ij} = \frac{E_i^{(r)} / E_j^{(r)}}{E_i^{(n)} / E_j^{(n)}},$$

Where  $E_i^{(r)}$  represents the regional employment and  $E_j^{(n)}$  the national. The two data on employment are cross-given iteratively to ensure well-diversified location quotients and thus a solid picture of regional economy. Suggested by Mattas

et al. (29), a correction by Flegg and Webber (30) was carried as follows:

$$\lambda = \log_2 \left( 1 + \frac{\sum_i E_i^{(r)}}{\sum_i E_i^{(n)}} \right)^\delta,$$

where  $0 \leq \delta \leq 1$  is a weighing parameter, outstanding the relative size of the region, to derive the FLQ location quotients:

$$FLQ_{ij} = CILQ_{ij} \cdot \lambda.$$

Finally, the  $\mathbf{q} = FLQ_{ij}$  coefficients are constrained in the range  $FLQ_{ij} \leq 1$  and the regional technical coefficients calculated, as suggested  $\mathbf{A}^{(3)} = \mathbf{q} \cdot \mathbf{A}^{(2)}$ .

Next the difference between the  $\mathbf{A}^{(2)}$  and  $\mathbf{A}^{(3)}$  should be calculated and summed column-wise:

$$\mathbf{i}^T \cdot [\mathbf{A}^{(2)} - \mathbf{A}^{(3)}],$$

to update the  $\mathbf{fp}_{l \times n}^{(3)}$  by adding the so-calculated sum difference to the import row. Due to the availability of superior data, this and further steps by Jensen et al. (24) were omitted.

By Jensen et al. (24) step 10 is devoted to the manual balancing of the produced regional I-O table, commonly using the RAS updating and balancing technique of I-O tables by Stone (31). RAS is an iterative approach that scales (or re-scales) the existing matrices in order to best comply the table coefficients with column and row sums (constraints or border conditions). A more general procedure called a Generalized RAS (GRAS) is popular. It was applied by Junius and Oosterhaven (32), Temursho et al. (33), and Temurshoev et al. (34). GRAS has a common benefit according to the RAS, i.e., that it can handle non-negative matrices. In general, it is formalized as follows:

$$\mathbf{X} = \hat{\mathbf{r}} \cdot \mathbf{A} \cdot \hat{\mathbf{s}},$$

hence the name RAS ( $\hat{\mathbf{r}} \cdot \mathbf{A} \cdot \hat{\mathbf{s}}$ ). Matrices  $\hat{\mathbf{r}}$  and  $\hat{\mathbf{s}}$  are correction factors, are diagonalized and contain non-negative numbers on diagonal, while  $\mathbf{A} = \mathbf{A}_{pxp}^{(6)}$ . The first correction factor ( $\hat{\mathbf{r}}$ ) is a row correction factor, while the second ( $\hat{\mathbf{s}}$ ) the column correction factor. Initially, the GRAS method separates the non-negative and negative elements of the matrix  $\mathbf{A}$  into two matrices:  $\mathbf{P}$  and  $\mathbf{N}$ , where the first contains non-negative elements and the second negative values. Further, the absolute value of the second matrix is calculated to update as follows  $\mathbf{N} = |\mathbf{N}|$ . It holds that  $\mathbf{A} = \mathbf{P} - \mathbf{N}$ . Sequentially, we can formulate:

$$\begin{aligned} (\hat{\mathbf{r}} \cdot \mathbf{P} \cdot \hat{\mathbf{s}} - \hat{\mathbf{r}}^{-1} \cdot \mathbf{N} \cdot \hat{\mathbf{s}}^{-1}) \cdot \mathbf{i} &= \mathbf{u}^*, \\ \mathbf{i} \cdot (\hat{\mathbf{r}} \cdot \mathbf{P} \cdot \hat{\mathbf{s}} - \hat{\mathbf{r}}^{-1} \cdot \mathbf{N} \cdot \hat{\mathbf{s}}^{-1}) &= \mathbf{v}^*, \end{aligned}$$

where  $\mathbf{u}^*$  and  $\mathbf{v}^*$  follow the next representation and  $\mathbf{i}$  is an identity vector:

$$\begin{aligned} \mathbf{u}^* &= e \cdot \mathbf{u}, \\ \mathbf{v}^* &= e \cdot \mathbf{v}. \end{aligned}$$

Here, the  $e$  is derived from the optimal solution definition  $\mathbf{Z} = \{z_{ij}\}$ ,  $\lambda = (\lambda_1, \dots, \lambda_m)$ ,  $\tau = (\tau_1, \dots, \tau_n)$ :

$$z_{ij} \begin{cases} r_i \cdot s_j \cdot e^{-1} & \text{if } a_{ij} \geq 0 \\ r_i^{-1} \cdot s_j^{-1} \cdot e^{-1} & \text{if } a_{ij} < 0 \end{cases}$$

and the  $e$  is defined as  $e^{\lambda_i} = r_i$  or simultaneously  $e^{\tau_j} = s_j$ . GRAS is proved to converge toward the minimum of error, stated with the following information loss problem:

$$x_{ij} = \arg \min \sum_i \sum_j |x_{ij}| \cdot \ln \frac{x_{ij}}{a_{ij}}.$$

Number of iterations, and hence the time complexity, depends on the desired information loss value  $\epsilon$ , which is typically provided by researcher. Alternatively, the fixed number of iterations can be specified, not relating to the desired information loss value  $\epsilon$ . In our case, implementation of the GRAS was taken from the Matlab File Exchange website<sup>5</sup> The algorithm was implemented by Temurshoev et al. (34).

We continued by steps 12–15 from original Jensen's numbering. These steps are devoted to further adjustments of the obtained regional I-O table. Furthermore, derivation of the inverse matrices is employed here:

$$\mathbf{L}_1 = (\mathbf{i} - \mathbf{A}^{(\text{GRAS})})^{-1},$$

where the  $\mathbf{A}^{(\text{GRAS})}$  represents the technical coefficients matrix after balancing with the GRAS. The information loss function ensures that the  $\mathbf{A}^{(\text{GRAS})}$  is as much similar to  $\mathbf{X}$ . The  $\mathbf{A}^{(\text{GRAS})}$  is enclosed with relation to households (endogenized) to form the Leontief type II inverse  $\mathbf{B}^{(\text{GRAS})}$ . The first is to calculate the simple and type I multipliers, while the second to calculate the total/truncated and type II multipliers, as follows:

$$\mathbf{L}_2 = (\mathbf{i} - \mathbf{B}^{(\text{GRAS})})^{-1}.$$

We have calculated five common different types of multipliers, for five different economic areas. These are outlined in the Table 3, following Miller and Blair (22) and as applied by Beko et al. (35) and Jagrić et al. (10). Several kinds of effects are captured by the multipliers. The simple multiplier captures direct and indirect, while the total type encloses also the induced effects. The direct effect is industry's initial economic impact on the economic ecosystem. The indirect effects come from transactions to other industries. Induced effects arise due to the enclosing the original IO table with additional industry sector, i.e., payments for labor services and consumer expenditure on goods, as explained by Miller and Blair (22). Next, the truncated

<sup>5</sup> <https://www.mathworks.com/matlabcentral/fileexchange/43231-generalized-ras-matrix-balancing-updating-biproportional-method>.

multiplier considers the induced effects (such as total) but does not sum the additional sector on payments for labor services.

Type I and type II multipliers are relative measures, calculated as a ratio between simple multiplier and coefficient vector of compensation of employees (type I), or the total multiplier value and coefficient vector in case of type II.

For every type of the multiplier five different alternative estimates were calculated (on the level of significance  $\alpha = 10\%$ ). Provided interval estimates can serve as an

alternative measure of quality for estimated multipliers. Also, we use the results on interval estimates to enhance the interpretation of results. For each of the five alternative estimates, a (rank) per centile was calculated and, an average and standard deviation were derived upon. Assuming provided per centile estimates distribute normally, an interval with lower and upper bounds was calculated. The assumption of normal distribution of alternatives is though and empirically very difficult to prove. We must

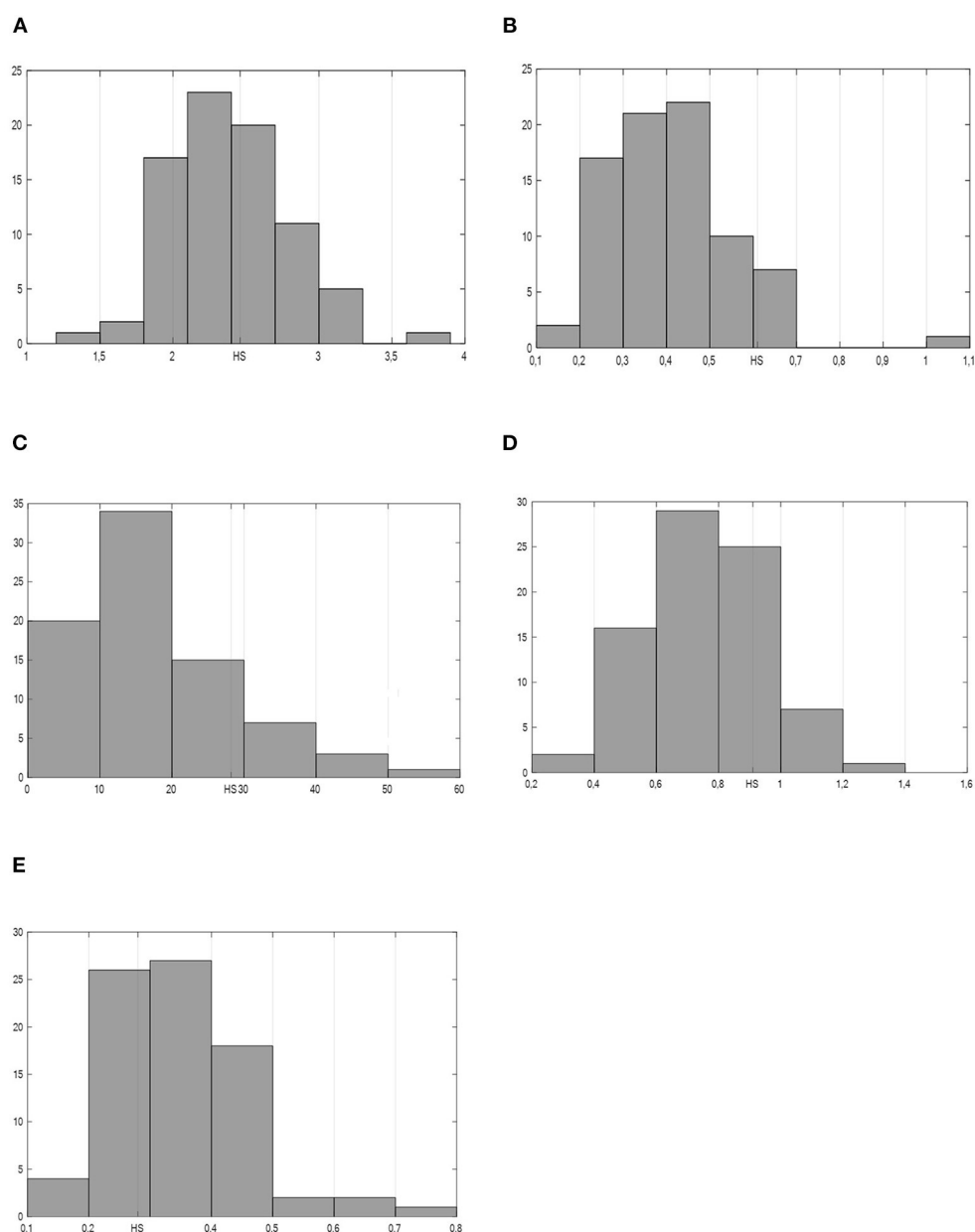


FIGURE 1

Distribution of total multipliers for all sectors—distribution (%) according to the multipliers' values. Position of the healthcare sector marked with HS. Source: Author's calculations. (A) Total output multiplier. (B) Total income multiplier. (C) Total employment multiplier. (D) Total value-added multiplier. (E) Total import multiplier.

TABLE 4 Estimated values of output multipliers and rank of the healthcare industry in the ranking of all industries in the economic ecosystem.

Type	Value	Rank	Percentile	Interval estimate ( $\alpha = 10\%$ )			
				Average	St. dev.	L. bound	U. bound
Simple	1.155937	73	92.4%	49.6%	43.8%	0.0%	100.0%
Total	2.466341	30	37.2%	20.7%	16.4%	0.0%	41.7%
Truncated	1.858659	47	59.0%	31.4%	28.0%	0.0%	67.3%

Interval estimates made under the assumption of normal distribution. Source: Author's calculations.

TABLE 5 Estimated values of input multipliers and rank of the healthcare industry in the ranking of all industries in the economic ecosystem.

Type	Value	Rank	Percentile	Interval estimate ( $\alpha = 10\%$ )			
				Average	St. dev.	L. bound	U. BOuND
Simple	0.494154	7	7.7%	12.1%	6.9%	3.2%	20.9%
Total	0.607682	7	7.7%	12.1%	6.9%	3.2%	20.9%
Truncated	0.607682	7	7.7%	12.1%	6.9%	3.2%	20.9%
Type I	1.067753	76	96.2%	65.0%	34.0%	21.4%	100.0%
Type II	1.313061	76	96.2%	65.0%	34.0%	21.4%	100.0%

Interval estimates made under the assumption of normal distribution. Source: Author's calculation.

note that the taken approach is not founded on a specific statistical theory.

## Results

Firstly, the comparison of the Welsh healthcare sector to other industries is given. The distribution of all total multipliers is shown in Figure 1. The abscissa represents magnitude of multipliers, while ordinate the frequency of multipliers. From the economic policy's perspective most favorable are high values for output, income, employment, and value-added multiplier. Contrary, for the import multiplier, the lowest values and highest rankings are most favorable, as this indicates the least leaking of economic impact through the imports. Our results indicate that in the comparison to our industries the position of the healthcare sector in the Welsh economy according to its impact on the local economy is above average in first four economic aspects (Figures 1A–D, while it is below average for the leaking through imports (Figure 1E).

## Output multipliers

We present the results on the output multipliers' estimations in Table 4: multipliers' values, ranks and percentiles. The rank reveals the comparison of the healthcare sector to other industries. The ranking of industries is made according to the multiplier's value, from the highest to the lowest one. Rank 1 would mean that an additional £1.00 spent for the industry's goods and services results in the most significant economic effects throughout the economy. The same industry will not

necessarily have the same rank for all multipliers, depending on the economic ecosystem structure.

The simple multiplier is the lowest, however including induced effects (total multiplier) results in considerably higher estimated multipliers associated with the healthcare sector. Truncated multiplier's value is found between the simple and total multipliers.

Results show that simple multiplier for healthcare sector is in overall very low and ranks the healthcare sector at the 92nd percentile. The results on the total and truncated multiplier reveal another perspective. Oosterhaven et al. (36) argued true value of the given multiplier in real world lies between the values of simple and total multipliers. If final demand for services provided by the healthcare sector increases for £1.00, the overall output for whole economy increases app. by £2.47 when direct, indirect and induced effects are enclosed.

Additionally, an interval estimates are presented in Table 4. Results on the simple multiplier show that the interval estimate is very wide, while it gets narrower for the total multiplier. The truncated multiplier's interval is again wider.

## Income multipliers

Income multipliers show how the increased income of employees affects overall economy. Whether the employees receive higher compensation, they can spend more according to the marginal propensity to consume theory. This positively affects the industry sectors within an economy due to the increased demand. The results are given in Table 5. An increase of the final demand for the healthcare sector's services by £1.00 would cause the change of income in all sectors of the Welsh



TABLE 6 Estimated values of employment multipliers and rank of the healthcare industry in the ranking of all industries in the economic ecosystem.

Type	Value	Rank	Percentile	Interval estimate ( $\alpha = 10\%$ )			
				Average	St. dev.	L. bound	U. bound
Simple	23.00742	14	16.7%	12.6%	7.2%	3.4%	21.8%
Total	28.25989	14	16.7%	12.2%	7.0%	3.2%	21.1%
Truncated	28.25989	14	16.7%	12.2%	7.0%	3.2%	21.1%
Type I	1.105412	75	94.9%	82.5%	16.1%	61.9%	100.0%
Type II	1.357772	70	88.5%	79.8%	11.2%	65.4%	94.1%

Interval estimates made under the assumption of normal distribution. Source: Author's calculations.

TABLE 7 Estimated values of value-added multipliers and rank of the healthcare industry in the ranking of all industries in the economic ecosystem.

Type	Value	Rank	Percentile	Interval estimate ( $\alpha = 10\%$ )			
				Average	St. dev.	L. bound	U. bound
Simple	0.66264	28	34.7%	35.0%	15.8%	14.8%	55.3%
Total	0.913746	21	25.7%	25.2%	13.3%	8.2%	42.2%
Truncated	0.913746	21	25.7%	25.2%	13.3%	8.2%	42.2%
Type I	1.086816	74	93.6%	56.0%	39.2%	5.8%	100.0%
Type II	1.498663	62	78.3%	46.6%	34.8%	1.9%	91.2%

Interval estimates made under the assumption of normal distribution. Author's calculations.

economy by '£0.50, considering only the direct and indirect effects, or for £0.61 when also including the induced effects.

The rank of the healthcare sector is seven in case of simple, total and truncated multipliers, meaning that income increments are within the top 10%, when all industries are compared. When considering interval estimation, it shows that healthcare sector ranks between the top 3 and 21%.

Increased compensation of employees in healthcare sector by £1.00 would cause an increase in the combined income across the economy of over £1.31. Again, the induced effects significantly contribute to the value. However, comparing relatively to other industry sectors, increase of compensation of employees only poorly contributes to increase of compensations in whole economy. The reason might be due to the high denominator, in other words, further increase of already high compensation in relative terms would not affect whole economy that much as an increase in large number of other sectors. However, the interval estimation is very wide therefore one must note the potential of overinterpretation when taking into account the wide interval estimate.

## Employment multipliers

Simple, total and truncated employment multipliers show how the increased demand in healthcare sector affects the number of employees in the whole economy. The results are presented in Table 6. Due to very low values, we express the change in final demand in millions of pounds. Thus,

employment multipliers reveal how many new jobs are created in the whole economy, if the final demand for the healthcare sector's services increases by £1,000,000.

Among all sectors in the economy, the healthcare sector is found at 14th rank or the 17th percentile, according to the estimated values of the simple, total and truncated employment multipliers. Otherwise, interval estimates forecast that the real population value should lie between 3 and 22%, for  $\alpha = 10\%$ .

## Value-added multipliers

Simple, total and truncated value-added multipliers are all below one (see Table 7), which is in concordance with expectations based on the theoretical background. Induced effects have a moderate effect, as the rank of the total/truncated multiplier improves only slightly. Interval estimation shows that lower and upper bounds are found in the lowest two thirds of the multipliers in all cases, although there is increased uncertainty in the simple multiplier compared with the total/truncated multiplier estimates. It means that in the case of an increase in final demand for healthcare services of £1.00, there will be ~£0.91 of additional value-added in the whole Welsh economy, including households.

The type I/II multipliers are calculated relative to initial effects. The results show that type I/II ranks are found in the last third in both cases, which means that increasing the value added in healthcare sector does not contribute much to the whole economy. However, one must note that the interval estimation

TABLE 8 Estimated values of import multipliers and rank of the healthcare industry in the ranking of all industries in the economic ecosystem.

Type	Value	Rank	Percentile	Interval estimate ( $\alpha = 10\%$ )			
				Average	St. dev.	L. bound	U. bound
Simple	0.183835	58	73.1%	60.0%	12.2%	44.4%	75.6%
Total	0.288937	54	68.0%	53.4%	18.7%	29.3%	77.4%
Truncated	0.288937	54	68.0%	53.4%	18.7%	29.3%	77.4%
Type I	1.151574	70	88.5%	48.2%	36.1%	2.0%	94.5%
Type II	1.809952	47	59.0%	39.0%	19.1%	14.5%	63.4%

Interval estimates made under the assumption of normal distribution. Source: Author's calculations.

is very wide, and as such point estimates should be interpreted with caution.

## Import multipliers

Finally, the results of estimated import multipliers are given in Table 8. Here, bear in mind, that lower values of multipliers are favorable reflecting the leakage effect as a part on the initial stimulus is lost for imports of inputs from other economic ecosystems. Further, note, that two different imports exist for geographic regions, i.e., international and interregional import, where statistical offices exhibit only the first among the two for a case of UK IO tables. Thus, interregional import needs to be estimated to some degree. Simple, total and truncated multipliers illustrates how the import for a whole Welsh economy changes, when the final demand for the healthcare sector's services increases by £1,00. Results for the simple multiplier denote that import increases to a minor degree only, ranking to the last third of all industry sectors. Induced effects add to the value of import multiplier, but do not affect much on the relative ranking to other sectors. Estimated standard deviation, and consequently interval bounds indicate that the results are reliable.

## Robustness check

To estimate whether the obtained results are robust we were benchmarking them. As a benchmark value we used a forecasted value derived from econometric models. These econometric models, developed on results for 19 European countries on I-O models for 2010, are found in an international study (21).

To consider the employment multiplier, one can note that the model reveals a remarkable, strong, non-linear negative relationship between GDP per capita and the employment multiplier based on the international data (see Figure 2). In this study, we use the model from the previous study and forecast the Welsh multipliers' value. Next, we compare the forecasted value to the here obtained results. When using the model to derive an expected value, we find that the latter is remarkably close to the real data results from this study. Namely, the benchmarking

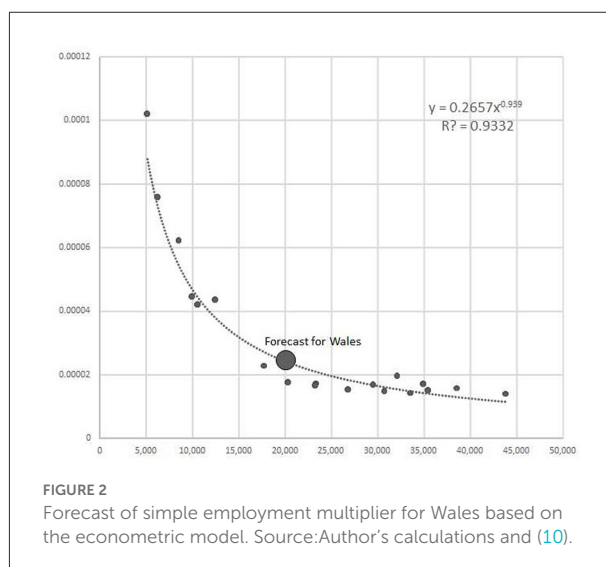


FIGURE 2 Forecast of simple employment multiplier for Wales based on the econometric model. Source: Author's calculations and (10).

model forecasted the value of the simple employment multiplier to be 24,67, while in this study empirically estimated value based on I-O table resulted in 23,01, both per an impulse of additional demand of £1,000,000. Such convergence between the two speaks for reasonable results of the present study.

## Discussion

In the literature, there are several measures discussed regarding the healthcare sectors' transformation in various countries (4, 6, 17, 19, 37–39). As in this study we explore the economic impact, we further discuss how the economic impact on the local economic ecosystem could be strengthened further. Applying some of the measures of the health policy from the above literature could namely support the Welsh healthcare sectors' economic interaction with the local economic ecosystem and thereby support the Welsh economic development in a post-COVID and post-Brexit period, such as:

- Strengthening access to healthcare in Welsh local environments through expanding services, e.g., including secondary outpatient services, equal distribution of services

by areas, improving availability and access, broadening preventive healthcare programs.

- Promoting a healthy and productive workforce to support regional economic development. Measures to support them include social measures to protect job and income security, promoting positive health-related behaviors.
- Supporting a viable and robust local healthcare sector by preserving local healthcare financing sources being spent within the Welsh economic ecosystem and attracting additional demand from abroad bringing income into the industry and closing supply-demand gaps.
- Promoting e-health by implementing new support and reimbursement mechanisms for easing patient access and promoting digital health literacy, build data policies to allow artificial-intelligence to support diagnosis and treatment decisions, and improving resource and capacities usage.

The obtained multipliers estimate an effect of additional final demand for the healthcare services provided by the Welsh healthcare sector as a whole. Evidence in other countries shows that the effect differs considerably by a single provider, and by region or municipality (10). The multipliers' values differ due to differences in its interconnection to the surrounding economic ecosystem. Therefore, it would be of benefit to study individual parts of the healthcare sector, such as an individual hospital. When doing so, a combination of input-output analysis and analysis of primary survey data could be used.

## Conclusions

As with any study, the results must be interpreted properly considering data and methodological characteristics and in the context of assumptions and limitations. Firstly, the here presented study is an economic study, therefore only economic effects are reflected. Therefore, no other kind of effects are considered, including changes in direct health outcomes that may result from changes in final demand of the healthcare sector's services. In interpreting the results, this should be taken into account, therefore discussing the perspective of the economic ecosystem only.

Further, there are assumption and limitations arising from the methodological regard in the economic research context. One should bear in mind that the study derives from a static model, reflecting the given moment in time. Additionally, there are assumed constant returns to scale, no supply constraints, fixed input structure, industry technology assumption and constant make matrix. Several further issues may affect results, such as transportation issues, tax policy, price changes and forward linkages, and significant structural changes. When the results are used, the characteristics of the here analyzed Welsh health sector in regard to the named assumptions have to be taken into account.

Another very important perspective of the results' interpretation comes from the fact that the study, contrary to many other economic studies does not express nor does it measure the effectiveness of health expenditures (e.g., intra-institutional effectiveness, organizational governance). Further, the results do not reflect the return and are therefore not a measure of return-on-investment.

The data used in the study is from the year 2017. The results are point-in-time estimated and therefore hold for the year explored and reflect the structure of the Welsh economy in the year 2017, respectively. Several factors might have caused the position of the healthcare sector in the Welsh economic ecosystem to be different at present, to name a few, business cycle, COVID-19 and Brexit. Nevertheless, the result can be interesting in the international context; namely, Wales is an example of a small high-income country. As we discussed in the study background, the literature gives reasons to believe that, although individual cases of countries differ, some common patterns are indicated.

The presented study aims to quantify the economic "footprint" of the Welsh healthcare sector to the wider economy in Wales. It expresses the economic impact of a change in final demand. The local healthcare sector reacts to this change either by providing additional services or its reduction. The economic impact is seen by the knock-on effect on the whole economic ecosystem. We monitor the impact by measuring the effects in the following dimensions: the economy's output, value-added, income, employment, and import. The study suggests several policy implications based on the estimated results.

The healthcare sector in Wales is vital in maintaining population health and wellbeing, but also is a significant sector of the economy, capable of stimulating economic output through investment and job creation. Using multipliers to show the contribution of a sector (in this case, the healthcare sector) to a national/regional economy can help decision/policy-making and investment prioritization within limited budgets. In this case, comparison to other industries (sectors) is interesting since often an alternative choice of projects or programmes can be financed due to limited public resources. Sectoral ranking compares the values of healthcare sectors' multipliers to other industries. Higher ranks suggest that an additional final demand for the industry's goods and services results in the most significant economic effects when measured as output, income, employment, or value-added change throughout the economy. Policy/investment decisions can also have an impact on the multipliers' values to change, such as by intensifying the interconnectedness of the healthcare providers to the local economy. Healthcare providers thus strengthen their role as anchoring institutions to local economies and communities.

The Welsh healthcare sector is consistently amongst the most influential sectors when across the entire range of economic measures is explored. Service sectors make up the top ten industries of the Welsh economy according to the

ranking by total output, total income, total value-added or total employment multiplier. Rankings by individual multiplier differ. All total multipliers (output, income, value-added, employment) rank the healthcare sector above the Welsh economy's average. The comparison from simple to total multipliers indicate, that in the case of the Welsh healthcare sector, an important part of the economic effects of the healthcare sector come as induced effects, namely, from household spending from income.

Regarding the leaking of economic effects through imports we found that none of the import multipliers (simple, total and truncated) is greater than the average in the economy. Greater demand in other sectors will, to a more significant extent, cause imports to rise compared to the effect of the same change in demand for services of the health sector. From the economic perspective, we argue that there are prevailing positive effects on the Welsh economy if the final demand for healthcare sectors' products and services rises, especially when compared with the impact of the same changes in other sectors.

These results challenge misperceptions of the healthcare sector as an economic drain, rather than a powerful stabilizer and investment multiplier. As Wales moves into the recovery period from the Coronavirus pandemic and faces challenges from Brexit and climate change, there is a significant opportunity to use investment in the healthcare sectors' services as an engine for a sustainable and equitable economic recovery toward creating an economy of wellbeing for all.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author/s.

## References

1. Dyakova M, Couzens L, Allen J, Van Emeren M, Stielke A, Cotter-Roberts A. *Placing Health Equity at the Heart of the COVID-19 Sustainable Response and Recovery: Building Prosperous Lives for All in Wales*. (2021). Available online at: <https://phwwhocc.co.uk/wp-content/uploads/2021/07/WHESRI-Covid-Report-Eng.pdf> (accessed April 11, 2022).
2. Hilsenrath P. Fiscal policy dilemmas and health spending in South Africa. *J Health Hum Serv Adm.* (1999) 21:310–24.
3. Castro-Leal F, Dayton J, Demery L. Public spending on health care in Africa: do the poor benefit? *Bull World Health Org.* (2000) 78:66–74.
4. Harris TR, et al. *Economic Impact and Linkages of the Local Health Sector on the Economy of Churchill County. Technical Report UCED 2003/04-16*. Reno: University of Nevada (2003).
5. Yamada G, Imanaka Y. Input-output analysis on the economic impact of medical care in Japan. *Environ Health Prev Med.* (2015) 20:379–87. doi: 10.1007/s12199-015-0478-y
6. NHS Strategy Unit. *Economic Impact of NHS Spending in the Black Country*. Stoke on Trent (2017).
7. Stuckler D, Reeves A, McKee M. Social and economic multipliers: what they are and why they are important for health policy in Europe. *Scand J Public Health.* (2017) 45(18\_suppl.):17–21. doi: 10.1177/1403494817707124
8. Gutiérrez-Hernández P, Abásolo-Alessón I. The health care sector in the economies of the European Union: an overview using an input-output framework. *Cost Effect Resour Allocat.* (2021) 19:4. doi: 10.1186/s12962-021-00258-8
9. Jagrić T, Grbenić SO, Jagrić V. What drives the healthcare sector's economic impact? Evidence from European countries. *Int J Health Governance.* (2021) 27:41–53. doi: 10.1108/IJHG-05-2021-0043
10. Jagrić T, Brown C, Boyce T, Jagrić V. The impact of the health-care sector on national economies in selected European countries. *Health Policy.* (2021) 125:90–7. doi: 10.1016/j.healthpol.2020.10.009
11. Buera FJ, Fattal-Jaef RN, Hopenhayn H, Neumeyer PA, Shin Y. *The Economic Ripple Effects of COVID-19*. Cambridge, MA: National Bureau of Economic Research (2021).
12. Chudik A, Mohaddes K, Pesaran MH, Raissi M, Rebucci A. A counterfactual economic analysis of Covid-19 using a threshold augmented multi-country model. *J Int Money Finan.* (2021) 119:102477. doi: 10.1016/j.jimonfin.2021.102477
13. Barrett MP, Das MS, Magistretti G, Pugacheva E, Wingender MP. After-effects of the COVID-19 pandemic: prospects for medium-term economic damage. *IMF Working Papers.* (2021) 2021:1. doi: 10.5089/9781513587905.001
14. Padhan R, Prabheesh KP. The economics of COVID-19 pandemic: a survey. *Econ Anal Policy.* (2021) 70:220–37. doi: 10.1016/j.eap.2021.02.012

## Author contributions

TJ and CB: conceptualization. TJ: methodology, validation, formal analysis, visualization, and supervision. TJ and DF: data gathering and software. DF and VJ: writing—original draft preparation. CB, OD, KA, MD, and VJ: writing—review and editing. All authors contributed to the article and approved the submitted version.

## Funding

This study was funded by Public Health Wales.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

15. Lang T, Burneika D, Noorköiv R, Plüschke-Altöf B, Pociute-Sereikiene G, Sechi G. Socio-spatial polarisation and policy response: Perspectives for regional development in the Baltic States. *Eur Urban Reg Stud.* (2022) 29:21–44. doi: 10.1177/09697764211023553
16. Kinge JM, Sælensminde K, Dieleman J, Vollset SE, Norheim OF. Economic losses and burden of disease by medical conditions in Norway. *Health Policy.* (2017) 121:691–8. doi: 10.1016/j.healthpol.2017.03.020
17. Forster T, Kentikelenis A, Bamba C. *Health Inequalities in Europe: Setting the Stage for Progressive Policy Action*. Dublin: Think tank for Action on Social Change (2018). 98 p.
18. Ogundari K, Awokuse T. Human capital contribution to economic growth in Sub-Saharan Africa: does health status matter more than education? *Econ Anal Policy.* (2018) 58:131–40. doi: 10.1016/j.eap.2018.02.001
19. Eurofound. *Challenges and Prospects in the EU: Quality of Life and Public Services*. Luxembourg (2019).
20. Cylus J, Al Tayara L. Health. An ageing labour force, and the economy: does health moderate the relationship between population age-structure and economic growth? *Soc Sci Med.* (2021) 287:114353. doi: 10.1016/j.socscimed.2021.114353
21. Jagrić T, Mun JC, Brown CE, Fister D. Economic impact of the health sector on the regional level – case of a small, open economy. *Lex Localis.* (2021) 19:621–58. doi: 10.4335/19.3.621-658(2021)
22. Miller RE, Blair PD. *Input–Output Analysis*. Cambridge: Cambridge University Press (2009).
23. Jones C, Bryan J, Munday M. *The Input–Output Tables for Wales 2007*. Cardiff: Cardiff Business School (2010). p. 1–38.
24. Jensen RC, Mandeville TD, Karunaratne ND. Regional economic planning: generation of regional input-output analysis. *Reg Econ Plann.* (2017) 9:1–251. doi: 10.4324/9781315103228
25. Mattas K, Loizou E, Tzouvelekas V. Rural development through input-output modeling. *Springer Optimiz Appl.* (2009) 25:273–295. doi: 10.1007/978-0-387-75181-8\_13
26. Semerak V, Zigic K, Loizou E, Golemanova-Kuhar A. *Regional Input-Output Analysis: Application on Rural Regions in Germany, the Czech Republic and Greece. 118th Seminar of the EAAE 15*. Ljubljana: Paper for 118th seminar of the EAAE (2010).
27. Gkatsikos A, Mattas K. The paradox of the virtual water trade balance in the Mediterranean region. *Sustainability.* (2021) 13:1–15. doi: 10.3390/su13052978
28. Bonfiglio A, Chelli F. assessing the behaviour of non-survey methods for constructing regional input–output tables through a Monte Carlo Simulation. *Econ Syst Res.* (2008) 20:243–58. doi: 10.1080/09535310802344315
29. Mattas K, Loizou S, Tzouvelekas V, Tsakiri M, Bonfiglio A. *Deriving Regional I-O Tables and Multipliers. Rural Balkans and EU Integration: An Input-Output Approach*. Milano (2006). p. 75–120.
30. Flegg AT, Webber CD. Regional size, regional specialization and the FLQ formula. *Reg Stud.* (2000) 34:563–9. doi: 10.1080/00343400050085675
31. Stone R. *Input-Output and National Accounts*. Paris: Organisation for European Economic Co-operation (1961). 202 p.
32. Junius T, Oosterhaven J. The solution of updating or regionalizing a matrix with both positive and negative entries. *Econ Syst Res.* (2003) 15:87–96. doi: 10.1080/0953531032000056954
33. Temursho U, Oosterhaven J, Cardenete MA. A multi-regional generalized RAS updating technique. *Spatial Econ Anal.* (2021) 16:271–86. doi: 10.1080/17421772.2020.1825782
34. Temurshoev U, Miller RE, Bouwmeester MC. A Note on the gras method. *Econ. Syst. Res.* (2013) 25:361–7. doi: 10.1080/09535314.2012.746645
35. Beko J, Jagrić T, Fister D, Brown C, Beznec P, Kluge H, et al. The economic effects of health care systems on national economies: an input-output analysis of Slovenia. *Appl Econ.* (2019) 51:4116–26. doi: 10.1080/00036846.2019.1588955
36. Oosterhaven J, Piek G, Stelder D. Theory and practice of updating regional versus interregional interindustry tables. *Paper Reg Sci.* (1986) 59:57–72. doi: 10.1111/j.1435-5597.1986.tb00982.x
37. Dayan M, Fahy N, Herve T, McCarey M, Jarman H, Greer S. *Understanding the Impact of Brexit on Health in the UK*. London: Nuffield Trust (2020). 12 p.
38. Holecki T, Kowalska-Bobko I, Fraczekiewicz-Wronka A, Węgrzyn M. Realization of the EU's cohesion policy in health care in the visegrad group countries in the perspective 2014–2020. *Front Public Health.* (2020) 8:133. doi: 10.3389/fpubh.2020.00133
39. Roland Berger G. *Future of Health 3 / Innovation Boosted*. Munich: Focus (2021). 28 p.





## OPEN ACCESS

## EDITED BY

Mariana Dyakova,  
Public Health Wales NHS Trust,  
United Kingdom

## REVIEWED BY

Chin Chin Sia,  
Taylor's University, Malaysia

## \*CORRESPONDENCE

Rachel Granger  
rachel.granger@bangor.ac.uk

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 02 August 2022

ACCEPTED 26 October 2022

PUBLISHED 15 November 2022

## CITATION

Granger R, Genn H and Tudor  
Edwards R (2022) Health economics of  
health justice partnerships: A rapid  
review of the economic returns to  
society of promoting access to legal  
advice.  
*Front. Public Health* 10:1009964.  
doi: 10.3389/fpubh.2022.1009964

## COPYRIGHT

© 2022 Granger, Genn and Tudor  
Edwards. This is an open-access article  
distributed under the terms of the  
[Creative Commons Attribution License](#)  
(CC BY). The use, distribution or  
reproduction in other forums is  
permitted, provided the original  
author(s) and the copyright owner(s)  
are credited and that the original  
publication in this journal is cited, in  
accordance with accepted academic  
practice. No use, distribution or  
reproduction is permitted which does  
not comply with these terms.

# Health economics of health justice partnerships: A rapid review of the economic returns to society of promoting access to legal advice

Rachel Granger<sup>1\*</sup>, Hazel Genn<sup>2</sup> and Rhiannon Tudor Edwards<sup>1</sup>

<sup>1</sup>Centre for Health Economics and Medicines Evaluation, Bangor University, Bangor, United Kingdom, <sup>2</sup>Faculty of Laws, University College London, London, United Kingdom

**Background:** Welfare legal problems and inadequate access to support services follow both the socioeconomic and the health inequalities gradients. Health Justice Partnership (HJP) is an international practitioner-led movement which brings together legal and healthcare professionals to address the root causes of ill health from negative social determinants. The aim of this paper was to identify the current evidence base for the cost-effectiveness of HJP or comparable welfare advice services.

**Methods:** A rapid review format was used, with a literature search of PubMed, CINAHL, ASSIA, PsycINFO, Medline, Cochrane Library, Global Health and Web of Science identifying 496 articles. After removal of duplicates, 176 papers were screened on titles and abstracts, and 20 papers met the eligibility criteria. Following a full-text screening, a further 14 papers were excluded due to lack of economic evaluations. Excluded papers' reference lists were scanned, with a further 3 further papers identified which met the inclusion criteria. A final pool of nine studies were included in this review.

**Results:** Studies focused on the financial benefit to service users, with only three studies reporting on cost effectiveness of the interventions. Only one study reported on the economic impact of change of health in service users and one study reported on changes in health service use.

**Conclusion:** This review highlights the current evidence gap in evaluating the cost-effectiveness of adequate access to free legal welfare advice and representation. We propose that an interdisciplinary research agenda between health economics and legal-health services is required to address this research gap.

## KEYWORDS

health justice partnerships (HJP), health economics, welfare legal advice, return on investment (ROI), rapid review, cost-consequence analysis (CCA), cost-utility analysis (CUA), public health

## Introduction

Socioeconomic deprivation is acknowledged to cast a long shadow on the health and wellbeing of affected populations, not only within but across generations (1). We are familiar with models of the socioeconomic determinants of health e.g., the Dahlgren-Whitehead model (2). The 2010 Marmot review (3) proposed six policy objectives required to reduce health inequalities:

1. Give every child the best start in life
2. Enable all children, young people and adults to maximize their capabilities and have control over their lives
3. Create fair employment and good work for all
4. Ensure a healthy standard of living for all
5. Create and develop healthy and sustainable places and communities
6. Strengthen the role and impact of ill-health prevention.

Successful and sustainable approaches to reducing these health inequalities will depend upon stronger collaborative working across sectors.

Experience of welfare legal problems and inadequate access to free legal support follows not only the socioeconomic gradient, but also the health inequalities gradient (4–7). Although legal issues are embedded in most social determinants of health and are recognized at the macro legislative level, the need for free legal services to improve health at a local or individual level has largely been overlooked. It was not specifically highlighted in the 10-year reviews by Marmot and colleagues (8, 9), nor in the current discourse on “leveling up” (10).

It is acknowledged that the root cause of a significant proportion of healthcare usage (in both primary and secondary healthcare) in socioeconomically disadvantaged populations is not only due to the direct health outcomes associated with depression but associated “non-health” socio-legal issues, such as family breakdown, employment problems, access to welfare benefits and inadequate housing (11). People on low income or experiencing poor physical or mental health are more likely to have a need for legal support in accessing welfare benefits, managing debt or addressing housing issues. However, they often have difficulty accessing legal support and frequently approach inappropriate sources, such as GPs who are unlikely to be able to provide guidance (12, 13). This additional strain on GPs in deprived areas is not only unlikely to be effective for the individual but it deflects primary care resources away from healthcare provision in already overburdened GP practices.

Health Justice Partnership (HJP) is an international practitioner-led movement which brings legal and healthcare professionals together to address the root causes of ill health among low income and vulnerable groups from negative social determinants (4). HJPs, which are also referred to as

medical-legal partnerships (MLP) in the US, are collaborations between health and free welfare legal services providing advice and support for patients experiencing health-harming challenges such as housing problems (e.g., landlord/tenant disputes, housing discrimination), benefits (e.g., benefits accessibility and claims denials), family (e.g., child support and civil protective orders) and consumer (e.g., bankruptcy and utility shut-offs). Welfare legal service providers working in partnership with health services are therefore highly relevant to public health, as they focus on prevention, by addressing upstream systematic social and legal problems that affect patient and population health. Many of the health issues experienced by individuals are due to, or exacerbated by, the effect of unenforced laws or incorrect denial of critical services or support that they are entitled to. Rather than creating new laws, the primary aim of HJP is to ensure that public bodies comply with current statutory responsibilities and that individuals receive the benefits and conditions to which they are legally entitled.

The aim of this paper was to present a rapid literature review to identify the current evidence base for the cost-effectiveness of HJP or comparable welfare advice services. In addition, to investigate if there is evidence for the impact of these services on wider measures, such as service user health and healthcare usage.

## Methods

### Search strategy

The literature search strategy followed rapid review procedure (14). The period 1st January 1995 to 14th July 2022 used covers the period since HJP were first reported (15). The following academic databases were examined: PubMed, CINAHL, ASSIA, PsycINFO, Medline, Cochrane Library, Global Health and Web of Science. Titles and abstracts were searched, with search terms based on the criteria of “social welfare legal advice” AND “health economic evaluation methods”. The full list of terms searched for were: “legal support” OR “legal advice” OR “legal service” OR “health justice” OR “health justice partnership” OR “health-justice partnership” OR “medical legal partnerships” OR “medical-legal partnerships” OR “health law partnership” OR “Citizens Advice” OR “CAB” OR “welfare legal advice” OR “welfare benefits” OR “welfare claims” OR “debt advice” OR “housing advice” OR “immigration advice” OR “family advice” AND “cost-benefit analysis” OR “cost-utility analysis” OR “cost-effective analysis” OR “cost effective\*” OR “social return on investment” OR “return on investment” OR “social cost-benefit analysis” OR “cost-minimization analysis” OR “cost-consequence analysis” An additional search in Google Scholar was also conducted using the same search terms.

TABLE 1 Summary of included studies.

References, (country)	Study details	Participants and setting	Key findings
Teufel et al. (16), US	<p><b>Study design:</b> Case study, mixed methods</p> <p><b>Type of Intervention:</b> Civil Legal Aid service provided for women experiencing intimate partner violence (IPV).</p> <p><b>Data collection methods/outcomes measured:</b> SROI, changes in private and public benefits income over a 12-months</p> <p><b>Quality rating:</b> medium</p>	<p><b>Sample size:</b> <math>n = 82</math></p> <p><b>Participants and setting:</b> Adult women currently experiencing IPV and who have accessed legal aid support from Iowa Legal Aid, US.</p> <p><b>Dates of data collection:</b> Service users in 2015-16</p>	<p><b>Primary findings:</b> Reported increase of income of service users of \$2.41 for every \$1 invested in the services. The average total income increase was \$5,500 per service user, which was driven by private rather than welfare income.</p> <p><b>Additional findings:</b> The odds for being in poverty decreased a year after using the service- approx. 2.5 times lower (<math>rOR = 0.28</math>) than before service use.</p>
Citizens Advice 2015/16 Report (17), UK	<p><b>Study design:</b> Case study</p> <p><b>Type of Intervention:</b> Standard CA welfare advice provided in CA centers.</p> <p><b>Data collection methods/outcomes measured:</b> ROI and users' and volunteers' evaluation (qualitative) of the CA service</p> <p><b>Quality rating:</b> medium</p>	<p><b>Sample size:</b> <math>n = 4,200</math> (<math>n = 2,700</math> service users, <math>n = 1,500</math> CA volunteers).</p> <p><b>Participants and setting:</b> Adults using the CA welfare advice service or adults working as CA volunteers in the UK.</p> <p><b>Dates of data collection:</b> Services users and CA volunteers in the financial year 2015/16</p>	<p><b>Primary findings:</b> For every £1 invested a total of £20.57 was generated, consisting of £10.97 financial benefits to service users, £1.52 of savings to government, and an estimated £8.08 in wider economic and social benefits (including participating and productivity for clients and volunteers).</p> <p><b>Additional findings:</b> 65–75% of clients stated that welfare issues were causing them stress and anxiety, although it was not reported how service usage changed these levels</p>
Woodhead et al. (18), UK	<p><b>Study design:</b> prospective quasi-experimental controlled trial</p> <p><b>Type of Intervention:</b> Provision of CA welfare advice in GP surgeries.</p> <p><b>Data collection methods/outcomes measured:</b> financial impact including ROI; proportion meeting criteria of common mental disorder using General Health Questionnaire and SWEMWBS scales; impact on health and social care utilization; changes in meeting criteria for common mental health disorders. Financial measurements were taken over 8 months, all others over 3 months.</p> <p><b>Quality rating:</b> High</p>	<p><b>Sample size:</b> <math>n = 816</math> (<math>n = 278</math> intervention and <math>n = 613</math> control)</p> <p><b>Participants and setting:</b> Adults using CA debt advice service in GP settings, UK.</p> <p><b>Dates of data collection:</b> Dec. 2015–Dec 2016</p>	<p><b>Primary findings:</b> ROI of additional income of £15 to service users per £1 funder investment. Service users increased welfare income by an average of £2,689 during 8-month study period. Common mental disorders reduced among women (<math>rOR = 0.37</math>) and black service users (<math>rOR = 0.09</math>) compared to controls. No changes were reported for consultation rates at 3 months.</p> <p><b>Additional findings:</b> Service users with a positive financial outcome reported improved wellbeing and reductions in financial strain (<math>rOR = 0.42</math>).</p>
Gabby et al. (19), UK	<p><b>Study design:</b> Pilot RCT, mixed methods, including economic analysis</p> <p><b>Type of Intervention:</b> Provision of CA welfare advice in GP surgeries in England and Wales.</p> <p><b>Data collection methods/outcomes measured:</b> trial feasibility, changes in depression score (Beck Depression Inventory) and Anxiety (Back Anxiety Inventory) over 4 months of trial, economic analysis planned, including HRQoL (using EQ-5D-5L) and SWEMWEBS and healthcare usage measures.</p> <p><b>Quality rating:</b> High</p>	<p><b>Sample size:</b> <math>n = 61</math> (<math>n = 32</math> intervention and <math>n = 29</math> control).</p> <p><b>Participants and setting:</b> adults using primary care services with mild-moderate depression (using Beck depression score) and debt worries, UK.</p> <p><b>Dates of data collection:</b> July 2014–Aug 2015</p>	<p><b>Primary findings:</b> Due to dropout rates, data was insufficient to carry out proposed economic evaluations.</p> <p><b>Additional findings:</b> Mean depression scores and anxiety scores improved in the service users compared to the control group in the descriptive statistics but were not statistically significant. Descriptive statistics showed lower levels of acute healthcare usage and higher levels of community healthcare service usage for service users.</p>

(Continued)

TABLE 1 (Continued)

References, (country)	Study details	Participants and setting	Key findings
Caiels and Thurston (20), UK	<p><b>Study design:</b> Case study, mixed methods</p> <p><b>Type of Intervention:</b> Provision of CA advice in GP surgeries. Referral by healthcare professionals or self-referral.</p> <p><b>Data collection methods/outcomes measured:</b> Improvements of financial situation of service users; changes in anxiety and general health (SF-12 questionnaire); participants and providers experience of the service.</p> <p><b>Quality rating:</b> Low</p>	<p><b>Sample size:</b> <math>n = 333</math> service users (<math>n = 81</math> participated in health measures and qualitative study).</p> <p><b>Participants and setting:</b> Adults using welfare advice services in primary healthcare settings in Warrington, UK.</p> <p><b>Dates of data collection:</b> Aug 2003–Sept. 2004</p>	<p><b>Primary findings:</b> Total financial improvement was £346,754 (mean average of £1,041 per participant), which was due to increased welfare benefits and debt written off.</p> <p><b>Additional findings:</b> 68% reported feeling less anxious after using the service, but there was no significant difference in the physical or mental health components of the SF-12 scores.</p>
Naven et al. (21), UK	<p><b>Study design:</b> Case Study, mixed methods</p> <p><b>Type of Intervention:</b> Money Advice provided welfare advice services in child health settings. Referral by healthcare professionals.</p> <p><b>Data collection methods/outcomes measured:</b> financial improvement to service users, service users and healthcare professionals experience, factors affecting implementation.</p> <p><b>Quality rating:</b> Low</p>	<p><b>Sample size:</b> <math>n = 2,516</math></p> <p><b>Participants and setting:</b> pregnant woman and families with children under 5 in the Greater Glasgow area, UK.</p> <p><b>Dates of data collection:</b> Oct. 2010–March 2012</p>	<p><b>Primary findings:</b> 1 in 2 service users were entitled to additional financial support and the average gain per service user was £3,404.</p> <p><b>Additional findings:</b> Service users reported a reduction in stress and an improvement in mood, security, self-worth and relationships with family and friends.</p>
Moffatt et al. (22), UK	<p><b>Study design:</b> Case report, mixed methods</p> <p><b>Type of Intervention:</b> Macmillan Canter Support provided welfare advice to people with cancer and their careers. In in primary and secondary healthcare settings and participants homes.</p> <p><b>Data collection methods/outcomes measured:</b> welfare benefit claims; user and provider experience, including impact on stress and engaging in daily activities</p> <p><b>Quality rating:</b> High</p>	<p><b>Sample size:</b> <math>n = 1,174</math></p> <p><b>Participants and setting:</b> patients diagnosed with cancer and their careers, UK.</p> <p><b>Dates of data collection:</b> April 2009–March 2010</p>	<p><b>Primary findings:</b> Welfare benefit claims increased by £70.30 per week (median).</p> <p><b>Additional findings:</b> Participants reported reduced levels of stress and anxiety, and an increase in wellbeing (qualitative data).</p>
Evans and McAteer (23), UK	<p><b>Study design:</b> Quasi-experimental, mixed methods with control (for economic analysis)</p> <p><b>Type of Intervention:</b> Social housing organizations provided debt advice to tenants with rent arrears.</p> <p><b>Data collection methods/outcomes measured:</b> changes in rent arrears, ROI, service users' evaluation of effectiveness for the debt advice.</p> <p><b>Quality rating:</b> Low</p>	<p><b>Sample size:</b> <math>n = 411</math> (<math>n = 92</math> for intervention, <math>n = 319</math> for control) for economic analysis. For qualitative analysis <math>n = 179</math> for qualitative study</p> <p><b>Participants and setting:</b> Adult social housing tenants in the London area with rent arrears.</p> <p><b>Dates of data collection:</b> July 2010–Oct. 2011</p>	<p><b>Primary findings:</b> Landlords gained £122 for every £100 invested, due to reduced arrears and associated costs. Average reduction of £360 rent arrears per service user a year after using service.</p> <p><b>Additional findings:</b> Half of service users reported that the service helped them avoid eviction or court proceedings.</p>

(Continued)

TABLE 1 (Continued)

References, (country)	Study details	Participants and setting	Key findings
Howel et al. (24), UK	<p><b>Study design:</b> Pilot RCT, mixed methods</p> <p><b>Type of Intervention:</b> Local authority provided welfare advice delivered in participants' homes by trained advisors.</p> <p><b>Data collection methods/outcomes measured:</b> Changes in income and economic evaluation using CCA and CUA. Health related QoL (EQ-%D questionnaire), social and physical function.</p> <p><b>Quality rating:</b> Medium</p>	<p><b>Sample size:</b> <math>n = 755</math> (intervention <math>n = 381</math>, control <math>n = 374</math>)</p> <p><b>Participants and setting:</b> Adults 60 years or over living in socio-economically deprived areas of NE England.</p> <p><b>Dates of data collection:</b> Over 24-month period, with recruitment between May 2012 and Feb. 2013</p>	<p><b>Primary findings:</b> Only 22% received additional benefits as participants were more affluent than expected (inclusion was based on status of area rather than individual).</p> <p>There was no effect on health outcomes.</p> <p>The intervention was not cost-effective.</p> <p><b>Additional findings:</b> The CUA showed that the intervention was more costly but also more effective than usual care. CCA highlighting that 38% of delivery costs were due to advisors traveling to participants' homes</p>

## Search inclusion

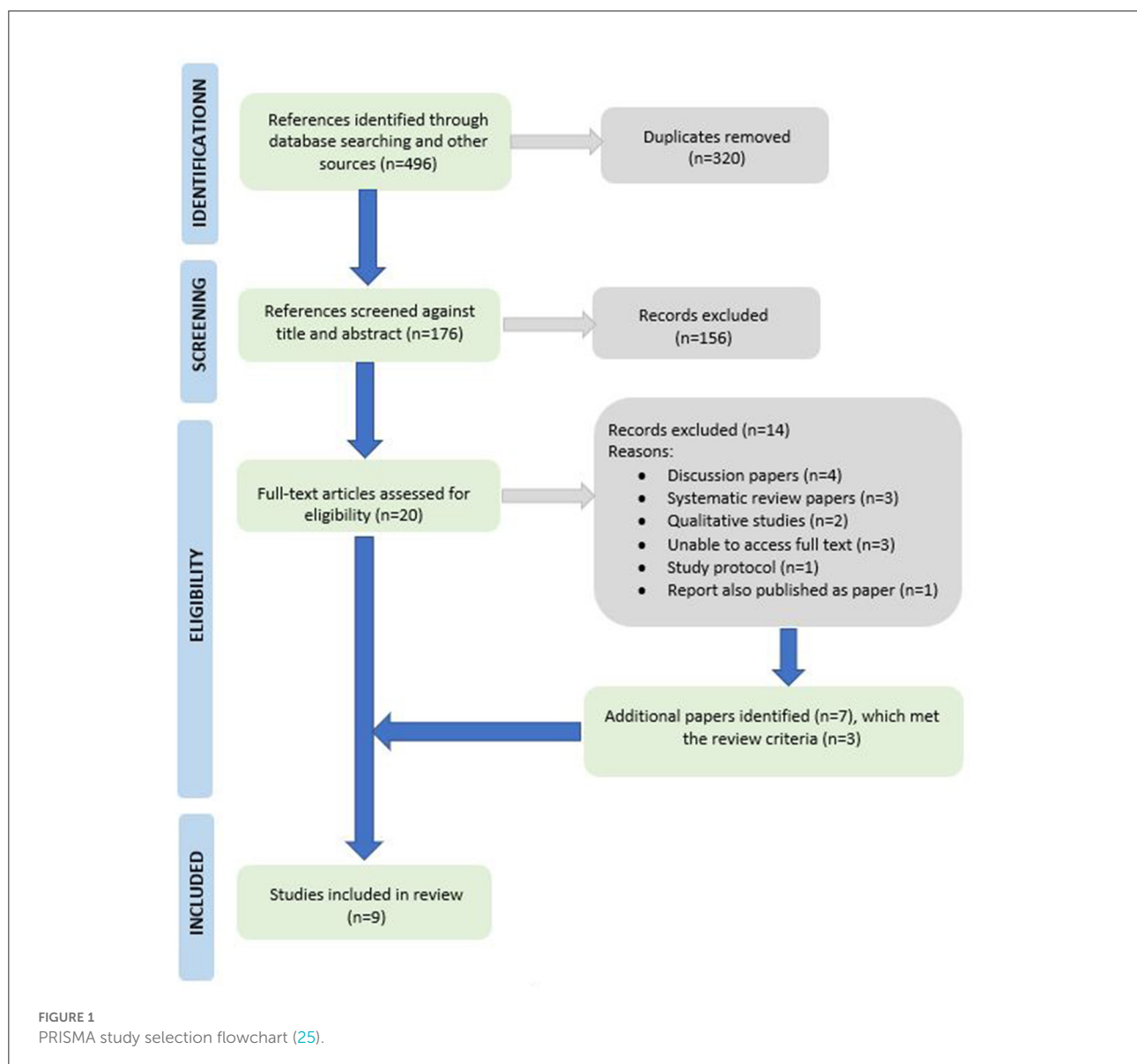
The database search identified 496 references. After the removal of duplicates, 176 references were screened against title and abstracts, with a further 156 papers being excluded. This left a total of 20 papers to be assessed on their full text articles. All searches and article assessments were carried out by the lead author (RG). Papers that did not contain financial or economic analyses were excluded. Excluded papers included systematic reviews, discussion papers, qualitative studies, a trial protocol paper and a report that was later published in a peer reviewed journal. Although reviews and discussion papers were not included, their reference lists were scanned to identify additional citations. This identified seven additional papers that were retrieved for further examination, three of which met the inclusion criteria for this review. A final pool of nine articles was included in this rapid review (see Table 1). Figure 1 shows the PRISMA flow diagram for this study. Quality assessments were carried out for the nine included articles using the Joanna Briggs Institute JBI critical appraisal tools for Case Reports, Randomized Controlled Trials, Quasi-Experimental and Economic Evaluation.

## Results

Of the nine papers identified, eight described studies conducted in the UK (17–24), and one described a study conducted in the US (16). Four were studies published in peer-reviewed journals (16, 18, 22, 24) and five were non-peer reviewed reports including: a 2015–16 Citizens Advice (CA) report (17), a National Institute of Health & Care Research (NIHR) study report (19), University of Chester digital repository report (20), a study report from the Glasgow Centre for Population Health (21), and a UK-based housing association study report (23). Of the nine studies, seven were mixed methods studies, with five of these being case reports (16, 17, 20–22), two being pilot RCTs (19, 24) and one was a quasi-experimental controlled trial (23). The ninth study was a quantitative quasi-experimental controlled trial (18). Only one study was classified as a HJP intervention (16); four of the studies had welfare advice provided by CA (17–20) or Money Advice, which is an equivalent service based in Scotland (21). One study described welfare advice provided by Macmillan Cancer Support (22), one study described social landlord associations providing welfare advice (23), and in one study welfare advice was provided by local authority welfare department (24). Of the nine studies included, the four peer reviewed studies (16, 18, 22, 24) were of moderate to high quality, according to the JBI quality appraisal checklists. Whereas the non-peer reviewed studies (17, 19–21, 23) were of low to moderate quality (see Appendix).

The single study that reported on a HJP was a study on the impact of civil legal aid services for women experiencing





intimate partner violence in the US (16). This small study ( $n = 82$ ) reported that 12 months after initial service use, women had an average increase in income of \$5,500, which was driven by significant increases in wages from jobs and child support (private income) and decreases in food stamps (public income). The scheme had a positive return on investment (ROI), as women's overall income increased by \$2.41 for every \$1 spent on the service. A year after accessing the service, the odds of women being in poverty was approx. 2.5 times lower [reverse odds ratio (rOR) = 0.28] than before service use. This indicated that as well as the financial improvements to service users and government (due to the reduction in public support) the intervention was able to improve the socio-economic status of service users.

The CA 2015/16 financial evaluation (17) reported a ROI of £20.57 for every £1 invested in welfare advice services. This

included £10.97 financial increase to service users (through benefits gained, debts written off and consumer problems resolved), £1.52 of savings to government (due to reduction in benefits claimed and health service demand), and £8.08 in wider economic and social benefits (for clients and CA volunteers). Sixty-five to seventy-five percent clients also stated that welfare issues were causing them stress and anxiety, although the impact of service use on these measures was not assessed.

Several of the studies included reviewed the provision of CA welfare advice services in primary or secondary healthcare settings. Woodhead et al., evaluated the cost-effectiveness of co-located welfare services, and the impact of debt advice on mental health and primary healthcare use (18). The study reported a ROI of £15 to service users per £1 of funder investment, with an average financial gain per participant of £2,689 over

the 8-month study period. The service also reduced the level of common mental disorders (CMD) diagnoses for specific demographic groups, with both women and black service users having a reduced likelihood of CMD diagnosis compared to controls ( $rOR = 0.37$  and  $rOR = 0.09$ , respectively). The authors reported that after 3 months there were no significant changes in GP consultation rates, although this was a shorter evaluation period than the 8 months used for the financial evaluation.

A feasibility RCT to determine the effect of debt counseling in primary care settings on mental health and healthcare use (19) was not able to complete the planned health economics evaluation due to a small trial size ( $n = 61$ ) and high dropout rate over the 12-months of the trial. Although the study did not report cost-effectiveness, we have included this study as it was one of the few studies to aim to complete a full economic evaluation. In addition, descriptive statistics from the health economic dataset indicate that the intervention group did have lower levels of acute admissions and higher levels of community service use for mental healthcare or alcohol/substance misuse than the control group. Further studies are needed to determine if these reported changes indicate significant changes in use of healthcare due to a welfare intervention.

Caiels and Thurston also reported an average of £1,041 financial gains for service users of welfare advice in primary care (20). Although the study did not include a ROI analysis, CA consultancy time per case type was included. A high number (68%) of service users also reported improvements in anxiety and general health in qualitative interviews, but these changes were not corroborated by the self-report questionnaire data (SF-12).

Three of the included studies focused on the provision of legal or welfare advice for specific target groups or welfare issues. The Healthier, Wealthier Children Project (21) provided welfare advice services to pregnant women and families with young children at risk of, or experiencing, child poverty. Welfare advice was provided in healthcare settings with referrals by midwives and health visitors. The service identified that almost half of service users were entitled to additional financial support and reported an average gain per service user of £3,404. Improvements in wellbeing were reported in qualitative interviews, but not quantified.

Moffatt et al. (22) evaluated a Macmillan Cancer Support funded welfare rights service to cancer patients. The authors reported that 96% of service users had successful welfare benefit claims, which led to a median increased weekly income of £70.30. A full cost evaluation was not completed in this study. Qualitative analysis highlighted that the impact of the intervention had lessened the impact of lost earnings, helped offset the costs associated with cancer, increased the ability to maintain independence, reduced stress and anxiety, and improved wellbeing and quality of life. Although this study did not look to include changes in these factors in their evaluation,

these are factors that may have the potential to show a higher level of economic return on this type of intervention.

Evans and McAteer (23) reported that a scheme for social landlords providing debt advice to their tenants who were in debt arrears decreased tenants' debt arrears by an average of £360 a year. The scheme had a positive ROI, with landlords recouping £122 for every £100 invested, due to both a reduction in arrears and the costs associated with addressing the debt. Half of participants reported that the service had helped them avoid court appearances or eviction. The threat of eviction is often a traumatic experience to tenants (26) and evictions also have high-cost implications for landlords (27). So, the study demonstrated that provision of welfare legal advice services can have financial benefits to both tenants and landlords, with potential further economic benefits due positive impacts of health and wellbeing of tenants.

Howel et al. (24) was the only paper to include both financial and health measures in their economic analyses. This included a within-trial cost-consequence analysis (CCA) to provide a breakdown and range of individual costs and benefits, and a Cost-Utility Analysis (CUA) that included both cost data and a measure of health-related quality of life (HRQoL) using the EQ-5D questionnaire. Although the provision of domiciliary advice to older people in socio-economically deprived areas was not cost effective in this trial, the study highlighted several issues that could be used as guidance for future studies. By targeting geographical areas rather than individuals with socio-economic inequalities, participants turned out to be more affluent than anticipated and therefore less eligible for the welfare service, indicating the need for more tailored and targeted interventions. The CUA showed that the intervention was more costly but also more effective than usual care, with the CCA highlighting that 38% of delivery costs were due to advisors traveling to participants' homes. This indicates that further work is required to explore the potential cost-effectiveness of services provided outside CA or healthcare settings. This may include online or group-based services or co-location with other multi-disciplinary centers already being used by potential service users, such as social/community centers or food banks.

## Discussion

The aim of this review was to determine the current evidence of the cost-effectiveness of legal and welfare rights services. Only nine studies were identified, including four peer-reviewed studies (of medium-high quality) and five non-peer reviewed reports (of low-medium quality).

Eight of the included studies reported financial improvement to services users, with the ninth study unable to report due to low recruitment. However, only three of the papers reported on cost-effectiveness of interventions or included an assessment on the financial impact on stakeholders

other than service users. Although this is in line with the studies' perspective, it is perhaps surprising that ROI was not more consistently investigated, considering that the focus of the studies was financial gain due to service provision.

In addition, few studies looked to determine the wider impact of the interventions on health or health service use. Although many of the studies used qualitative interviews to investigate changes in mental and physical health, only three studies used quantitative measures and one study used a health economic measure (CUA) to evaluate the impact of the interventions on participants' health. As discussed in the introduction, a significant amount of primary and secondary healthcare usage is reported to be driven by non-health socio-legal issues. However only one study reported on changes in healthcare usage (18). No changes were reported after 3 months in the study, although this was acknowledged as a rather short time period for follow-up. As the socio-economic problems that are addressed by legal and welfare programs often have adverse impacts on mental and physical health, it seems reasonable to conclude that health measures should be included in legal and welfare service evaluations.

The Legal Aid, Sentencing and Punishment of Offenders (LASPO) Act of 2012 is acknowledged to have significantly restricted legal aid funding in the UK (28). It is perhaps not surprising that many of the studies identified in this review were provided by charities such as CA. CA provides similar welfare advice to HJP, including providing advocacy to some clients, and has continued to receive funding from government and local councils post-2012. However, the search included pre-2012 studies and US based studies, where HJP is well-established (15). As only one HJP specific study, and only a total of four peer-reviewed welfare intervention studies with health economic evaluations were identified in this review, it indicates that there is a lack of economic evaluations of these services.

We propose that developing effective methods to measure the impact of HJP and similar interventions may be difficult due to the following reasons. These types of interventions are often used to treat diverse populations or interventions, where outcomes can vary significantly across different population groups or intervention types. There may be barriers to information sharing between healthcare organizations and legal partners, which was highlighted in a recent study (29). There are also considerable differences in the US and UK healthcare systems, the two countries with the main utilization of health justice interventions (15), which may mean it is difficult to compare the impact of interventions. The requirement to

develop a more standardized approach to evaluating legal and welfare studies has been highlighted (30). A more consistent quantitative approach to intervention assessments would also give the ability to provide a consistent health economic assessment of these types of interventions.

In conclusion, this rapid literature review highlights the current evidence gap in what we know about the potential cost-effectiveness to society of enabling people to have adequate access to welfare advice and specialist free legal advice and representation. Based on the geographical location of reviewed articles we propose an initial UK/US focused interdisciplinary research agenda between health economics and legal-health services to address this research gap, with the intention to extend this to a more international research agenda in future years.

## Author contributions

RG, HG, and RT: review conceptualization. RG: database searches, article assessments, paper reviews, paper quality assessments, and writing review. HG and RT: editing review and supervision. All authors have read and agreed to the published version of the manuscript.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2022.1009964/full#supplementary-material>

## References

1. Maguire D, Buck D. *Inequalities in Life Expectancy-Changes Over Time and Implications for Policy*. King's Fund (2015).

2. Dahlgren G, Whitehead M. *Policies and Strategies to Promote Equity in Health*. Institute for Futures Studies (2007). Available online at: [http://repository.uji.es/xmlui/bitstream/handle/10234/187797/GoeranD\\_Policies\\_and\\_strategies\\_to\\_promote\\_social\\_equity\\_in\\_health.pdf?sequence=\\$1oratthttps://www.iffs.se/](http://repository.uji.es/xmlui/bitstream/handle/10234/187797/GoeranD_Policies_and_strategies_to_promote_social_equity_in_health.pdf?sequence=$1oratthttps://www.iffs.se/)

media/1326/20080109110739filmZ8UVQv2wQFShMRF6cuT.pdf (accessed June 7, 2022).

3. Marmot M, Allen J, Goldblatt P, Boyce T, McNeish D, Grady M, et al. *The Marmot Review: Fair Society, Healthy Lives*. London: UCL (2010).

4. Genn H. When law is good for your health: mitigating the social determinants of health through access to justice. *Curr Leg Probl.* (2019) 72:159–202. doi: 10.1093/clp/cuz003

5. Balmer NJ, Patel A, Denvir C, Pleasence P. *Unmanageable Debt and Financial Difficulty in the English and Welsh Civil and Social Justice Survey: Report for the Money Advice Trust*. London: Legal Services Commission (2010).

6. Coumarelos C, Pleasence P, Wei Z. Law and disorders: Illness/disability and the experience of everyday problems involving the law. *Justice Issue.* (2013) 17:1–23. doi: 10.3316/ielapa.277728567019202

7. Prettitore P. *Do the Poor Suffer Disproportionately From Legal Problems?* Available online at: <https://www.brookings.edu/blog/future-development/2022/03/23/do-the-poor-suffer-disproportionately-from-legal-problems/> (accessed June 21, 2022).

8. Marmot M. Health equity in England: the Marmot review 10 years on. *BMJ.* (2020) 368:m693. doi: 10.1136/bmj.m693

9. Marmot M, Allen J, Goldblatt P, Herd E, Morrison J. *Build Back Fairer: The Covid-19 Marmot Review*. The Health Foundation (2020). Available online at: <https://www.health.org.uk/publications/build-back-fairer-the-covid-19-marmot-review> (accessed June 10, 2022).

10. Gov.uk. *Policy paper Leveling Up in the United Kingdom* (2022). Available online at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1052046/Executive\\_Summary.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1052046/Executive_Summary.pdf) (accessed July 15, 2022).

11. Advice C. *Royal College of General Practitioners. Advice in Practice: Understanding the Effects of Integrating Advice in Primary Care Settings*. London: Citizens Advice (2018).

12. Finn D, Goodship J. *Take-Up of Benefits and Poverty: An Evidence and Policy Review*. JRF/CESI Report. London: Center for Economic and Social Inclusion (2014).

13. Pleasence P, Balmer NJ, Buck A. The health cost of civil-law problems: further evidence of links between civil-law problems and morbidity, and the consequential use of health services. *J Empir Leg Stud.* (2008) 5:351–73. doi: 10.1111/j.1740-1461.2008.00127.x

14. Tricco AC, Khalil H, Holly C, Feyissa G, Godfrey C, Evans C, et al. Rapid reviews and the methodological rigor of evidence synthesis: a JBI position statement. *JBI Evid Synth.* (2022) 20:944–9. doi: 10.11124/JBIES-21-00371

15. Beardon S, Woodhead C, Cooper S, Ingram E, Genn H, Raine R. International evidence on the impact of health-justice partnerships: a systematic scoping review. *Public Health Rev.* (2021) 42:1603976. doi: 10.3389/phrs.2021.1603976

16. Teufel J, Renner LM, Gallo M, Hartley CC. Income and poverty status among women experiencing intimate partner violence: A positive social return on investment from civil legal aid services. *Law Soc Rev.* (2021) 55:405–28. doi: 10.1111/lasr.12572

17. Citizens Advice. *Modelling Our Value to Society in 2015/16*. Available online at: <https://www.citizensadvice.org.uk/Global/Public/Impact/ModellingthevalueoftheCitizensAdviseservicein201516.pdf> (accessed July 22, 2022).

18. Woodhead C, Khondoker M, Lomas R, Raine R. Impact of co-located welfare advice in healthcare settings: prospective quasi-experimental controlled study. *Br J Psychiatry.* (2017) 211:388–95. doi: 10.1192/bjp.bp.117.202713

19. Gabbay MB, Ring A, Byng R, Anderson P, Taylor RS, Matthews C, et al. Debt counselling for depression in primary care: an adaptive randomised controlled pilot trial (DeCoDer study). *Health Technol Assess.* (2017) 21:1. doi: 10.3310/hta21350

20. Caiels J, Thurston M. *Evaluation of the Warrington District CAB GP Outreach Project*. Centre for Public Health Research, Chester: University College Chester (2005).

21. Naven L, Withington R, Egan J. *Maximising Opportunities: Final Evaluation Report of the Healthier, Wealthier Children (HWC) Project*. Glasgow Centre for Population health (2012). Available online at: [tinyurl.com/cdnd8us](http://tinyurl.com/cdnd8us) (accessed May 13, 2013).

22. Moffatt S, Noble E, White M. Addressing the financial consequences of cancer: qualitative evaluation of a welfare rights advice service. *PLoS ONE.* (2012) 7:e42979. doi: 10.1371/journal.pone.0042979

23. Evans G, McAteer M. *Does Debt Advice Pay? A Business Case for Social Landlords*. London: The Financial Inclusion Centre (2011).

24. Howel D, Moffatt S, Haighton C, Bryant A, Becker F, Steer M, et al. Does domiciliary welfare rights advice improve health-related quality of life in independent-living, socio-economically disadvantaged people aged ≥ 60 years? Randomised controlled trial, economic and process evaluations in the North East of England. *PLoS ONE.* (2019) 14:e0209560. doi: 10.1371/journal.pone.0209560

25. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* (2021) 372:n71. doi: 10.1136/bmj.n71

26. Tsai J, Huang M. Systematic review of psychosocial factors associated with evictions. *Health Soc Care Commun.* (2019) 27:e1–9. doi: 10.1111/hsc.12619

27. Holl M, Van Den Dries L, Wolf JR. Interventions to prevent tenant evictions: a systematic review. *Health Soc Care Commun.* (2016) 24:532–46. doi: 10.1111/hsc.12257

28. Low Commission on the Future of Advice and Legal Support (England and Wales), Low CM. *Tackling the Advice Deficit: A Strategy for Access to Advice and Legal Support on Social Welfare Law in England and Wales*. London: Legal Action Group (2014).

29. Thorpe JH, Cartwright-Smith L, Gra E, Mongeon M, National Center for Medical Legal Partnership. *Information Sharing in Medical-Legal Partnerships: Foundational Concepts and Resources* (2020). Available online at: <https://medicallegalpartnership.org/wp-content/uploads/2017/07/Information-Sharing-in-MLPs.pdf> (accessed May 25, 2022).

30. Nerlinger AL, Alberti PM, Gilbert AL, Goodman TL, Fair MA, Johnson SB, et al. Evaluating the efficacy of medical-legal partnerships that address social determinants of health. *Progr Commun Health Partnerships Res Educ Act.* (2021) 15:25. doi: 10.1353/cpr.2021.0027



## OPEN ACCESS

## EDITED BY

Rasheda Khanam,  
University of Southern  
Queensland, Australia

## REVIEWED BY

Chijioke Okoli,  
University of Southern  
Queensland, Australia  
Brian Beach,  
University College London,  
United Kingdom

## \*CORRESPONDENCE

James Allen  
james.allen@wales.nhs.uk

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 29 September 2022

ACCEPTED 18 November 2022

PUBLISHED 15 December 2022

## CITATION

Allen J, Cotter-Roberts A,  
Darlington O, Dyakova M, Masters R  
and Munford L (2022) Understanding  
health inequalities in Wales using the  
Blinder-Oaxaca decomposition  
method.  
*Front. Public Health* 10:1056885.  
doi: 10.3389/fpubh.2022.1056885

## COPYRIGHT

© 2022 Allen, Cotter-Roberts,  
Darlington, Dyakova, Masters and  
Munford. This is an open-access  
article distributed under the terms of  
the [Creative Commons Attribution  
License \(CC BY\)](#). The use, distribution  
or reproduction in other forums is  
permitted, provided the original  
author(s) and the copyright owner(s)  
are credited and that the original  
publication in this journal is cited, in  
accordance with accepted academic  
practice. No use, distribution or  
reproduction is permitted which does  
not comply with these terms.

# Understanding health inequalities in Wales using the Blinder-Oaxaca decomposition method

James Allen<sup>1\*</sup>, Andrew Cotter-Roberts<sup>1</sup>, Oliver Darlington<sup>1</sup>,  
Mariana Dyakova<sup>1</sup>, Rebecca Masters<sup>1</sup> and Luke Munford<sup>2</sup>

<sup>1</sup>World Health Organization Collaborating Centre on Investment for Health and Well-Being, Public Health Wales, Cardiff, United Kingdom, <sup>2</sup>School of Health Sciences, University of Manchester, Manchester, United Kingdom

**Background:** Throughout Wales and the world, health inequality remains a problem that is interconnected with a wider and complex social, economic and environmental dynamic. Subsequently, action to tackle inequality in health needs to take place at a structural level, acknowledging the constraints affecting an individual's (or community's) capability and opportunity to enable change. While the 'social determinants of health' is an established concept, fully understanding the composition of the health gap is dependent on capturing the relative contributions of a myriad of social, economic and environmental factors within a quantitative analysis.

**Method:** The decomposition analysis sought to explain the differences in the prevalence of these outcomes in groups stratified by their ability to save at least £10 a month, whether they were in material deprivation, and the presence of a limiting long-standing illness, disability or infirmity. Responses to over 4,200 questions within the National Survey for Wales ( $n = 46,189$ ; 2016–17 to 2019–20) were considered for analysis. Variables were included based on (1) their alignment to a World Health Organization (WHO) health equity framework ("Health Equity Status Report initiative") and (2) their ability to allow for stratification of the survey sample into distinct groups where considerable gaps in health outcomes existed. A pooled Blinder-Oaxaca model was used to analyse inequalities in self-reported health (fair/poor health, low mental well-being and low life satisfaction) and were stratified by the variables relating to financial security, material deprivation and disability status.

**Results:** The prevalence of fair/poor health was 75% higher in those who were financially insecure and 95% higher in those who are materially deprived. Decomposition of the outcome revealed that just under half of the health gap was "explained" i.e., 45.5% when stratifying by the respondent's ability to save and 46% when stratifying by material deprivation status. Further analysis of the explained component showed that "Social/Human Capital" and "Income Security/Social Protection" determinants accounted the most for disparities observed; it also showed that "Health Services" determinants accounted the least. These findings were consistent across the majority of scenarios modeled.



**Conclusion:** The analysis not only quantified the significant health gaps that existed in the years leading up to the COVID-19 pandemic but it has also shown what determinants of health were most influential. Understanding the factors most closely associated with disparities in health is key in identifying policy levers to reduce health inequalities and improve the health and well-being across populations.

#### KEYWORDS

health inequality, health equity, health gap, mental well-being, life satisfaction, decompositions methods, contributing factors

## Introduction

The effects of globalization have delivered a number of population health benefits, though not fairly distributed to all, with high unemployment levels, rising inequalities, and poor health outcomes remaining a problem (1). Health inequity is interconnected with wider and complex social, economic and environmental factors (2). Action to tackle inequalities and inequities in health outcomes must take place at a structural and system level, acknowledging the constraints affecting an individual's or community's capability and opportunity to enable change (3).

There are stark inequalities in health outcomes in the UK population and despite continuous research and recommendations to reduce these (4), issues remain in closing the health gaps. In Wales, differences in health outcomes have been observed for many years between the most and least deprived areas, and in some cases have worsened (5, 6). For example, the gap in death rates between the most and least deprived quintiles has slightly widened in recent years (7), largely driven by worsening life expectancy in the most deprived areas of Wales (8). The COVID-19 pandemic has also had an impact on health outcomes in Wales, particularly so among the most deprived (9).

Wales has a policy landscape which is well positioned towards helping the identification and tackling of health inequities. The Well-being of Future Generations (Wales) Act provides an overarching framework for understanding commitments toward reducing inequality (10). The Socio-economic Duty underlines the need to understand how public bodies' actions influence inequality and requires more equitable decision-making (11). "A Healthier Wales", the Welsh Government's long-term plan for health and social care, outlines the need to measure health and well-being outcomes, and drives transformative change in places where these outcomes can be improved (12).

Despite the wealth of data exposing inequalities in health and their trends, and the policy commitment to reducing these, achieving a healthier and a more equal Wales, the specific drivers

of the health gap remain poorly explored and understood. While the Social Determinants of Health (SDH) concept is well established (2), understanding the health gap composition and contributing factors is essential to identify its drivers and opportunities to reduce it.

The application of novel analytical methods to inform public health priorities are not only key to exploring the factors contributing to health inequities, but are crucial in identifying the policy levers to tackle them. With the much needed recovery from COVID-19 and the emergence of other social and economic challenges, such as the cost of living crisis, it is now more important than ever to understand the drivers of the health gap in Wales.

A promising method for exploring the health gap is the use of decomposition methods, which have the capacity to attribute sources of the compound construct of social inequality in health to independent conditions (13). While decomposition methods have been utilized to explore a range of issues in relation to health inequities – including age (14), gender (15), employment type (16) and socio-economic status (17) – they remain somewhat uncommon within public health (13). While some studies have analyzed self-reported or perceived health in the European context – specifically in Ireland (18), Latvia (19) and across Europe (20) – decomposition of the gaps in self-reported/perceived health remains an underutilized method. To the authors' knowledge, this is the first decomposition analysis using the Blinder-Oaxaca method of self-reported health in Wales and the UK.

This analysis is answering this need, aiming to explore and 'decompose' the gaps in measures of self-reported health and well-being, and quantify their relationship with the wider determinants for healthy prosperous lives for all.

## Methods

This study is based on a secondary analysis of the National Survey for Wales (NSW) and was analyzed using Stata 14.

The NSW is conducted by the Office for National Statistics (ONS) on behalf of the Welsh Government. Initiated in 2012, the NSW covers a broad range of topics, and since 2016 has incorporated a number of other surveys including the Welsh Health Survey, the Arts in Wales Survey, the Welsh Outdoor Recreation Survey and the Active Adults Survey. Topics include:-

- Local area and environment
- Well-being and finances
- Housing
- Democracy and government
- Population health
- Internet and media
- Culture and Welsh language
- Sport and recreation
- Children and education
- NHS and social care

The NSW is conducted *via* a random sample (using the Royal Mail postcode address file) and a large scale telephone survey with a sample size of approximately 1,000 individuals per month. Prior to the COVID-19 pandemic (and for the time period of this study), the survey was conducted *via* face-to-face interviews.

Survey respondents are aged 16+ and not all questions in the survey are asked of the whole sample, e.g., some questions are only asked of pensioners/non-pensioner adults, this restricts what analysis is possible.

## Using a WHO health equity framework to decompose disparities in health

The WHO Regional Office for Europe's Health Equity Status Report identified five "essential conditions" (wider determinants) that impact health equity, namely, "health services", "income security and social protection", "living conditions", "social and human capital" and "employment and working conditions" (1) (see [Supplementary Figure 1](#) in the [Supplementary material](#) for the full definitions and examples).

These five conditions were used in conjunction with the Blinder-Oaxaca decomposition method to further understand the drivers of disparities in health.

The first step in being able to decompose the health gap according to the five essential conditions was to assemble a single dataset comprising all the questions and associated responses that were collected as part of the National Survey for Wales (NSW) between 2016–17 and 2019–20. From this combined dataset, we could then identify:

a) The questions most aligned to the five essential conditions

b) The questions allowing for stratification of the population into distinct groups where potentially significant gaps in health outcomes were present, and to generate the health outcomes themselves.

The combined survey data (2016–17 to 2019–20) yielded responses to over 4,200 questions by 46,189 people.

To be able to decompose the gap in health outcomes between distinct population groups according to the five essential conditions, questions from the surveys were categorized based on their ability to act as proxy variables for those five essential conditions.

We used a systematic approach to classifying the available questions; for each of the included questions, two reviewers independently attempted to categorize them according to the five essential conditions, health outcomes, and population stratification variables (or as irrelevant to the study). Where the two reviewers disagreed on the categorization of a variable, the final decision was made by consensus, with the final category of each question being mapped back onto the combined analysis dataset.

When determining which variables representing the five essential conditions, stratification factors and health outcomes should be included in the final decomposition analysis, a qualitative assessment must be made regarding both the perceived strength of a given question as a proxy for an essential condition, but also the corresponding sample size for the analysis resulting from its inclusion. As such, a balance must be struck between trying to include those variables that are felt to be the best indicators, while retaining enough observations to enable robust statistical analysis.

In order to determine this, a technical team made assessments of the questions and their alignment to each essential condition. This created a shortlist of the most appropriate questions for inclusion in the analysis under each condition. The final variable selection was then made by choosing the combination of variables from this shortlist that covered all five essential conditions, appropriate stratification factors and health outcomes, while minimizing the reduction in sample sizes due to the requirement for complete cases only.

In the case of stratification factors particularly, variables measured at an individual level were chosen in preference to area-based measures. For example, the ability of an individual respondent to save at least £10 a month was thought to be a better measure of relative financial deprivation than Welsh Index of Multiple Deprivation (WIMD), which will inherently capture less inter-person variation as it is based on the demographics of approximately 1,500 people living in an area. People living in more deprived areas are not necessarily deprived, however, we can say that someone who is unable to save at least £10 a month is likely less financially secure than someone who can.

## Data considerations

It was not possible to use questions that were not asked concurrently over the 4 year period as the decomposition analysis requires complete cases only.

An important consideration was which questions could be included in the analysis alongside one another. For example, if one question was only asked in the 2016–17 survey, and conversely, another question was only asked in the 2019–20 survey, these two questions could never be jointly included in the analysis, as a single respondent would have been unable to provide answers to both questions due to the cross-sectional design of the survey.

The wording of the questions must remain the same over the 4 year period to be included in the analysis. Although there were cases where questions in different years may have been in effect the same, or attempted to investigate the same issue, it was not possible to quantify how similar two questions were, or subsequently decide a threshold to determine if questions were similar enough to aggregate across survey years.

## Variables included in the decomposition

The final decomposition analysis included 16 variables aligned to the five essential conditions, which are categorized as follows:

- Employment and working conditions: excessive hours worked and job satisfaction
- Health services: satisfaction with health services
- Income security and social protection: not in paid work, use of food banks and trouble keeping up with bills
- Living conditions: satisfaction with local area, internet access, if the respondent was living in a single person household and if the respondent felt safe in the local area
- Social and human capital: highest qualification, sense of trust in their community, sense of community more broadly, if they volunteered and participation in sports and other activities

The outcomes considered for the decomposition were: reported poor or fair health, low mental well-being, and low life satisfaction (see [Supplementary Table 1](#) for coding of variables).

The decomposition analysis sought to explain the differences in the prevalence of these outcomes in groups stratified by their ability to save at least £10 a month, whether they were in material deprivation, and the presence of a limiting long-standing illness, disability of infirmity. A full description of the survey questions included in the analysis and how they were mapped to analysis

variables is shown in [Supplementary Table 1](#). Any responses where the respondent either refused to answer the question, or did not know the answer to the question were omitted from the analysis.

Mapping of analysis variables was done to either demonstrate negative outcomes/ active participation in an activity, as a result of this, the polarity of coding is inconsistent across variables. This should be borne in mind when interpreting results. It should also be stated that if the reference/base category for predictor variables was changed, it could impact/change the results of the decomposition analysis.

## Statistical analysis

The survey design and subsequent data management means that the analyzed dataset considers the 4 years' worth of survey data as one time period, meaning a cross-sectional study design,

The logit models used a pooled form of the Blinder-Oaxaca decomposition that generates a two-fold decomposition which uses the coefficients from a pooled model over both groups as the reference coefficients, aligned with the work of Neumark (21) and Oaxaca and Ransom (22). This is partly due to an index problem, where it is not clear which regression co-efficient should be used as the reference.

The formula for the decomposition is as follows:

$$y^{Group\ 1} - y^{Group\ 2} = \Delta x\beta^P + [x^{Group\ 1}(\beta^{Group\ 1} - \beta^P) + x^{Group\ 2}(\beta^P - \beta^{Group\ 2})] \quad (1)$$

$y$  = health variable of interest

$\beta$  = coefficients

$x$  = vector of underlying conditions

$\beta^P$  = pooled coefficients

Predicted means for the outcome of interest is presented in percentage form, alongside a breakdown of the difference in predicted mean by explained/unexplained component. The explained component has been broken down further using the WHO health equity framework and presented in graphical form. Full breakdowns are presented in [Supplementary Tables](#). Percentages shows how much of the total difference in a health outcome is accounted for by the level of observed covariates in the model. This follows a similar approach taken by Rahimi and Nazari (23).

Whether the prevalence of an outcome was significantly different from another was determined by whether the 95% confidence intervals were overlapping or not; statistical significance of the explained/unexplained component was determined by a significance threshold of  $\alpha = 0.05$ .

## Results

### The health gap between those who are able to make a saving of at least £10/month and those who are not

This analysis quantifies the prevalence of low mental well-being, low life satisfaction and fair/poor health in those who are able to make financial savings and those who are not (Figures 1–3). 31.7% of survey respondents who were not able to make savings reported low mental well-being, compared to 16.6% of those who were able to save, a significant difference of 15.1 percentage points. 4.3% of survey respondents not able to make savings reported low life satisfaction compared to 1.1% of respondents who were able to make savings, a significant difference of 3.2 percentage points. 26.8% of survey respondents who were not able to make savings reported being in fair/poor health, compared to 15.3% of respondents who were able to make savings, a significant difference of 11.5 percentage points.

Decomposing the gap in prevalence of self-reported health between those able to make a saving of at least £10/month and those who are not, reveals that Social and Human Capital (26.4–40.4% of explained component) and Income Security and Social Protection (40.2–51.2% of explained component) are the essential conditions accounting the most for the differences in fair/poor health, low mental well-being and low life satisfaction. The Living Conditions and Health Services are the essential conditions accounting the least for differences in health (Figures 1–3).

From the gap in prevalence of fair/poor health between those who are able to save at least £10/month and those who are not (11.5 percentage point difference) – 45.5% can be explained by systematic differences in the essential conditions; and 54.5% remains unexplained, both statistically significant ( $p < 0.05$ ). From the explained component, Income Security and Social Protection and Social and Human Capital accounts the most, 40.2% and 40.1% (both statistically significant  $p < 0.05$ ), respectively; while Living Conditions (7.8%;  $p = 0.05$ ) and Health Services (3.1%;  $p = 0.08$ ) accounts the least (Figure 1).

From the gap in the prevalence of low mental well-being (15.1 percentage point difference) – 53.4% can be explained by systematic differences in the essential conditions; and 46.6% remains unexplained (both components statistically significant ( $p < 0.05$ ). From the explained component, Social and Human Capital (40.4%;  $p < 0.05$ ) and Income Security and Social Protection (40.4%;  $p < 0.05$ ) account the most for differences in health and have equal shares, relative to the other essential conditions. Health Services accounts the least for differences in fair/poor health (1.4%;  $p = 0.24$ ) (Figure 2).

While the gap in prevalence of low life satisfaction (Figure 3) is smaller than the gap observed in low mental well-being and fair/poor health (Figures 1, 2), the prevalence of low life satisfaction is still approximately four times higher in those that are not able to make a saving than those who are, and still significantly higher. From this, 48.1% can be explained ( $p < 0.05$ ) by systematic differences in the essential conditions; while more than half of the gap (51.9%) remains unexplained ( $p = 0.08$ ). Of the explained component, Income Security and Social Protection (51.2%;  $p < 0.05$ ) and Social and Human Capital (26.4%;  $p < 0.05$ ) accounts the most for the differences in low life satisfaction; while Living Conditions accounts the least, 4.7% ( $p = 0.26$ ) (Figure 3).

### The health gap between those who report being in material deprivation and those who do not

Breaking down self-reported measures of health by whether the respondent is in material deprivation or not reveals stark health gaps. The prevalence of negative health outcomes (fair/poor health, low mental well-being and low life satisfaction) is at least twice as high in those who report being in material deprivation compared to those who do not: 22.9 significant percentage point difference in the prevalence of low mental well-being; 14.7 significant percentage point difference in fair/poor health; and a 5.2 significant percentage point difference in low life satisfaction.

The decomposition analysis of the health gaps observed between those in material deprivation and those who aren't shows that most of the gap cannot be explained by the model (54–73.9%). Of the proportion that can be explained, Social and Human Capital and Income Security and Social Protection accounts the most for differences in health. In the majority of scenarios, Health Services accounts the least for the differences in health (Figures 4–6).

46% ( $p < 0.05$ ) of the gap in fair/poor health between those who report being in material deprivation and those who do not can be explained by the model; 54% ( $p < 0.05$ ) of the gap remains unexplained. From the explained component, Social and Human Capital and Income Security and Social Protection accounts the most for differences in fair/poor health, 46.5 and 37.1%, respectively, both statistically significant ( $p < 0.05$ ) (Figure 4).

Social and Human Capital accounts the most for differences in low mental well-being (49.1% of explained component;  $p < 0.05$ ); Health Services accounts the least (0.9% of explained component;  $p = 0.36$ ) (Figure 5). Income Security and Social Protection accounts the most (~44.9% of explained component;  $p < 0.05$ ) for differences in low life satisfaction and Living

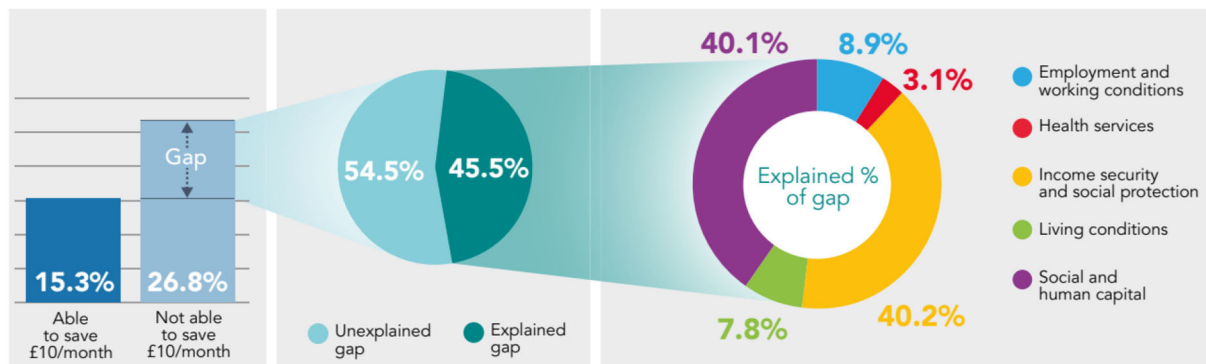


FIGURE 1

Decomposing the gap in prevalence of fair/poor health between those who are able to make a saving of at least £10/month, and those who are not using the Blinder-Oaxaca methodology, non-pensioner adults (aged 16–65), Wales, 2016–17 to 2019–20.

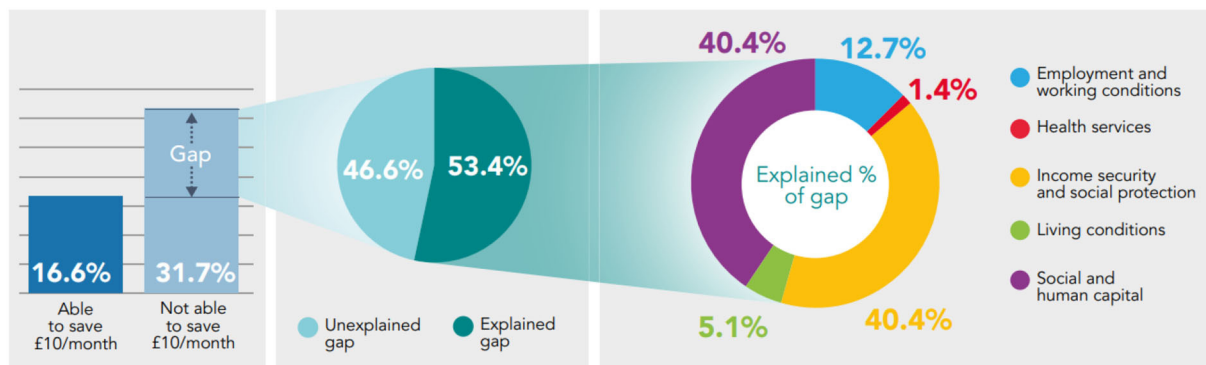


FIGURE 2

Decomposing the gap in prevalence of low mental well-being between those who are able to make a saving of at least £10/month, and those who are not using the Blinder-Oaxaca methodology, non-pensioner adults (aged 16–65), Wales, 2016–17 to 2019–20.

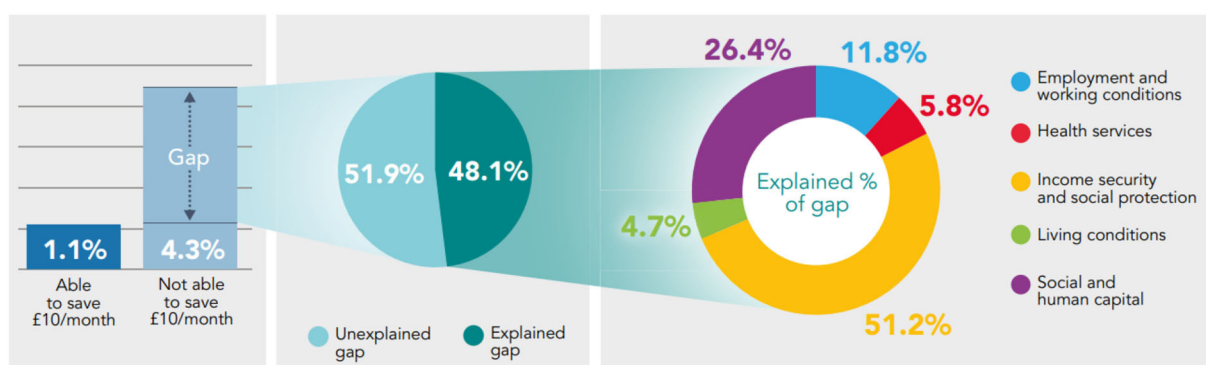


FIGURE 3

Decomposing the gap in prevalence of low life satisfaction between those who are able to make a saving of at least £10/month, and those who are not using the Binder-Oaxaca methodology, non-pensioner adults (aged 16–65), Wales, 2016–17 to 2019–20.



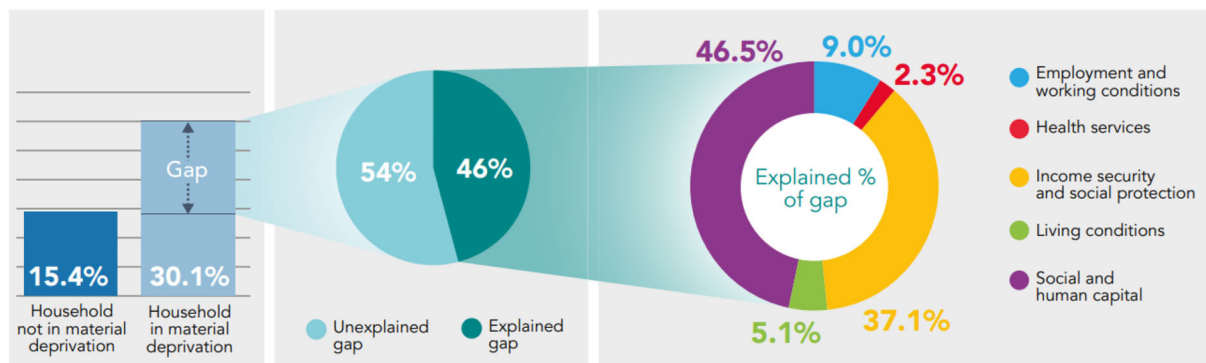


FIGURE 4

Decomposing the gap in prevalence of fair/poor health between those who report being in material deprivation and those who do not using the Binder-Oaxaca methodology, persons aged 16+, Wales, 2016–17 to 2019–20.

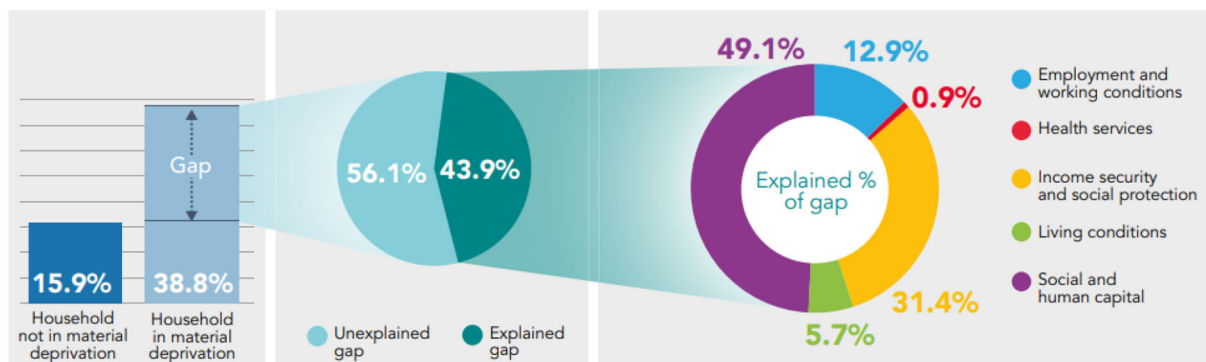


FIGURE 5

Decomposing the gap in prevalence of low mental well-being between those who report being in material deprivation and those who do not using the Binder-Oaxaca methodology, persons aged 16+, Wales, 2016–17 to 2019–20.

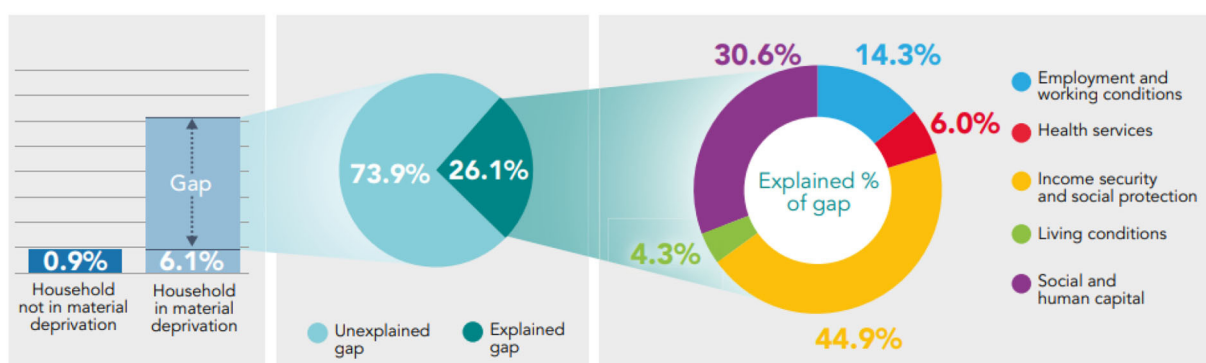


FIGURE 6

Decomposing the gap in prevalence of low life satisfaction between those who report being in material deprivation and those who do not using the Binder-Oaxaca methodology, persons aged 16+, Wales, 2016–17 to 2019–20.

Conditions accounts the least (4.3% of explained component;  $p = 0.5$ ) (Figure 6).

## The health gap between those who report a limiting long-standing illness, disability or infirmity and those who do not

Analysis shows that the prevalence of low mental well-being and low life satisfaction is significantly higher in those who report a limiting long-standing illness, disability or infirmity, compared to those who do not (Figures 7, 8). 4.8% of survey respondents who report a limiting long-standing illness, disability or infirmity report low life satisfaction, compared to 0.7% in respondents who do not, a significant difference of 4.1 percentage points. The prevalence of low mental well-being is also higher in those reporting a limiting long-standing illness, disability or infirmity (30.9%) compared to those not reporting (15.2%), a significant difference of 15.7 percentage points.

Exploring the health gap experienced between those who report a limiting long-standing illness, disability or infirmity and those who do not, shows that a large proportion of the gap in low mental well-being and low life satisfaction cannot be explained by the model: 66.2% of the gap observed in low mental well-being and 88% of the gap in low life satisfaction is unexplained by the model ( $p < 0.05$ ). Of the explained component, Social and Human Capital accounts the most for differences in health ( $p < 0.05$ ) (Figures 7, 8).

Decomposing the gap in low mental well-being shows that from the explained component, Social and Human Capital accounts the most for the difference in low mental well-being (57.1%;  $p < 0.05$ ), and Health Services accounts for the least, 1.3% ( $p = 0.3$ ) (Figure 7).

Of the small proportion of the health gap in low life satisfaction that can be explained (12%), Social and Human Capital and Income Security and Social Protection accounts the most for differences in health, 43.7% ( $p < 0.05$ ) and 24% ( $p < 0.05$ ), respectively. Health Services and Living Conditions accounts the least for differences in low life satisfaction, 8% ( $p = 0.103$ ) and 3.4% ( $p = 0.71$ ), respectively (Figure 8).

## Discussion

Exploring the persisting inequalities in Wales has revealed stark differences in health outcomes before COVID-19. Since the start of the pandemic there is growing evidence on the unequal impact COVID-19 has had on different population groups (9).

The persistent gaps and fragmentation in public health data and the need to invest in strong health information systems has been acknowledged by the WHO (24). Wales (and the wider UK) benefits from collecting robust data

on demographics, health outcomes and lots of the wider determinants (essential conditions) needed for health. This provides a data landscape comparatively richer than other countries in the WHO European Region.

The decomposition analysis has revealed what more can be done in the population health intelligence field to gain a deeper understanding to what is driving health inequity in Wales and beyond. It has quantified the health gaps that exist in Wales between population groups, whether the groups are defined financially (by their ability to make financial savings); materially (by whether they are materially deprived); or physically (by whether they have long-standing limiting illness, disability or infirmity). Reporting of negative health outcomes (fair/poor health, low mental well-being, and low life satisfaction) is found to be significantly higher in those who are disadvantaged.

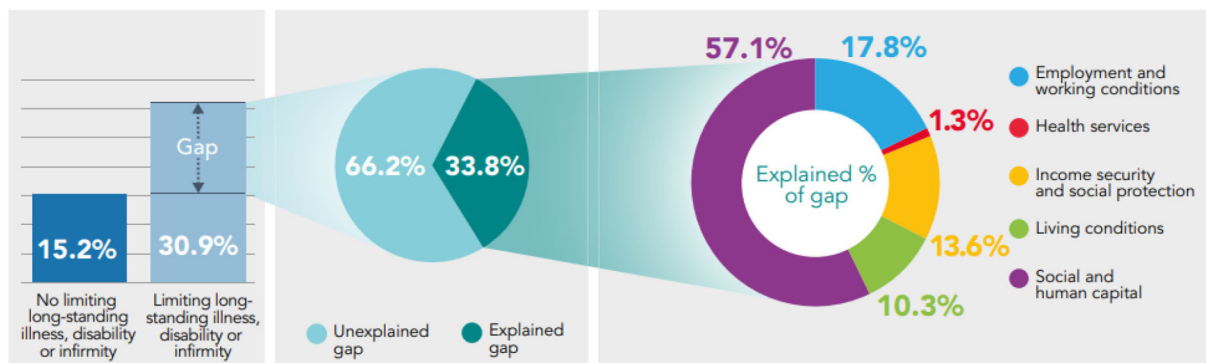
The applied decomposition analysis has not only quantified the health gap, but it has also generated a unique insight into the drivers (essential conditions) that contribute the most to the differences in health within defined population groups. This can allow policy and decision-makers to see the potential of applying this methodology further to identify policy areas most likely to influence the health gaps and reduce inequities in health.

The analysis uses the NSW which surveys Welsh residents aged 16+. This means that the health gaps measured are only representative of the Welsh adult population and do not capture how the wider determinants of health are associated with health outcomes in children aged <16.

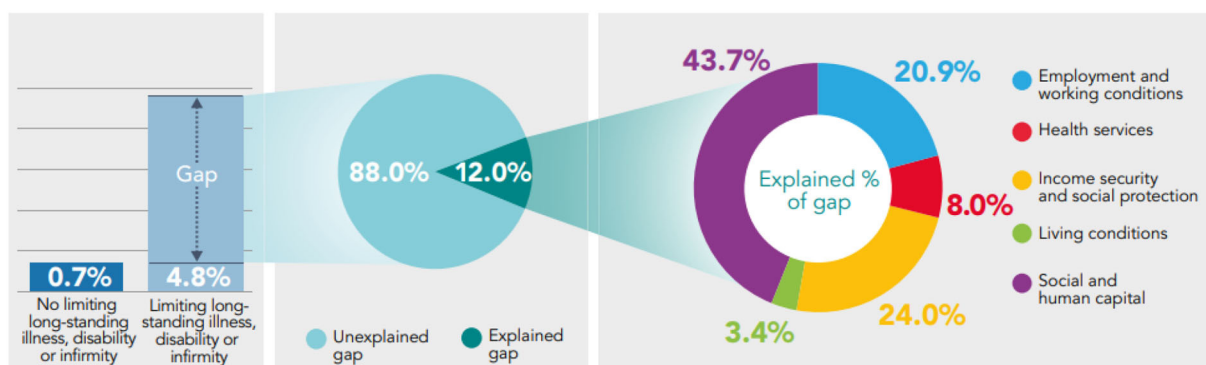
The study uses self-reported data meaning survey respondents may not provide answers that are accurate and may be more likely to give responses that are socially desirable. For some variables, recognized scales are used as a measurement tool e.g. well-being is measured using the Warwick-Edinburgh Mental Well-being Scale (WEMWBS). For other variables, Likert scales have been used, where the respondent is provided with five possible answers to a statement indicating positive-to-negative strength. However, problems with using self-reported health as a method of measurement remain, particularly in that its relative nature makes it susceptible to changing contexts. For example, a recent analysis from the Netherlands on self-reported health pre and post COVID-19 pandemic found improvements in the levels of reported health. However, without substantial improvements in the health services or general living conditions, these are theorized to be due to uninfected individuals evaluating their health more positively than under normal circumstances – partly through social comparison with infected individuals (25).

The analysis uses survey data ranging from 2016–17 to 2019–20, which means that any health gaps quantified have not taken into account the impact of the COVID-19 pandemic in exacerbating inequalities (26), which would likely impact the results of the analysis.

Variables measured using the NSW have been used as proxies for each of the essential conditions, which, taken in



**FIGURE 7**  
Decomposing the gap in prevalence of low mental well-being between those reporting a limiting long-standing illness, disability or infirmity, and those who do not using the Binder-Oaxaca methodology, persons aged 16+, Wales, 2016–17 to 2019–20.



**FIGURE 8**  
Decomposing the gap in prevalence of low life satisfaction between those reporting a limiting long-standing illness, disability or infirmity, and those who do not using the Binder-Oaxaca methodology, persons aged 16+, Wales, 2016–17 to 2019–20.

isolation are difficult to measure (e.g., there are limited variables within the NSW that align to Health Services). Mapping the variables to the essential conditions is detailed in the methods section and need to be considered when interpreting results; full details of coded variables and analytical values used are presented in [Supplementary Table 1](#).

It should be noted that although we used a systematic approach to categorize the available questions into those aligning to the five essential conditions to minimize bias, ultimately the decision is a subjective one based on our judgement, and the included variables, and associated results, should be considered in that context.

Data management and survey design means that the analyzed dataset considers the 4 years' worth of survey data as one time period, meaning a cross-sectional study design. This type of survey design limits the analysis to exploring strengths of associations between variables and no causality can be determined from the analysis.

The analysis reveals that there is variation in the extent to which “essential conditions” were represented in the survey. For example, there is significantly less variables aligning to Health Services compared to alignment to Social and Human Capital. This impacted our approach to analysis.

The data requirements of the methodology demand a large survey sample sizes and, in our experience, the inconsistency of survey questions over different years of survey data proves challenging. This has restricted what has been feasible in this exploratory analysis and it has limited the proxy variables chosen for each of the essential conditions.

In all scenarios, Social and Human Capital and Income Security and Social Protection account for the largest portions of differences in self-reported general health, mental well-being and life satisfaction. Health Services and Living Conditions are found to have a much smaller contribution. Our findings therefore align with long established linkages between income and health and well-being (27–30), and also

with continued contemporary trends in self-reported health across Europe surrounding income (18, 19) and in North America surrounding education (16, 31). In addition, our findings support empirically derived evidence indicating the significant impact education (32) and income (17, 33) have on general health. However, the work of Sinha et al. (34) indicates that there are potentially better indicators of poor health than income, and that tackling persistent deprivation in dimensions such as housing conditions and social isolation may be more fruitful.

While income has been highlighted as a key driver in health gaps and health inequity in some studies in Europe – including in Ireland (18) and Latvia (19) – the time period focus of these studies was in the wake of the Great Recession, and related more to the effects of economic downturn on health. In addition, an analysis of self-reported health across Europe (20) indicated that decreasing household income had little effect on self-reported health, while decreasing employment and transitions to economic inactivity had a significant impact. Our analysis focuses on a slightly different contextual outlook, particularly economically tumultuous time periods [2016–17 in the wake of the European Union (EU) referendum; and 2019–20 with the looming fallout of the COVID-19 pandemic] that were not *yet* characterized by economic downturn. Our analysis also offers a unique lens in terms of context, highlighting the driving factors in health gaps in self-reported health in a somewhat fragile, post-industrial economy in Western Europe.

This analysis has shown that the health services alone cannot address the health gap in Wales and other sectors play a greater role in tackling them. These findings are consistent with the wider evidence base showing that it is the wider determinants (referred to as essential conditions throughout this paper) that

exert the greatest impact on health and well-being. Studies have shown that only 20% of a person's health outcomes are attributed to access to good quality health care and have highlighted the crucial role of communities and local settings (35, 36).

It is also important to note that the health sector is delivering more than clinical services; it also delivers public health (prevention) services, as well as its strong links with the wider economic, social and environmental domains, such as education and employment, all of which are interconnected with population well-being and health equity.

The National Health Service (NHS), often referred to as an “anchor”, can go beyond direct healthcare and look to influence the wider determinants of health by purchasing locally for social benefit, use buildings and spaces to support communities, widen access to quality work, work more closely with partners and reduce its environmental impact (37, 38).

## Application for investment prioritization

Comparing government or local expenditure to the drivers of health inequity, can provide useful insights into where further resources and investment can be shifted and targeted to make the most difference.

Within the total identifiable expenditure in Wales (2019/20), the largest category is Social Protection which, when broken down further, covers expenditure on personal social services, unemployment benefits etc., accounting for 43% (£14.8 billion) of total expenditure in Wales. It is followed by the Health sector which accounts for 23% (£8.3 billion) of total expenditure.

Triangulation of the results from the decomposition analysis and Wales' expenditure data has the potential to reveal

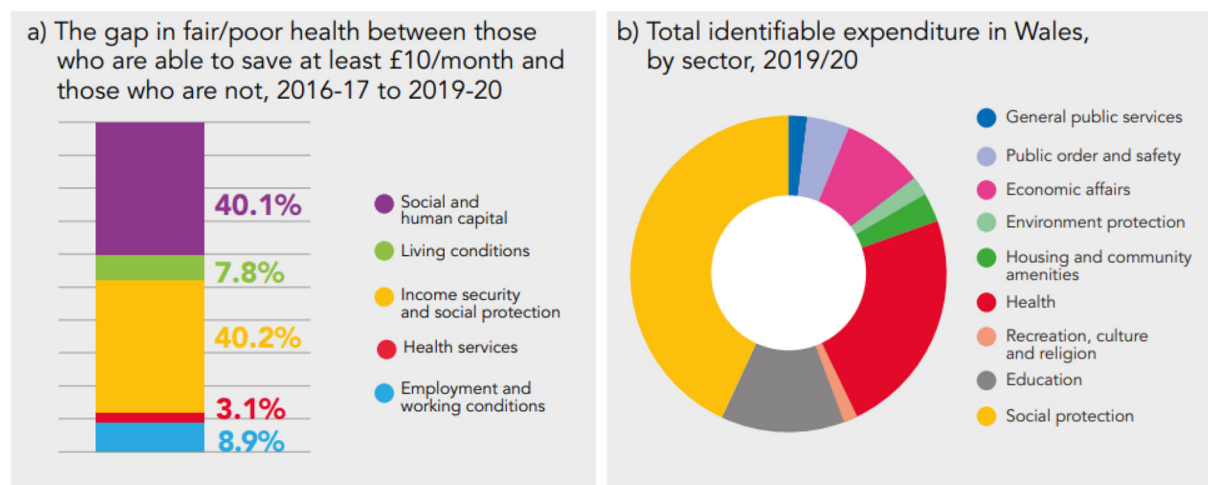


FIGURE 9  
Comparing findings from the decomposition of the health gap (a) to government expenditure data (b).

alignment or mismatch; and can provide a useful lever for informing and strengthening the case for investing in well-being and health equity (Figure 9). This analysis suggests that with a longer term view, health gaps can be tackled through greater investment in prevention and the wider determinants of health, rather than reactive investment in the provision of clinical (care) services (39).

This study has outlined the challenges and opportunities in applying the decomposition analysis method.

Further exploration, research, data gathering and analysis is needed, engaging with and involving relevant groups and communities, to understand the health gap and its drivers, for example:

- Exploring the application of the decomposition methodology to linked data to allow for stronger alignment between the WHO HESri framework and individual-level variables, particularly those that represent health services;
- Exploring other stratification factors, for example, those that capture deprivation, but are measured on an individual-level;
- Applying the methodology to longitudinal survey data (e.g., Understanding Society and the Millennium Cohort Study), to assess whether causality can be determined, and to what extent;
- Applying the methodology to a dataset that captures the impacts of COVID-19; and
- Using the methodology as part of a mixed methods study in a defined population group, combining the decomposition method to quantify and understand the health gap, and also using qualitative methods (such as in depth interviews) to further understand factors contributing to observed gaps

Application of the Decomposition Analysis across different countries, population groups, settings and health outcomes can develop the methodology further to help explain the health gap and its drivers better.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://beta.ukdataservice.ac.uk/datacatalogue/series/series?id=2000035>.

## Ethics statement

This is a secondary analysis of National Survey for Wales data which was accessed through the UK Data Service. Ethical review and approval was not required for the study on human participants in accordance with the local legislation and

institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

JA conceptualized and developed the manuscript. JA, AC-R, and OD performed the mapping of survey variables to WHO health equity framework. JA and OD performed data analysis and subsequent quality check. AC-R, MD, RM, and LM reviewed and contributed to the writing of the paper. Manuscript has been amended by JA following reviewer feedback. All authors contributed to the article and approved the submitted version.

## Funding

This study was supported by Public Health Wales.

## Acknowledgments

The analysis has benefitted from significant input from Lin Yang (WHO European Office for Investment for Health and Development) to whom we are very grateful. We are thankful for the support and extensive feedback, provided by the Welsh Health Equity Status Report initiative Joint Scientific and Advisory Group.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2022.1056885/full#supplementary-material>



## References

1. Healthy, Prosperous Lives for All: The European Health Equity Status Report (2019). WHO Regional Office for Europe. Available online at: <https://www.euro.who.int/en/publications/abstracts/health-equity-status-report-2019> (accessed January 24, 2022).
2. Institute of Medicine (US). *The Future of the Public's Health in the 21st Century*. Washington, DC: National Academies Press (2003), p. 509.
3. Marmot M. The health gap: Doctors and the social determinants of health. (2017). p. 686–93. Available online at: <http://journals.sagepub.com/doi/10.1177/1403494817717448> (accessed May 31, 2022).
4. Marmot Review. *Fair Society, Healthy Lives: The Marmot Review*. London: UCL (2010).
5. Tudor Hart J. *The Inverse Care Law*. (1971). Available online at: <https://linkinghub.elsevier.com/retrieve/pii/S014067367192410X> (accessed May 31, 2022).
6. Chief Medical Officer. *Annual Report 2021 to 2022. Welsh Government* (2022). Available online at: <https://gov.wales/chief-medical-officer-annual-report-2021-2022> (accessed July 1, 2022).
7. Life Expectancy and Mortality in Wales. *Public Health Wales*. (2020). Available online at: <https://phw.nhs.wales/services-and-teams/observatory/data-and-analysis/life-expectancy-and-mortality-in-wales-2020/> (accessed January 24, 2022).
8. Welsh Government. *A More Equal Wales: The Socio-Economic Duty*. Welsh Government (2020). Available online at: <https://gov.wales/more-equal-wales-socio-economic-duty> (accessed January 24, 2022).
9. Placing health equity at the heart of the COVID-19 sustainable response and recovery: Building prosperous lives for all in Wales. *Public Health Wales*. (2021). Available online at: <https://phwwhocc.co.uk/resources/welsh-health-equity-status-report-whesri/> (accessed January 24, 2022).
10. The Well-being of Future Generations. *Welsh Government* (2015). Available online at: <https://gov.wales/well-being-of-future-generations-wales> (accessed January 24, 2022).
11. *Socio-Economic Duty. An Overview*. Welsh Government (2020). Available online at: <https://gov.wales/socio-economic-duty-overview> (accessed January 24, 2022).
12. *A Healthier Wales: Our Plan for Health and Social Care*. Welsh Government (2021). Available online at: <https://gov.wales/sites/default/files/publications/2021-09/a-healthier-wales-our-plan-for-health-and-social-care.pdf> (accessed January 24, 2022).
13. Gustafsson PE, Linander I, Mosquera PA. Embodying pervasive discrimination: a decomposition of sexual orientation inequalities in health in a population-based cross-sectional study in Northern Sweden. *Int J Equity Health*. (2017) 16:22. doi: 10.1186/s12939-017-0522-1
14. Idler E, Cartwright K. What Do We Rate When We Rate Our Health? Decomposing age-related contributions to self-rated health. *J Health Soc Behav*. (2018) 59:74–93. doi: 10.1177/0022146517750137
15. Platt J, Prins S, Bates L, Keyes K. Unequal depression for equal work? How the wage gap explains gendered disparities in mood disorders. *Soc Sci Med*. (2016) 149:1–8. doi: 10.1016/j.socscimed.2015.11.056
16. Mueller JT. Decomposing differences in poor self-rated health between those in agriculture and natural resource occupations and the rest of the labor force. *J Agromedicine*. (2021) 26:109–19. doi: 10.1080/1059924X.2020.1713275
17. San Sebastian M, Hammarström A, Gustafsson PE. Socioeconomic inequalities in functional somatic symptoms by social and material conditions at four life course periods in Sweden: a decomposition analysis. *BMJ Open*. (2015) 5:e006581. doi: 10.1136/bmjopen-2014-006581
18. Mazeikaite G, O'Donoghue C, Sologon DM. The great recession, financial strain and self-assessed health in Ireland. *Eur J Health Econ*. (2019) 20:579–96. doi: 10.1007/s10198-018-1019-6
19. Berke-Berga A, Paul P, Valtonen H. Examining health inequalities in Latvia: a decade of association between socioeconomic position and perceived health status. *Biomed Res Int*. (2017) 2017:1–10. doi: 10.1155/2017/7541416
20. Brzezinski M. What accounts for the rise of low self-rated health during the recent economic crisis in Europe? *Int J Equity Health*. (2019) 18:21. doi: 10.1186/s12939-019-0926-1
21. Neumark D. *Employers' Discriminatory Behavior and the Estimation of Wage Discrimination*. (1988). Available online at: <https://www.jstor.org/stable/145830?origin=crossref> (accessed January 24, 2022).
22. Oaxaca RL, Ransom MR. *On Discrimination and the Decomposition of Wage Differentials*. (1994). Available online at: <https://linkinghub.elsevier.com/retrieve/pii/0304407694900744> (accessed January 24, 2022).
23. Rahimi E, Hashemi Nazari SS. *A Detailed Explanation and Graphical Representation of the Blinder-Oaxaca Decomposition Method With its Application in Health Inequalities* (2021). Available online at: <https://ete-online.biomedcentral.com/articles/10.1186/s12982-021-00100-9> (accessed January 24, 2022).
24. Data, Analytics and Delivery for Impact in Focus. *World Health Organization* (2021). Available online at: <https://www.who.int/publications/i/item/in-focus-2021> (accessed January 24, 2022).
25. Van de Weijer MP, Vries LP, Pelt DHM, Ligthart L, Willemsen G, Boomsma DI, et al. Self-rated health when population health is challenged by the COVID-19 pandemic; a longitudinal study. *Soc Sci Med*. (2022) 306:115156. doi: 10.1016/j.socscimed.2022.115156
26. Bambra C, Riordan R, Ford J, Matthews F. *The COVID-19 Pandemic and Health Inequalities*. (2020). Available online at: <https://jech.bmj.com/lookup/doi/10.1136/jech-2020-214401> (accessed February 8, 2022).
27. Mackenbach JP, Martikainen P, Looman CW, Dalstra JA, Kunst AE, Lahelma E. The shape of the relationship between income and self-assessed health: an international study. *Int J Epidemiol*. (2005) 34:286–93. doi: 10.1093/ije/dyh338
28. Doorslaer E. van, Koolman X. Explaining the differences in income-related health inequalities across European countries. *Health Econ*. (2004) 13:609–28. doi: 10.1002/hec.918
29. Berkman LF, Kawachi I, Glymour MM. *Income Inequality and Health in Social Epidemiology*. Oxford: Oxford University Press (2000), p. 349–67.
30. Kaplan GA. People and places: contrasting perspectives on the association between social class and health. *Int J Health Serv*. (1996) 26:507–19. doi: 10.2190/4CUU-7B3G-G4XR-OK0B
31. Veenstra G, Vanzella-Yang A. Does household income mediate the association between education and health in Canada? *Scand J Public Health*. (2021) 49:857–64. doi: 10.1177/1403494820917534
32. Veronesi G, Kee F, Hicks B, Forrest H, Tunstall-Pedoe H, Kuulasmaa K, et al. Decomposing the educational gradient in allostatic load across European populations. What matters the most: differentials in exposure or in susceptibility? *J Epidemiol Community Health*. (2020) 27:jech-2020-213946. doi: 10.1136/jech-2020-213946
33. Carrieri V, Jones AM. The income-health relationship 'beyond the mean': new evidence from biomarkers: the income-health relationship 'beyond the mean. *Health Econ*. (2017) 26:937–56. doi: 10.1002/hec.3372
34. Sinha K, Davillas A, Jones AM, Sharma A. Do socioeconomic health gradients persist over time and beyond income? A distributional analysis using UK biomarker data. *Econ Hum Biol*. (2021) 43:101036. doi: 10.1016/j.ehb.2021.101036
35. Remington PL, Catlin BB, Gennuso KP. *The County Health Rankings: Rationale and Methods*. (2015). Available online at: <https://pophealthmetrics.biomedcentral.com/articles/10.1186/s12963-015-0044-2> (accessed June 1, 2022).
36. Population Health and the Population Health Management Programme. *National Health Service* (2022). Available online at: <https://www.england.nhs.uk/integratedcare/what-is-integrated-care/phm/> (accessed January 24, 2022).
37. The NHS. *As an Anchor Institution*. The Health Foundation. (2022). Available online at: <https://www.health.org.uk/news-and-comment/charts-and-infographics/the-nhs-as-an-anchor-institution> (accessed January 24, 2022).
38. Anchor Institutions and How They Can Affect People's Health. *The King's Fund* (2021). Available online at: <https://www.kingsfund.org.uk/publications/anchor-institutions-and-peoples-health> (accessed January 24, 2022).
39. Masters R, Anwar E, Collins B, Cookson R, Capewell S. *Return on Investment of Public Health Interventions: A Systematic Review*. (2017). Available online at: <https://jech.bmj.com/lookup/doi/10.1136/jech-2016-208141> (accessed May 31, 2022).



## OPEN ACCESS

## EDITED BY

Rebecca Masters,  
Public Health Wales NHS Trust,  
United Kingdom

## REVIEWED BY

Wei-Chen Lee,  
University of Texas Medical Branch at  
Galveston, United States  
Barun Majumder,  
The University of Tennessee, Knoxville,  
United States  
Cate M. Bailey,  
Melbourne School of Population and  
Global Health, Australia

## \*CORRESPONDENCE

Rhiannon Tudor Edwards  
✉ r.t.edwards@bangor.ac.uk

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 02 September 2022

ACCEPTED 09 December 2022

PUBLISHED 23 December 2022

## CITATION

Edwards RT (2022) Well-being and  
well-becoming through the  
life-course in public health economics  
research and policy: A new  
infographic.  
*Front. Public Health* 10:1035260.  
doi: 10.3389/fpubh.2022.1035260

## COPYRIGHT

© 2022 Edwards. This is an  
open-access article distributed under  
the terms of the [Creative Commons  
Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use,  
distribution or reproduction in other  
forums is permitted, provided the  
original author(s) and the copyright  
owner(s) are credited and that the  
original publication in this journal is  
cited, in accordance with accepted  
academic practice. No use, distribution  
or reproduction is permitted which  
does not comply with these terms.

# Well-being and well-becoming through the life-course in public health economics research and policy: A new infographic

Rhiannon Tudor Edwards\*

Centre for Health Economics and Medicines Evaluation (CHEME), Bangor University, Bangor, Gwynedd, United Kingdom

**Background:** The term “well-becoming” is not new, but is not routinely used in our everyday language or in research in public health economics. It has been applied in early years research. Well-becoming can be thought of as our multitude of life-journeys toward meaning and purposefulness.

**Objective:** To develop a new infographic in the spirit of the Dahlgren and Whitehead rainbow infographic of social determinants of health. The purpose being to redefine well-being as a process of growth through life, articulated as well-becoming.

**Methods:** A rapid review of life-course stage appropriate models of well-being was undertaken with stages of the life-course as defined as: preconception and birth; early years; adolescence; working, parenting and caring; older age, and death. Infographics in this area were identified and the information above was used to design a new infographic with the concept of well-being and well-becoming at its center.

**Results:** A new infographic reflecting an underlying concept of “the wheel of life” is presented. It shows movement through the life-course at its center, with concentric rings summarizing personal, local, and national and global factors that have an impact on well-being and well-becoming of individuals through the life-course. Of note, is the inclusion of death, which is a topic often avoided. Prepared during 2021–22, the infographic reflects the role of pandemic and war within the national and global ring of influential factors. I reflect on three ways in which health economists are currently using a life-course approach and the concept of well-becoming in the economic evaluation of individual programs and at a population level of government policy.

**Conclusion:** Moving from solely focusing on a concept of well-being to a concept of well-being and well-becoming acknowledges the influence that socioeconomic and other conditions in a particular life-course stage have on subsequent life-course stages, and the cost-effectiveness of intervening across the life-course.

## KEYWORDS

public health, prevention, health economics, well-being, well-becoming, new infographic, life-course stages, economic evaluation

## Introduction

“Well-being” in the concept of population health can be thought of as “the balance point between an individual’s resource pool and the challenges faced” (1). The World Health Organization (WHO) has promoted the concept of well-being since 1948 (2). There is still little consensus as to how it should be measured across many academic disciplines, including health economics, and the term is often used interchangeably with terms like “happiness” and “health-related quality of life” (3). Notably, however, the HM Treasury Green Book, update in 2021, has introduced the use of well-being adjusted life years (WELLBYs) based on life satisfaction measurement (4). In psychology and behavioral economics research, there is a distinction made between hedonic well-being and eudaimonic well-being (5). The hedonic viewpoint is based on the notion that increased pleasure and avoidance of pain leads to happiness (6). The eudaimonic viewpoint is defined more broadly to incorporate dynamic processes such as self-actualisation and the degree to which a person is fully functioning in society. Well-being is often made up of multiple components and is normative or subjective.

“Well-becoming” can be thought of as “our multitude of life-journeys toward meaning and purposefulness, not some steady-state of managed contentment” (7). The term well-becoming is not new, but is not a term we routinely use in our everyday language or in research in public health and health economics. Where it has appeared, it has predominantly been in early years research (8, 9). In an education context it has been used to carefully distinguish between how we help children in “being well” in the present and in well-becoming in shaping their future “being” and hence opportunities. In the field of health economics, the only place we have found reference to it is in the development of capability measures through the life-course (10). In mainstream economics, the financial benefits of investing in well-becoming are found in the work of James Heckman, a Chicago Nobel Prize-winning economist (11). Heckman demonstrated the life-time benefits of investing in high-quality pre-school care and the mitigating influence this can have on those with the worst start in life. Heckman has revised downwards some of his original estimates, but his arguments are still very powerful. Well-becoming is based on the concept of assets-based public health, which is concerned with identifying protective factors that support health and well-being (12).

Most references to the term “well-becoming” appear in research surrounding child development, for example, “in contrast to the immediacy of well-being, well-becoming describes a future focus (i.e., preparing children to be productive and happy adults, and to avoid social exclusion)” (13). Biggeri and Santi (14) discuss the concept of well-becoming in terms of system change in education to promote flourishing through a capability

model aimed to support creativity, critical thinking and care.

It has been argued that concern for well-becoming should also be a concern for future generations (15). This links the concern for well-being with the concern for sustainable development and sustainable living (15). For policy makers and public health economists here in the UK, this attunes closely to the Well-being of Future Generations Act passed in Wales (16). In a later paper, Falkenberg (17) introduces the WB2-Framework for well-being and well-becoming. Falkenberg posits five components of well-being and well-becoming in an educational setting. These five components are: (1) Having Agentic Capabilities Linked to Human Needs; (2) Experiencing Situational Opportunities to Engage One’s Agentic Capabilities; (3) Enjoying Life; (4) Living a Meaningful Life, and (5) Experiencing Personal and Communal Connections that Contribute to One’s Well-being and Well-Becoming. Agentic refers to an individual’s power to control his or her own goals, actions and destiny. In the US in 2021, the Youth Transition Funders Group made recommendations for investing in the well-being and well-becoming of America’s young people (defined as the onset of puberty to the mid-20s) (18). They refer to well-being and well-becoming of young people in an equitable, inclusive, and holistic (whole person, whole life) context and offer a series of recommendations to transform public systems and communities to nurture and enhance lifelong well-being for vulnerable young people as they make the transition into adulthood. Again, from a UK public health economics perspective, this echoes emerging work on adverse childhood experiences and their life-time costs (19). The ethos of health economics is predicated on a societal goal of health gain, which implies health gain or reducing health losses from where we are now. In the same way, the concept of well-becoming is predicated on a goal of improving well-being (or minimizing potential well-being losses) in future life-course stages.

This paper presents a new infographic explaining the concept of well-becoming for the purpose of health economics research and policy support, within a life-course model. This new infographic builds on the much-loved Dahlgren-Whitehead (20) rainbow model of determinants of health. This paper moves on to present three ways in which health economists are currently taking a life-course approach to economic evaluation. First, the paper acknowledges that health economists have taken a life-time horizon in technical guidance produced by the National Institute for Health and Care Excellence (NICE) which calculates the absolute impact of an intervention across the life-course, but not necessarily the granular impact of different life-course stages (21). Second, the paper contrasts this with advances in the capability paradigm, based on Sen’s contribution in development economics (22). The capability movement in health economics is producing life-course stage specific measures focusing on capabilities rather than quality-adjusted life years (QALYs) (10). Third, the paper illustrates

calculation of costs of “late intervention” with case a study relating to dementia costs.

The paper sets out an agenda for research priorities in health economics to further the use of a well-becoming lens in the use of evidence in public policy. First, the use of differing time-horizons in economic evaluation of interventions to promote well-becoming needs to be routine. Second, there is a need for the acknowledgment of the need for intersectoral transfers where certain sectors pay to initiate well-becoming and others reap the financial benefits across the life-course. Finally, there is a need to explore how “money” can be put to work within the economy as a lever to engage effective and cost-effective interventions to promote well-being and well-becoming.

## Methods

Scoping reviews are used to identify knowledge gaps, set research agendas, and identify implications for decision-making (23). Using a scoping review methodology spanning the last 20 years), I reviewed models of the basic needs we all share across the life-course and how they constitute the wider determinants of our health, well-being and well-becoming. Based on this review, a new infographic was developed, as shown in Figure 1.

The new well-being and well-becoming wheel infographic was piloted with health economists working at the Center for Health Economics and Medicines Evaluation (CHEME) at Bangor University during 2022. The infographic is being translated into Welsh as it has been developed in a bilingual country.

## Results

### Development of a new infographic

In synthesizing the findings of the scoping review, I started with two overarching conceptual models and associated infographics. These were Maslow's (24) hierarchy of needs and the Dahlgren-Whitehead (20) rainbow model of health determinants. These appear as very static representations of human need and the wider determinants of health. They do not show any movement through the life-course. There seemed a need for a new infographic given the direction of many government policies increasingly taking a life-course approach to promoting well-being at local and national level. In 2018, The Health Foundation put forward a “road map” of what makes us healthy, referring to factors such as good work; our surroundings; money and resources; housing; education and skills; the food we eat; transport, and family, friends and communities (25). This model helped shape the red inner ring of the new infographic shown in Figure 1.

A number of models of the factors that influence well-being have been put forward, which are life-course stage specific.

For example, UNICEF (26) identified six dimensions of child well-being, which are: material well-being; health and safety; educational well-being; family and peer relationships; behaviors and risks, and subjective well-being. An example of a model of well-being in adolescence was put forward by Ross et al. (27). This model is made up of five domains, which are: good health and optimum nutrition; connectedness, positive values, and contribution to society; safety and a supportive environment; learning, competence, education, skills, and employability, and agency and resilience. A model of factors determining well-being in the workplace was put forward by the Chartered Institute of Personnel and Development (28). These factors span: pay and benefits; contracts; work-life balance; job design and the nature of work; relationships at work; employee voice, and health and well-being. With respect to promoting well-being in older age, the World Health Organization (29) put forward a model of factors necessary for age-friendly living. These span: housing; social participation; respect and social inclusion; civic participation and employment; communication and information; community support and health services; outdoor spaces and buildings, and transportation. Many of these factors are represented in the second concentric ring on the new infographic, labeled as local factors. A recent model of factors that can influence what might be considered a good death is offered by Campbell (30). This includes: place of death; one's company in death; cause of death, and one's manner of facing death.

Figure 1 shows the new infographic entitled “The well-being and well-becoming wheel”. This infographic reflects an underlying concept of “the wheel of life”. The wheel of life is a cyclic representation of life found on the walls of Tibetan Buddhist temples and monasteries (31). The infographic shows movement through the life-course at its center, with concentric rings summarizing personal, local, and national and global factors that have an impact on well-being and well-becoming on individuals through the life-course. The choice of the life stages has come from a review of existing models in the literature (25–30).

Of note, is the inclusion of death, which is a topic often avoided in the discussion of life-course stages (32). Prepared during 2021–22, the infographic reflects the role of pandemic and war within the international and global ring of influential factors. The first concentric ring is red and reflects personal factors that determine or have an impact through the life-course on well-being and well-becoming. These are: employment and career; purpose and contribution; mental health; physical health; relationship and social connection; recreation and fun; education and growth; personal identity; financial stability, and home and work environment. Of note is the inclusion of “Purpose and Contribution” to reflect the work of Paul Dolan who describes happiness as experiences of pleasure and purpose over time (33). The second concentric ring is green and reflects local factors that determine or have an



## The Well-being & Well-becoming Wheel

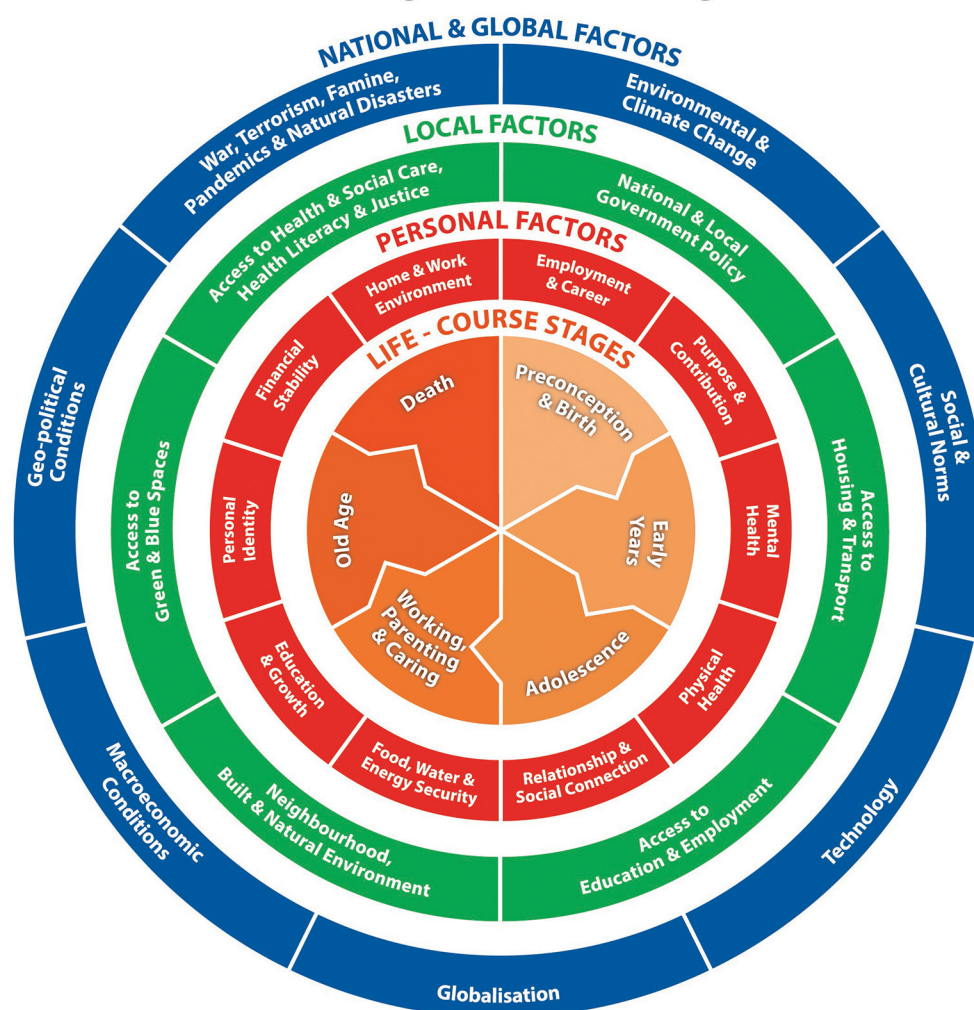


FIGURE 1  
The well-being and well-becoming wheel.

impact on well-being and well-becoming through the life-course. These are: national and local government policy; access to housing and transport; access to education and employment; neighborhood, built and natural environment; access to green and blue spaces; access to health and social care, health literacy and justice. Neighborhoods are explicitly mentioned to reflect the emphasis placed on neighborhood environments as key determinants of the health and life expectancy gradient by Michael Marmot in “The Marmot Review” and “The Marmot Review 10 Years On” reports (34, 35). The third concentric ring is blue and reflects national and global factors that determine or have an impact on well-being and well-becoming through the life-course. These are: environmental change (e.g., climate change); social and cultural norms; technology; globalization; macroeconomic conditions; geo-political conditions, and war, terrorism, famine, pandemics and natural disasters.

### Example of a life-course stage approach to public health prevention—dementia

Livingston et al. (36) in a Lancet Commission report set out 12 potentially modifiable risk factors for dementia. I use this as an example for taking a life-course approach to public health policy for a specific condition. Table 1 shows what percentage of prevalence of dementia could be reduced by eliminating 12 risk factors across the life-course. These are: limited or less education; hearing loss; traumatic brain injury; hypertension; alcohol (>21 units per week); obesity; smoking; depression; social isolation; physical inactivity; air pollution, and diabetes. This report used three life-course stages and relates the above risk factors to life, midlife, and later life. Overall, Livingston et al. conclude that 40% of risk factors may be modifiable earlier in the life-course, while 60% are at present unknown.



**TABLE 1** Modifiable risk factors for dementia by life stage [adapted from Livingston et al. (36)].

Life stage	Risk factor	Percentage reduction in dementia prevalence if risk factor is eliminated (%)
Early life	Less education	7
Midlife	Hearing loss	8
	Traumatic brain injury	3
	Hypertension	2
	Alcohol >21 units per week	1
	Obesity	1
Later life	Smoking	5
	Depression	4
	Social isolation	4
	Physical inactivity	2
	Air pollution	2
	Diabetes	1
Sum of potentially modifiable risk factors		40
Unknown risk factors		60

## Current use of a life-course approach to well-being and well-becoming in health economics

Health economics has evolved over the last 60 years within a medical, evidence-based model of health. Within this medical model of health, NICE has promoted use of a lifetime horizon in health technology assessment in its reference case for the evaluation of cost-effectiveness (21). Most economic evaluation studies are of single interventions which form part of pathways of care for patients and are treatment or cure focused. The application of health economics to public health requires a far more broad perspective of analysis with which to view costs and outcomes, and a far more diverse toolbox of methods of analysis spanning cost benefit analysis and social return on investment analysis through to econometric modeling at a population level. Hence, just as there has been a move to a more socioeconomic conceptualization of health, I am amongst other health economists who have aligned themselves with such a paradigm shift in health economics. This has been in terms of public health economics (37) and in terms of addressing equity considerations in cost-effectiveness analysis (38).

As a challenge to the QALY used by NICE, there is a programme of work developing in the capability paradigm of outcome measurement in health economics. This centers

around a framework based on conceiving capabilities as evolving across the life-course (10). Concerning children and young people, the term well-being capability is used. There is definitely a synergy of ideas evolving and the need for expanding the evaluative space beyond health functioning toward broader capabilities is very relevant to my understanding of well-being and well-becoming. The capability movement in outcome measurement in health economics is addressing the challenge of measuring outcomes within a life-course model. This approach allows for the development of an economic evaluation framework that places different capabilities at the center of attention depending on where an individual is at in their life-course trajectory (10). A recent paper by Deidda et al. (39) is a good example of a cost-effectiveness analysis of a public health prevention intervention which used both QALYs and well-being capabilities in the area of reducing sedentary behavior across four European countries. It is still useful to have evidence of the cost per QALY of preventative interventions as this allows for comparison with the cost per QALY of new medicines routinely funded by the NHS. It has been estimated that 80 percent of chronic health problems, such as premature heart disease, stroke and diabetes, are preventable (40).

A life-course approach to dynamic microsimulation modeling can support long-term thinking in the development and evaluation of government policy particularly with respect to the early years. Skarda et al. (41) present such an example of a dynamic microsimulation model for childhood policy analysis that models developmental, economic, social and health outcomes from birth to death for each child in the Millennium Cohort Study (MCS) in England, together with public costs and a summary well-being measure. The model draws on observational data from the MCS focusing on health, conduct disorder, mortality, health-related quality of life, public costs and a general well-being metric. The paper includes a discussion of the shortcomings of unweighted benefit cost analysis and alternatives including utilitarian and prioritarian approaches to economic evaluation based on explicitly individual well-being and social welfare functions (38).

It may be that it is not single cost-effectiveness studies that have the biggest impact on shifting emphasis from “cure to prevention”, but rather the availability of a growing body of evidence on cost-effectiveness and return on investment that effectively shifts thinking in political circles toward a longer time horizon for policy. This was perhaps encapsulated as far back as 1977 when Weiss (42), an American scholar of education and policy analysis, wrote: “the major use of social research is not the application of specific data to specific decisions. Rather, government decision makers tend to use research indirectly, as a source of ideas, information, and orientations to the world. Although the process is not easily discernible, over time it may have profound effects on policy. Even research that challenges

current values and political feasibilities is judged useful by decision makers.”

Another approach in health economics which could be characterized by a life-course approach is the calculation of costs of the “late intervention” in childhood problems. Chowdry and Fitzsimmons (43) estimated the financial sum spent at local authority level across England and Wales as a result of late intervention in early childhood problems. Of the total annual spend of £16.6 billion in 2016–17 prices, £6.4 billion was spent by local government (39%), £3.7 billion was spent by the NHS (22%); £2.7 billion was spent by the Department for Work and Pensions (16%); £1.6 billion was spent by the police (10%), £1.5 billion was spent by the criminal justice system (9%), and £655 million was spent by education (4%).

## Discussion

Michael Marmot has argued that: “Given the attack on science by politicians of bad faith, it is important to recognize that epidemiology and public health have a crucial role to play in providing evidence to improve health of society and reduce inequalities” (44). This paper began by presenting a working definition of well-being and well-becoming. The concept of well-becoming is not new, but it is not a word we use very frequently in discussions about public health and health economics. It embodies the concept of “flow” and “growth” through the life-course. Obviously, trajectories through the life-course are not always positive and can fluctuate. However, these concepts support the design and development of public health policy and the way we go about economic evaluation of such policies by providing a dynamic lens, rather than a static lens, and inherently changing our time horizon and perhaps our time preference in tackling health and social problems.

I have not found any examples of publications that, prior to this paper, examine side-by-side models of the determinants of well-being at different life-course stages. This was done as a precursor to the design of the new well-being and well-becoming infographic, presented here in Figure 1. At the time of writing, world leaders were meeting at COP27 and I came across, late in the day, an infographic known as Doughnut Economics, a model of human well-being which recognizes that well-being depends on enabling every person to lead a life of dignity and opportunity, while safeguarding the integrity of Earth’s life-supporting systems (45). In some senses, the infographic developed here for the field of health economics complements the work of Raworth (45).

This new Well-being and Well-becoming Wheel infographic does not attempt to convey directions for causality or feedback loops whilst it recognizes that these are complex and many. Neither does it attempt to convey the fact that the central life-course stages can sometimes be overlapping and are very

different from individual to individual. Instead, it attempts to convey the concept of flow, growth and well-becoming through life as a basis for how we approach the design of public health interventions, evaluate their effectiveness and cost-effectiveness, and set overarching priorities for public spending (37).

In the evaluation of specific diagnostic and therapeutic interventions, using the NICE (21) reference case, health economists are using a life-course approach in terms of time horizon, but arguably not in terms of a wider life-course trajectory context. In addition to this, some health economists are developing capabilities-based outcome measures as a challenge to the QALY paradigm. Health economists taking a life-course approach in population level econometric modeling of government policy. And health economists are beginning to quantify the cost of late intervention.

This infographic has been prepared as part of a new book exploring the health economics of well-being and well-becoming through the life-course to be published by Oxford University Press in 2023. The book argues that with an agenda for research priorities in health economics to further the use of a well-becoming lens in the use of evidence in public policy. These priorities include use of differing time-horizons in economic evaluation of interventions to promote well-becoming; acknowledgment of the need for intersectoral transfers where certain sectors pay to initiate well-becoming and others reap the financial benefits across the life-course, and finally, how “money” can be put to work within the economy as a lever to engage effective and cost-effective interventions to promote well-being and well-becoming in society.

## Conclusion

Health economists in the field of public health have a crucial role given the relatively short time-horizon of politics and local planning to provide evidence of both short term and longer term costs and outcomes of using resources in different ways to address population health priorities (37). A life-course lens on well-being and well-becoming applied to health economics research routinely may in time help to shift the focus of policy further toward commitment to a prevention agenda. This is the first time that this new well-being and well-becoming infographic has been published and it is hoped that it can be a useful addition to emerging debate.

## Author contributions

RTE conceived this paper, undertook the research, and the infographic was her idea.

## Funding

The time involved to develop this paper and infographic is funded by Health and Care Economics Cymru. Health and Care Economics Cymru was funded by Welsh Government through Health and Care Research Wales.

## Acknowledgments

Thanks to Dr. Holly Whiteley and Kalpa Pisavadia at the Center for Health Economics and Medicines Evaluation (CHEME) at Bangor University for discussing with me early drafts of the infographic. Thanks to Tom Pollock of Excellent Design for producing the infographic. Thanks to Dr. Catherine Lawrence for providing reader support.

## References

- Dodge R, Daly A, Huyton J, Sanders L. The challenge of defining well-being. *Int J Well-being*. (2012) 2:222–35. doi: 10.5502/ijw.v2i3.4
- Almond D, Currie J. Human capital development before age five. *Handbook Labor Econ*. (2011) 1:1315–486. doi: 10.1016/S0169-7218(11)02413-0
- Medvedev ON, Landhuis CE. Exploring constructs of well-being, happiness and quality of life. *PeerJ*. (2018) 6:e4903. doi: 10.7717/peerj.4903
- HM Treasury. *Wellbeing Guidance for Appraisal: Supplementary Green Book Guidance*. (2021). Available online at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/1005388/Wellbeing\\_guidance\\_for\\_appraisal\\_-\\_supplementary\\_green\\_book\\_guidance.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005388/Wellbeing_guidance_for_appraisal_-_supplementary_green_book_guidance.pdf) (accessed October 26, 2022).
- Ryan RM, Deci EL. On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annu Rev Psychol*. (2001) 52:141. doi: 10.1146/annurev.psych.52.1.141
- Kahneman D, Diener E, Schwarz N. *Well-being: Foundations of Hedonic Psychology*. New York, NY: Russell Sage Foundation (1999).
- Kane P. *Not Well-being, but Well-becoming*. London: The Guardian (2007).
- Cassidy C. Well-being, being well or well becoming: who or what is it for and how might we get there?. In: *Well-being, Education and Contemporary Schooling*. Milton Park: Routledge (2017). p. 13–26. doi: 10.4324/9781315618593-2
- Nsamenang AB. Fathers, families, and children's well-becoming in Africa. In: Lamb MA, editor. *The Role of the Father in Child Development*. John Wiley & Sons, Inc (2010). p. 388–412.
- Mitchell PM, Husband S, Byford S, Kinghorn P, Bailey C, Peters TJ, et al. Challenges in developing capability measures for children and young people for use in the economic evaluation of health and care interventions. *Health Econ*. (2021) 30:1990–2003. doi: 10.1002/hec.4363
- Heckman JJ. The case for investing in disadvantaged young children, CESifo DICE Report. *ifo Institut für Wirtschaftsforschung an der Universität München, München*. (2008) 6:3–8. Available online at: <https://www.econstor.eu/bitstream/10419/166932/1/ifo-dice-report-v06-y2008-i2-p03-08.pdf>
- Morgan A, Ziglio E. Revitalising the evidence base for public health: an assets model. *Promot Edu*. (2007) 14:17–22. doi: 10.1177/10253823070140020701x
- Ben-Arieh A, Frønes I. Taxonomy for child well-being indicators: A framework for the analysis of the well-being of children. *Childhood*. (2011) 18:460–76. doi: 10.1177/0907568211398159
- Biggeri M, Santi M. The missing dimensions of children's well-being and well-becoming in education systems: capabilities and philosophy for children. *J Hum Develop Capabil*. (2012) 13:373–95. doi: 10.1080/19452829.2012.694858
- Falkenberg T. *Opening Address at the Working Conference: "Understanding and Assessing Well-being and Well-becoming in Manitoba Schools"*. Manitoba: Faculty of Education, University of Manitoba (2015).
- Welsh Government. *Wellbeing of Future Generations Act (Wales)*. (2015). Available online at: <https://www.legislation.gov.uk/anaw/2015/2/contents> (accessed October 26, 2022).
- Falkenberg T. *Framing Human Well-being and Well-becoming: An Integrated Systems Approach*. Well-being and Well-becoming in Schools Research Initiative. Well-being in Schools Paper Series No. 2 (2019).
- Langford BH, Krauss SM, Legters L. *Investing in the Well-being and Well-becoming of America's Young People: Recommendations for Philanthropy, Policy, and Practice* (2021).
- Bellis MA, Hughes K, Ford K, Rodriguez GR, Sethi D, Passmore J. Life course health consequences and associated annual costs of adverse childhood experiences across Europe and North America: a systematic review and meta-analysis. *Lancet Public Health*. (2019) 4:e517–28. doi: 10.1016/S2468-2667(19)30145-8
- Dahlgren G, Whitehead M. *Levelling up (part 2): A Discussion Paper on European Strategies for Tackling Social Inequalities in Health* (No. EUR/06/5062295). Copenhagen: WHO Regional Office for Europe (2006).
- NICE. *sGuide to the Methods of Technology Appraisal*. (2013). Available online at: [www.nice.org.uk/process/pmg9](http://www.nice.org.uk/process/pmg9) (accessed October 26, 2022).
- Sen A. Equality of What? In: S. M. MacMurrin ed *The Tanner Lectures on Human Values*, vol. 4 (2nd ed.), Cambridge: Cambridge University Press (2010). p. 195–220.
- Tricco AC, Lillie E, Zarin W, O'Brien K, Colquhoun H, Kastner M, et al. A scoping review on the conduct and reporting of scoping reviews. *BMC Med Res Methodol*. (2016) 16:1–10. doi: 10.1186/s12874-016-0116-4
- Maslow AH. *A Theory of Human Motivation*. Hawthorne, CA: BN Publishing (2017).
- UNICEF. *Child Poverty in Perspective: An Overview of Child Wellbeing in Rich Countries. Innocenti Report Card 7*. Florence: UNICEF Innocenti Research Centre (2007).
- UNICEF. *An Overview of Child Well-being in Rich Countries: A Comprehensive Assessment of the Lives and Well-being of Children and Adolescents in the Economically Advanced Nations* (2007).
- Ross DA, Hinton R, Melles-Brewer M, Engel D, Zeck W, Fagan L. Adolescent well-being: a definition and conceptual framework. *J Adolescent Health*. (2020) 67:472–6. doi: 10.1016/j.jadohealth.2020.06.042
- Findlay P, Lindsay C, McIntyre S, Roy G, Stewart R, Dutton E. *CIPD Good Work Index 2021: UK Working Lives Survey* (2021).
- World Health Organization. *Health at Key Stages of Life: The Life-Course Approach to Public Health* (No. WHO/EURO: 2011-4335-44098-62200). (2011). World Health Organization. Regional Office for Europe.
- Campbell SM. Well-being and the good death. *Ethical Theory Moral Practice*. (2020) 23:607–23. doi: 10.1007/s10677-020-10101-3

## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

31. Dalai Lama XIV. *The Wheel of Life: Buddhist Perspectives on Cause and Effect*. (2015). New York, NY: Simon and Schuster.
32. Scobie S, Hutchings R. *End of Life Care Explained: What is it, How is it Provided, and What are the Challenges?* (2022). Available online at: <https://www.nuffieldtrust.org.uk/resource/end-of-life-care-explained-what-is-it-how-is-it-provided-and-what-are-the-challenge> (accessed October 26, 2022).
33. Dolan P. *Happiness by Design: Finding Pleasure and Purpose in Everyday Life*. Penguin, UK (2014).
34. Marmot M, Allen J, Goldblatt P, Boyce T, McNeish D, Grady M, Geddes I. *The Marmot Review: Fair society, Healthy Lives. Strategic Review of Health Inequalities in England Post-2010*. (2010). London: The Marmot Review.
35. Marmot M, Allen J, Boyce T, Goldblatt P, Morrison J. Health equity in England: the Marmot review 10 years on. *BMJ*. (2020) 30:368. doi: 10.1136/bmj.m693
36. Livingston G, Huntley J, Sommerlad A, Ames D, Ballard C, Banerjee S. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *Lancet*. (2020) 396:413–46. doi: 10.1016/S0140-6736(20)30367-6
37. Edwards RT, McIntosh E. *Applied Health Economics for Public Health Practice and Research*. Oxford: Oxford University Press (2019).
38. Cookson R, Griffin S, Norheim OF, Culyer AJ. *Distributional Cost-Effectiveness Analysis: Quantifying Health Equity Impacts and Trade-Offs*. Oxford: Oxford University Press (2020). doi: 10.1093/med/9780198838197.001.0001
39. Deidda M, Coll-Planas L, Tully MA, Giné-Garriga M, Kee F, Roqué i Figuls M. Cost-effectiveness of a programme to address sedentary behaviour in older adults: results from the SITLESS RCT. *Eur J Public Health*. (2022) 32:415–21. doi: 10.1093/eurpub/ckac017
40. World Health Organization. *Overview—Preventing Chronic Diseases: A Vital Investment*. Geneva: WHO (2020).
41. Skarda I, Asaria M, Cookson R. *LifeSim: A Lifecourse Dynamic Microsimulation Model of the Millennium Birth Cohort in England*. medRxiv (2021). doi: 10.1101/2021.02.12.21251642
42. Weiss CH. Research for policy's sake: The enlightenment function of social research. *Policy Anal*. (1977) 3:531–45.
43. Chowdry H, Fitzsimons P. *The Cost of Late Intervention: EIF Analysis 2016*. London: Early Intervention Foundation (2016).
44. Marmot M. Social justice, epidemiology and health inequalities. *Eur J Epidemiol*. (2017) 32:537–46. doi: 10.1007/s10654-017-0286-3
45. Raworth K. A doughnut for the anthropocene: humanity's compass in the 21st century. *Lancet Planetary Health*. (2017) 1:e48–9. doi: 10.1016/S2542-5196(17)30028-1



## OPEN ACCESS

## EDITED BY

Rebecca Masters,  
Public Health Wales NHS Trust,  
United Kingdom

## REVIEWED BY

Ewelina Chawłowska,  
Poznan University of Medical  
Sciences, Poland  
Enver Envi Roshi,  
University of Medicine, Tirana, Albania  
Haixia Liu,  
Binzhou Medical University, China

## \*CORRESPONDENCE

Da Feng  
✉ fengda@hust.edu.cn

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 18 September 2022

ACCEPTED 16 December 2022

PUBLISHED 11 January 2023

## CITATION

Zheng Z, Feng Z, Zhang D, Sun X,  
Dong D, Luo Y and Feng D (2023)  
Does self-medication reduce medical  
expenditure among the middle-aged  
and elderly population? A four-wave  
longitudinal study in China.  
*Front. Public Health* 10:1047710.  
doi: 10.3389/fpubh.2022.1047710

## COPYRIGHT

© 2023 Zheng, Feng, Zhang, Sun,  
Dong, Luo and Feng. This is an  
open-access article distributed under  
the terms of the [Creative Commons  
Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use,  
distribution or reproduction in other  
forums is permitted, provided the  
original author(s) and the copyright  
owner(s) are credited and that the  
original publication in this journal is  
cited, in accordance with accepted  
academic practice. No use, distribution  
or reproduction is permitted which  
does not comply with these terms.

# Does self-medication reduce medical expenditure among the middle-aged and elderly population? A four-wave longitudinal study in China

Zehao Zheng<sup>1</sup>, Zhanchun Feng<sup>2</sup>, Donglan Zhang<sup>3</sup>,  
Xiaobo Sun<sup>4</sup>, Dong Dong<sup>5</sup>, Youxi Luo<sup>6</sup> and Da Feng<sup>1\*</sup>

<sup>1</sup>School of Pharmacy, Tongji Medical College of Huazhong University of Science and Technology, Wuhan, China, <sup>2</sup>School of Medicine and Health Management, Tongji Medical College of Huazhong University of Science and Technology, Wuhan, China, <sup>3</sup>Division of Health Services Research, Department of Foundations of Medicine, New York University Long Island School of Medicine, Mineola, NY, United States, <sup>4</sup>School of Statistics and Mathematics, Zhongnan University of Economics and Law, Wuhan, China, <sup>5</sup>JC School of Public Health and Primary Care, The Chinese University of Hong Kong, Shatin, NT, Hong Kong SAR, China, <sup>6</sup>School of Science, Hubei University of Technology, Wuhan, China

**Introduction:** Self-medication has a high prevalence in the middle-aged and elderly population in China. Despite the published evidence demonstrating the economic benefits of self-medication, limited research has addressed the relationship between self-medication and individual medical expenditures, especially within the Chinese population. This study examined the effect of self-medication on individual medical expenditures in China and analyzed the heterogeneity between outpatient and inpatient cases.

**Methods:** We conducted a panel data analysis using data from four waves of the China Health and Retirement Longitudinal Study (CHARLS). Two-part mixed-effect models were implemented to estimate the effect of self-medication on total outpatient and inpatient expenses and out-of-pocket (OOP) costs, where mixed-effects logit regression was used as the first part, and generalized linear mixed models with log link and gamma distribution was used as the second part.

**Results:** We identified 72,041 responses representing 24,641 individuals, of which 13,185 responses incurred outpatient expenses and 9,003 responses incurred inpatient costs. Controlling for all covariates, we found that self-medication behaviors were significantly associated with a higher probability of outpatient service utilization (OR = 1.250, 95% CI = 0.179 to 0.269;  $P < 0.001$ ), but displayed no significant association with outpatient expenses. Respondents who had taken self-medication were less likely to use inpatient services (OR = 0.865, 95% CI = -0.201 to -0.089;  $P < 0.001$ ), and their inpatient expenses were significantly reduced by 9.4% ( $P < 0.001$ ). Inpatient OOP costs were significantly reduced by 10.7% ( $P < 0.001$ ), and outpatient OOP costs were significantly increased by 11.3% ( $P < 0.001$ ) among respondents who had self-medicated.



**Conclusions:** This study allowed us to identify the economic value of self-medication among the middle-aged and elderly population in China. Future work should guide the middle-aged and elderly to take responsible self-medication to reduce their economic burden.

#### KEYWORDS

self-medication, medical expenditure, middle-aged and elderly population, longitudinal study, two-part mixed-effect model, China

## 1. Introduction

As a global public health issue, self-medication has become part of the healthcare system. The World Health Organization (WHO) defines it as the “selection and use of [herbal or chemical] medicines by individuals to treat self-recognized illnesses or symptoms” (1). The World Self-Medication Industry (WSMI) emphasizes responsible self-medication, describing it as “the practice whereby individuals treat their ailments and conditions with medicines which are approved and available without prescription, and which are safe and effective when used as directed” (2). Self-medication has positive effects on both personal health and healthcare systems; thus, it has attracted widespread attention in recent years (3, 4). With the improvement of the population’s health literacy, self-medication has played an increasingly important role in the medical system.

Self-medication has become a common phenomenon that is widely practiced worldwide. As shown by previous studies, at least 43.8% of respondents self-medicated frequently in the United States (5), the prevalence of self-medication was approximately 25 % among older Europeans (6), and the prevalence rate in Spain was 12.7% (7). In developing countries, the prevalence of self-medication was 26.3% in Chile (8) and 76.3% in Brazil (9). Self-medication has a long history and a solid mass foundation in China (10). During the previous 12 months, 74.6% of respondents practiced self-medication (11). Furthermore, 45.4% of respondents would select self-medication if they felt physical discomfort during the 2 weeks preceding the survey, which was higher than the proportion who chose to “see the doctor” (12). Among the middle-aged and elderly people in China, the prevalence of self-medication during the previous month was 45.52% (13). Such a high prevalence has sparked a strong focus on self-medication among scholars.

Self-medication of middle-aged and elderly people shows particularity who seem to have a higher susceptibility to self-medicate (14). It is well established from a variety of studies that the elderly are the largest consumers of medicines in most countries (15, 16). The existing research recognizes that the elderly are one of the population groups with a higher prevalence of self-medication, resulting from a higher prevalence of diseases (17). On the one hand, age-related changes in pharmacokinetics and pharmacodynamics put the middle-aged and elderly at higher risk of medication than other age groups (18). On

the other hand, their choices of medication are prone to be influenced by the surrounding environment. A wide variety of pharmaceutical products on the market, and the extensive publicity surrounding these products, often target the middle-aged and elderly (19). In this context, irresponsible self-medication by middle-aged and elderly people frequently occurs, with harmful consequences. All of these make self-medication by the middle-aged and elderly extremely complicated, which deserves major attention.

It is worth noting that self-medication has potential risks if taken inappropriately. Without proper consultation from healthcare professionals, self-medication increases the risk of drug abuse (20), consumption of inappropriate medication (21), and adverse drug events (22). In the meantime, the high proportion of sales of antibiotics without a prescription in China has been reported in the body of literature (23). Self-medication has exacerbated the abuse of antibiotics, which contributes to the development of antibiotic resistance. Despite its negative effects, the advantages of self-medication, especially the economic benefits, have been widely recognized. With the rapid growth of medical expenses, cost containment has gradually become a consensus in the healthcare system (24, 25). Previous research has shown that self-medication plays an active role in decreasing healthcare costs (26). Self-medication reduces the burden on healthcare services caused by minor and trivial ailments, leaving doctors with more energy to deal with patients in need (27). Self-medication reduces the need for clinic visits, thereby enabling cost reductions, which is the major cause of self-medication among patients (4, 28). Time saving is another factor that motivates patients to self-medicate (29, 30). Patients avoid spending travel time to the hospital and waiting in line for medical services at clinics or physicians’ offices. Without a doubt, self-medication brings savings in costs and increased productivity (31). Studies have revealed that 45.5% of respondents performed self-medication to save money and 82% did so to save time (32).

Although many studies have explored the economic value of self-medication and affirmed its role in reducing medical expenditures (33–35), most quantitative studies concentrated on the national level or on certain diseases. Much of the research focused on the individual patient has been, up to now, descriptive in nature, and analyses of data about the savings in costs caused by self-medication from the perspective of patients

are limited. This study conducted a panel data analysis using data from the 2011, 2013, 2015, and 2018 waves of the China Health and Retirement Longitudinal Study (CHARLS), and examined the effect of self-medication on individual medical expenditures among the middle-aged and elderly population in China. The heterogeneity between outpatient and inpatient cases was also analyzed. Our study quantified the effect of self-medication on savings in the cost of healthcare and its reduced burden on healthcare services. Our work also filled the gaps in the research on the middle-aged and elderly population in China. In the meantime, the CHARLS provided longitudinal data that delivered more accurate estimates.

## 2. Materials and methods

### 2.1. Data source

Our work is a longitudinal study based on data from four waves of the China Health and Retirement Longitudinal Study (CHARLS), namely 2011, 2013, 2015, and 2018. The CHARLS is a national population-based survey that includes assessments of social, economic, and health circumstances of community residents. The CHARLS collects high-quality data through face-to-face interviews with a structured questionnaire. The project, using multistage stratified probability-proportionate-to-size sampling, selected a nationally representative sample of Chinese residents aged 45 years and older. The data were collected from 28 provinces, 150 counties/districts, and 450 villages/urban communities across the country. The total sample size of the CHARLS baseline survey in 2011 was 17,708 individual respondents. Around 70% of the original 2011 sample participated in the follow-up survey throughout the following waves, and the response rate was over 86% (36). Detailed descriptions of the survey design and procedures can be found in the original study documentation (37).

In this study, we included data from participants who had responded in “Module E: Health Care and Insurance”, and we excluded respondents who had missing values of dependent or independent variables. Respectively, 16,966, 16,946, 19,603, and 18,526 samples were included in Wave 1, 2, 3, and 4. In view of the statistical method used, the final analytical sample was not necessarily a balanced panel. A response from certain individuals might be excluded from our analyses while the rest of the responses from the same individuals might be included (38).

### 2.2. Study variables

#### 2.2.1. Self-medication

In the CHARLS Waves 1, 2, and 3, the question about self-medication was: “How did you treat yourself

during the past month?” The answer options included: (1) Consumed over-the-counter modern medicines; (2) Consumed prescription medicines; (3) Consumed traditional herbs or traditional medicines as treatment; (4) Consumed tonics/health supplements; (5) Used healthcare equipment; (6) Others; and (7) None. If the respondent chose consumed over-the-counter modern medicines, prescription medicines, or traditional herbs or traditional medicines as treatment, he was regarded as taking self-medication (13). In Wave 4, three types of medications were combined. The question about self-medication was: “Did you take any purchased medicine during the past month?” The respondents replied “Yes”, which indicated taking self-medication. These two definitions are consistent with the meaning of self-medication defined by the WHO (1).

#### 2.2.2. Dependent variables

In the CHARLS, medical expenditure was self-reported as the total amount paid during 1 month preceding the survey date for outpatients or 1 year preceding the survey date for inpatients. Participants were asked about their outpatient expenditure *via* the following question: “How much did all the visits to medical facilities cost during the last month? (Include self-paid part and reimbursement part)”. These medical facilities were reported by participants as places they had visited in the last 4 weeks for outpatient treatment. The self-paid part was asked separately and defined as outpatient out-of-pocket (OOP) costs. Inpatient expenditure was asked *via* the following question: “What was the medical cost for all the hospitalizations you received during the past year? (Only include fees paid to the hospital, including ward fees but excluding wages paid to a hired nurse, transportation costs, and accommodation costs for yourself or family members).” The self-paid part of inpatient expenditure was defined as inpatient OOP costs.

#### 2.2.3. Independent variables

We used Anderson’s behavior model to select independent variables, including predisposing factors, enabling factors, and need factors (39). The classifications of the categorical variables were informed by published evidence. Predisposing factors included age, gender, marital status (40) (married = married with spouse present/cohabitated, and unmarried = married but not living with spouse temporarily for reasons such as work/separated/divorced/widowed/never married), and education status (41) (primary school and below and secondary school and above). Enabling factors included residential area (42) (rural and urban), socioeconomic status quartiles [annual per capita household consumption expenditure (43)], region (east, west, and center), and medical insurance schemes. Need factors consisted of self-rated health (very good, good, fair, poor, and very poor) and number of chronic diseases. Different medical insurance schemes were considered in our study,

including Urban employee medical insurance (UEBMI), Urban resident medical insurance (URBMI), New rural cooperative medical insurance (NCMS), and Urban and rural resident medical insurance (URRBMI). Multiple/Other was indicated if the patient was a policyholder or primary beneficiary of more than one type of listed health insurance, or a policyholder or primary beneficiary of any insurance other than UEBMI, URBMI, NCMS, and URRBMI (44). Health behaviors such as smoking (yes and no) and drinking (often, sometimes, and never) were also considered.

## 2.3. Statistical analysis

Generally, medical expenditure is not normally distributed and shows more zero numbers. The two-part model (TPM) has been widely used for analyzing medical expenditure to address the problem of excess zeroes (45). The first part estimated the likelihood of an individual incurring any expenditure by a logit model. The second part was a generalized linear regression estimating medical expenditure among those with positive expenditure. The TPM with random effects could provide a method for analyzing repeated measurement data. Two-part mixed-effect models have been used to analyze longitudinal count data with excess zeros (46).

### 2.3.1. Part 1 – Selection equation: Mixed-effects logit regression

Selection equation, the first part of the two-part mixed-effect model, considered a binomial distribution – whether any medical expenditures were incurred ( $y > 0$ ) or not ( $y = 0$ ) – and implemented a mixed-effects logit regression to estimate the probability of medical service utilization. There is  $N$  number of participants, each of whom had multiple interviewed records. The probability function of medical service utilization was defined as:

$$\Pr(y_{ij} > 0 | x_{ij}, u_i) = G(x_{ij}\beta_{p1} + u_i + \varepsilon_{ij}) \quad (1)$$

Here,  $i = 1, \dots, N$  individuals, with the  $i$  individual having  $j = 1, \dots, n_i$  interviewed records. The outcome ( $y_{ij}$ ) was a binary response, where  $y_{ij} > 0$  if medical expenditure was positive, and  $y_{ij} = 0$  if otherwise. The outcome could be influenced by a set of fixed effects  $x_{ij}$  and random effects  $u_i$ .  $\beta_{p1}$  were their associated regression coefficients for the Part 1 model. Considering no random slope,  $u_i$  was the random intercept for each individual (47). For the logit regression, this function estimated the probability of ( $y_{ij} > 0$ ).

### 2.3.2. Part 2 – Regression equation: Mixed-effects linear model with log link and gamma distribution

Conditional to any medical expenditure incurred ( $y_{ij} > 0$ ), the intensity of medical expenditure could be fitted with a generalized linear mixed model (GLMM) called “regression equation”. The GLMM, an extension of the generalized linear model and mixed linear model, could process hierarchical data, making it suitable for the CHARLS database. Including random effects in the model addressed the problems of correlations, excessive dispersion, and heterogeneity among the data. The GLMM was also insensitive to missing data, which reduced the bias in the study’s outcomes caused by data missing from the CHARLS database. The estimated intensity of medical expenditure was defined as:

$$g[E(y_{ij})] = x_{ij}\beta_{p2} + U_i + v_{ij}, \quad y_{ij} > 0 \quad (2)$$

Here,  $i = 1, \dots, N$  individuals, with the  $i$  individual having  $j = 1, \dots, n_i$  interviewed records with positive expenditure. The outcome ( $y_{ij}$ ) represented medical expenditure of each individual.  $\beta_{p2}$  were the associated regression coefficients for the Part 2 model and  $x_{ij}$  were set as fixed effects. Without considering any random slopes,  $U_i$  indicated the random intercept for each individual (47). The generalized linear mixed model was specified as log link and gamma distribution, which are commonly used in econometric analyses of medical expenditure due to their asymptotic properties for non-negative outcomes (48).

## 2.4. Statistical software

All statistical calculations were carried out using the R software (version 4.1.2; R Development Core Team, URL <http://www.R-project.org>, 2021). Generalized linear mixed models were performed using the library “glmmTMB”. The optimizer was considered to adjust the model.

## 3. Results

### 3.1. Sample characteristics

We identified 72,041 responses representing 24,641 individuals in the unbalanced panel data, of which 13,185 responses incurred outpatient expenses and 9,003 responses incurred inpatient costs. A total of 9,338 eligible individuals had incurred outpatient costs 1 month before the interview, and they generated 1–4 responses among the four waves. Table 1 summarizes the demographics of the included outpatients in different years. The individuals were aged 59.73 years on average and consisted of 41.43% men and

TABLE 1 Demographic characteristics of outpatients ( $N = 13,185$ ).

Groups		2011 ( $N = 3,115$ )		2013 ( $N = 3,526$ )		2015 ( $N = 3,613$ )		2018 ( $N = 2,931$ )	
		<i>n</i> , %		<i>n</i> , %		<i>n</i> , %		<i>n</i> , %	
Self-medication	No	1,436	46.10	1,266	35.90	1,393	38.56	928	31.66
	Yes	1,679	53.90	2,260	64.10	2,220	61.44	2,003	68.34
Age	<45	75	2.41	88	2.50	184	5.09	40	1.36
	45~54	1,006	32.30	1,103	31.28	1,150	31.83	854	29.14
	55~64	1,151	36.95	1,287	36.50	1,189	32.91	937	31.97
	≥65	883	28.35	1,048	29.72	1,090	30.17	1,100	37.53
Gender	Female	1,829	58.72	2,082	59.05	2,094	57.96	1,718	58.61
	Male	1,286	41.28	1,444	40.95	1,519	42.04	1,213	41.39
Educational status	Middle	882	28.31	1,127	31.96	1,264	34.98	1,012	34.53
	Primary	2,233	71.69	2,399	68.04	2,349	65.02	1,919	65.47
Residential area	Rural	2,517	80.80	2,734	77.54	2,607	72.16	2,094	71.44
	Urban	598	19.20	792	22.46	1,006	27.84	837	28.56
Marital status	Married	2,699	86.65	3,060	86.78	3,178	87.96	2,496	85.16
	Unmarried	416	13.35	466	13.22	435	12.04	435	14.84
Region	East	1,016	32.62	1,080	30.63	1,178	32.60	936	31.93
	Mid	1,034	33.19	1,115	31.62	1,123	31.08	907	30.95
	West	1,065	34.19	1,331	37.75	1,312	36.31	1,088	37.12
Self-rated health	Very good	34	1.09	62	1.76	107	2.96	125	4.26
	Good	180	5.78	201	5.70	200	5.54	216	7.37
	Fair	739	23.72	919	26.06	983	27.21	1,321	45.07
	Poor	1,295	41.57	1,445	40.98	1,412	39.08	922	31.46
	Very poor	867	27.83	899	25.50	911	25.21	347	11.84
Number of chronic diseases	0	528	16.95	622	17.64	700	19.37	274	9.35
	1	858	27.54	926	26.26	787	21.78	492	16.79
	≥2	1,729	55.51	1,978	56.10	2,126	58.84	2,165	73.87
Medical insurance scheme	None	154	4.94	120	3.40	302	8.36	68	2.32
	NCMS	2,356	75.63	2,610	74.02	2,341	64.79	1,705	58.17
	UEBMI	289	9.28	415	11.77	386	10.68	320	10.92
	URBMI	121	3.88	171	4.85	132	3.65	112	3.82
	URRBMI	36	1.16	51	1.45	73	2.02	321	10.95
	Multiple/other	159	5.10	159	4.51	379	10.49	405	13.82
Smoke	No	2,360	75.76	2,529	71.72	2,828	78.27	2,340	79.84
	Yes	755	24.24	997	28.28	785	21.73	591	20.16
Drink	No	2,285	73.35	2,541	72.06	2,498	69.14	2,086	71.17
	Often	595	19.10	705	19.99	816	22.59	620	21.15
	Sometimes	235	7.54	280	7.94	299	8.28	225	7.68

58.57% women. Of these, 8,162 (61.90%) respondents had taken self-medication 1 month before the interview. Women (59.00%) had performed more self-medication, same as

the respondents that were married (87.18%), had attended primary school or below (66.93%), or were living in rural areas (74.78%).

TABLE 2 Demographic characteristics of inpatients ( $N = 9,003$ ).

Groups		2011 ( $N = 1,472$ )		2013 ( $N = 2,073$ )		2015 ( $N = 2,421$ )		2018 ( $N = 3,037$ )	
		<i>n</i> , %		<i>n</i> , %		<i>n</i> , %		<i>n</i> , %	
Self-medication	No	701	47.62	842	40.62	1,039	42.92	1,040	34.24
	Yes	771	52.38	1,231	59.38	1,382	57.08	1,997	65.76
Age	<45	20	1.36	30	1.45	76	3.14	24	0.79
	45~54	381	25.88	517	24.94	573	23.67	578	19.03
	55~64	531	36.07	785	37.87	787	32.51	897	29.54
	≥65	540	36.68	741	35.75	985	40.69	1,538	50.64
Gender	Female	754	51.22	1,076	51.91	1,274	52.62	1,579	51.99
	Male	718	48.78	997	48.09	1,147	47.38	1,458	48.01
Educational status	Middle	447	30.37	633	30.54	850	35.11	928	30.56
	Primary	1,025	69.63	1,440	69.46	1,571	64.89	2,109	69.44
Residential area	Rural	1,088	73.91	1,571	75.78	1,665	68.77	2,113	69.58
	Urban	384	26.09	502	24.22	756	31.23	924	30.42
Marital status	Married	1,277	86.75	1,790	86.35	2,097	86.62	2,484	81.79
	Unmarried	195	13.25	283	13.65	324	13.38	553	18.21
Region	East	398	27.04	564	27.21	698	28.83	788	25.95
	Mid	485	32.95	679	32.75	784	32.38	1,022	33.65
	West	589	40.01	830	40.04	939	38.79	1,227	40.40
Self-rated health	Very good	16	1.09	37	1.78	49	2.02	121	3.98
	Good	75	5.10	110	5.31	111	4.58	194	6.39
	Fair	283	19.23	477	23.01	554	22.88	1,177	38.76
	Poor	622	42.26	788	38.01	936	38.66	1,045	34.41
	Very poor	476	32.34	661	31.89	771	31.85	500	16.46
Number of chronic diseases	0	213	14.47	289	13.94	353	14.58	198	6.52
	1	333	22.62	472	22.77	466	19.25	412	13.57
	≥2	926	62.91	1,312	63.29	1,602	66.17	2,427	79.91
Medical insurance scheme	None	59	4.01	58	2.80	193	7.97	46	1.51
	NCMS	1,026	69.70	1,487	71.73	1,480	61.13	1,754	57.75
	UEBMI	206	13.99	289	13.94	311	12.85	386	12.71
	URBMI	73	4.96	95	4.58	122	5.04	126	4.15
	URRBMI	16	1.09	38	1.83	45	1.86	305	10.04
	Multiple/other	92	6.25	106	5.11	270	11.15	420	13.83
Smoke	No	1,112	75.54	1,473	71.06	1,915	79.10	2,417	79.59
	Yes	360	24.46	600	28.94	506	20.90	620	20.41
Drink	No	1,108	75.27	1,546	74.58	1,742	71.95	2,263	74.51
	Often	272	18.48	389	18.77	500	20.65	572	18.83
	Sometimes	92	6.25	138	6.66	179	7.39	202	6.65

Among the four waves, we identified 9,003 responses representing 6,861 individuals that had incurred inpatient

costs 1 year before the interview. [Table 2](#) summarizes the demographics of the included inpatients over the 4 years.



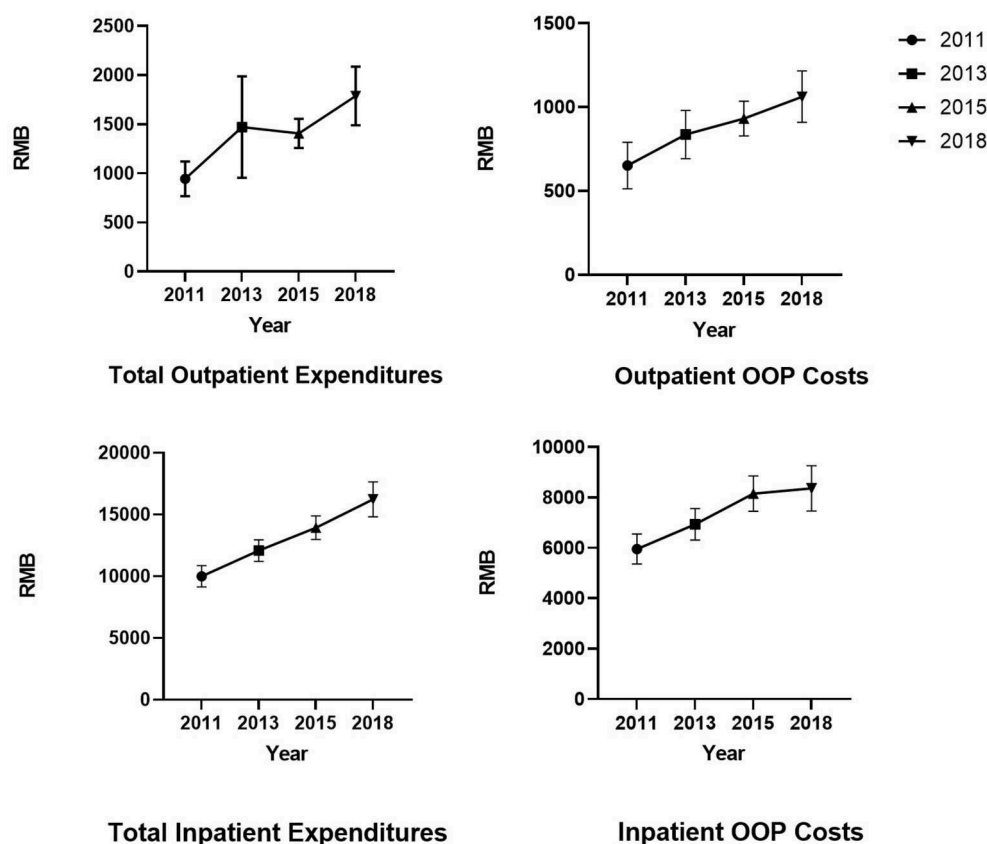


FIGURE 1  
The mean of total medical expenditures and out-of-pocket (OOP) costs.

The respondents were aged 62.66 years on average and consisted of 47.98% men and 52.02% women. Of these, 5,381 (59.77%) respondents had taken self-medication 1 month before the interview.

### 3.2. Descriptive statistics

Figure 1 reports the mean of total medical expenditures and out-of-pocket (OOP) expenditure in different groups. Costs were adjusted to 2018 RMB using the consumer price index. The mean of monthly total outpatient costs in 2011, 2013, 2015, and 2018 was ¥944.61, ¥1,471.71, ¥1,407.68, and ¥1,789.23, respectively. The mean of annual total inpatient costs in 2011, 2013, 2015, and 2018 was ¥9,991.01, ¥12,068.57, ¥13,932.96, and ¥16,227.11, respectively. Although we used CPI to eliminate the effect of inflation, medical expenditure showed an increasing trend over the years. Regarding self-medication, patients who self-medicated had lower inpatient expenditures and OOP costs for inpatient care.

### 3.3. Two-part mixed-effects models

To evaluate the impact of self-medication on medical expenditures, this study applied two-part mixed-effects models. Logit regression was used as the first part and a gamma distribution and log link were performed for the second part. Outpatient expenditures are presented in Table 3 and inpatient expenditures in Table 4.

The estimator showed that self-medication behaviors were significantly associated with a higher probability of outpatient service utilization (OR = 1.250, 95% CI = 0.179 to 0.269;  $P < 0.001$ ), but displayed no significant association with outpatient expenses ( $P = 0.087$ ). Respondents who took self-medication were less likely to use inpatient services (OR = 0.865, 95% CI = -0.201 to -0.089;  $P < 0.001$ ), and their inpatient expenses were significantly reduced by 9.4% ( $P < 0.001$ ). The second part indicated a significant increase in healthcare expenditures with increasing age ( $P < 0.001$ ;  $P = 0.018$ ). Women had lower total medical expenditures compared with men ( $P < 0.001$ ). Respondents living in

TABLE 3 Parameter estimates from two-part mixed-effects model on outpatient expenditures.

Independent variable	First part				Second part			
	Estimate	S.E.	OR (95%CI)	P	Estimate	S.E.	Exp ( $\beta$ )	P
Self-medication	0.223	0.024	1.250 (1.194, 1.309)	<0.001	0.05	0.029	1.051	0.087
Age	−0.004	0.001	0.996 (0.994, 0.999)	0.003	0.007	0.002	1.007	<0.001
Gender	−0.094	0.032	0.910 (0.856, 0.968)	0.003	0.262	0.04	1.300	<0.001
Educational status	0.002	0.026	1.002 (0.952, 1.054)	0.945	−0.016	0.032	0.984	0.62
Residential area	−0.147	0.034	0.863 (0.808, 0.922)	<0.001	0.235	0.043	1.264	<0.001
Marital status	0.015	0.035	1.015 (0.947, 1.087)	0.675	−0.126	0.043	0.882	0.004
<b>Region (Ref: East)</b>								
Mid	−0.068	0.031	0.934 (0.879, 0.993)	0.028	−0.09	0.04	0.914	0.025
West	0.028	0.031	1.029 (0.969, 1.092)	0.352	−0.124	0.039	0.884	0.002
<b>Self-rated health (Ref: Fair)</b>								
Very good	−0.739	0.064	0.477 (0.421, 0.542)	<0.001	−0.109	0.092	0.897	0.237
Good	−0.493	0.045	0.611 (0.559, 0.667)	<0.001	−0.076	0.062	0.926	0.217
Poor	0.340	0.027	1.406 (1.333, 1.483)	<0.001	0.203	0.034	1.225	<0.001
Very poor	0.705	0.035	2.024 (1.891, 2.166)	<0.001	0.551	0.041	1.735	<0.001
Number of chronic diseases	0.206	0.008	1.228 (1.210, 1.247)	<0.001	0.085	0.009	1.089	<0.001
Per capita household expense	0.130	0.012	1.138 (1.112, 1.166)	<0.001	0.231	0.015	1.260	<0.001
<b>Medical insurance scheme (Ref: None)</b>								
NCMS	0.272	0.051	1.312 (1.187, 1.450)	<0.001	0.003	0.065	1.003	0.969
UEBMI	0.313	0.063	1.368 (1.209, 1.547)	<0.001	0.306	0.08	1.358	<0.001
URBMI	0.161	0.076	1.174 (1.011, 1.364)	0.035	0.212	0.096	1.236	0.027
URRBMI	0.248	0.077	1.281 (1.103, 1.489)	0.001	−0.011	0.096	0.989	0.905
Multiple/other	0.393	0.063	1.481 (1.308, 1.677)	<0.001	0.152	0.079	1.164	0.055
Smoke	−0.271	0.033	0.762 (0.715, 0.813)	<0.001	−0.277	0.041	0.758	<0.001
<b>Drink (Ref: No)</b>								
Often	−0.151	0.032	0.860 (0.807, 0.916)	<0.001	−0.291	0.041	0.747	<0.001
Sometimes	−0.015	0.043	0.985 (0.906, 1.071)	0.724	−0.166	0.052	0.847	0.002
<b>Year (Ref: 2011)</b>								
2013	0.121	0.031	1.129 (1.063, 1.198)	<0.001	0.251	0.036	1.285	<0.001
2015	−0.068	0.030	0.934 (0.880, 0.992)	0.026	0.342	0.037	1.408	<0.001
2018	−0.361	0.035	0.697 (0.650, 0.746)	<0.001	0.495	0.043	1.640	<0.001

non-rural areas were significantly associated with lower medical costs ( $P < 0.001$ ), same as those living in central and western regions ( $P < 0.001$ ,  $P < 0.001$ ;  $P = 0.025$ ,  $P = 0.002$ ). Respondents who self-reported with “poor” and “very poor” health levels were found to have significantly higher medical expenditures ( $P < 0.001$ ). With the increase in the number of chronic diseases, a significant increase in medical expense was also observed ( $P < 0.001$ ). Regarding socioeconomic status, respondents with higher per capita

household expenditure were significantly associated with higher medical costs ( $P < 0.001$ ).

Table 5 shows that annual inpatient OOP costs were significantly reduced by 10.7% ( $P < 0.001$ ) and monthly outpatient OOP costs were significantly increased by 11.3% ( $P < 0.001$ ) in respondents who had taken self-medication. Nevertheless, the impact of medical insurance schemes on total costs and OOP costs showed great heterogeneity. Compared to the uninsured cases, all schemes increased total medical

TABLE 4 Parameter estimates from two-part mixed-effects model on inpatient expenditures.

Independent variable	First part				Second part			
	Estimate	S.E.	OR (95%CI)	P	Estimate	S.E.	Exp ( $\beta$ )	P
Self-medication	−0.145	0.028	0.865 (0.818, 0.915)	<0.001	−0.098	0.025	0.906	<0.001
Age	0.027	0.002	1.027 (1.024, 1.030)	<0.001	0.003	0.001	1.003	0.018
Gender	0.454	0.037	1.574 (1.464, 1.693)	<0.001	0.345	0.031	1.412	<0.001
Educational status	0.034	0.032	1.035 (0.973, 1.101)	0.281	0.062	0.028	1.064	0.026
Residential area	−0.008	0.040	0.992 (0.918, 1.072)	0.838	0.174	0.035	1.190	<0.001
Marital status	−0.001	0.041	0.999 (0.922, 1.082)	0.980	−0.069	0.035	0.933	0.048
<b>Region (Ref: East)</b>								
Mid	0.179	0.038	1.196 (1.110, 1.289)	<0.001	−0.321	0.034	0.725	<0.001
West	0.374	0.037	1.453 (1.351, 1.564)	<0.001	−0.394	0.033	0.674	<0.001
<b>Self-rated health (Ref: Fair)</b>								
Very good	−0.665	0.078	0.514 (0.441, 0.599)	<0.001	−0.03	0.079	0.970	0.703
Good	−0.401	0.056	0.670 (0.600, 0.748)	<0.001	−0.028	0.056	0.973	0.622
Poor	0.496	0.034	1.642 (1.537, 1.754)	<0.001	0.157	0.03	1.171	<0.001
Very poor	1.067	0.041	2.908 (2.683, 3.152)	<0.001	0.349	0.034	1.418	<0.001
Number of chronic diseases	0.271	0.009	1.312 (1.289, 1.335)	<0.001	0.026	0.007	1.026	<0.001
Per capita household expense	0.269	0.015	1.309 (1.272, 1.347)	<0.001	0.322	0.012	1.379	<0.001
<b>Medical insurance scheme (Ref: None)</b>								
NCMS	0.462	0.067	1.588 (1.393, 1.810)	<0.001	−0.027	0.063	0.974	0.669
UEBMI	0.643	0.079	1.902 (1.631, 2.219)	<0.001	0.312	0.072	1.367	<0.001
URBMI	0.481	0.093	1.618 (1.347, 1.943)	<0.001	0.106	0.085	1.112	0.208
URRBMI	0.463	0.092	1.589 (1.326, 1.904)	<0.001	0.003	0.083	1.003	0.97
Multiple/other	0.653	0.079	1.922 (1.646, 2.244)	<0.001	0.182	0.072	1.199	0.011
Smoke	−0.462	0.039	0.630 (0.584, 0.680)	<0.001	−0.306	0.033	0.736	<0.001
<b>Drink (Ref: No)</b>								
Often	−0.423	0.039	0.655 (0.607, 0.707)	<0.001	−0.236	0.034	0.790	<0.001
Sometimes	−0.284	0.054	0.753 (0.678, 0.837)	<0.001	−0.17	0.049	0.844	<0.001
<b>Year (Ref: 2011)</b>								
2013	0.380	0.040	1.462 (1.351, 1.582)	<0.001	0.21	0.036	1.233	<0.001
2015	0.337	0.039	1.400 (1.296, 1.513)	<0.001	0.263	0.036	1.301	<0.001
2018	0.569	0.042	1.767 (1.626, 1.919)	<0.001	0.307	0.038	1.359	<0.001

expenditure whether outpatient or inpatient, but statistically significant differences were only found in UEBMI ( $P_{\text{outpatient}} < 0.001$ ;  $P_{\text{inpatient}} < 0.001$ ) and Multiple/Other insurances ( $P_{\text{inpatient}} = 0.011$ ). On the other hand, none of the schemes had a significant effect on outpatient out-of-pocket expenditures. In particular, the percentage savings for inpatient out-of-pocket expenditures were 21.0% ( $P = 0.011$ ) in UEBMI, 16.6% ( $P = 0.026$ ) in NCMS, and 22.8% ( $P = 0.006$ ) in Multiple/Other insurances.

## 4. Discussion

This study was a longitudinal data analysis to investigate the impact of self-medication on the medical expenditures of middle-aged and elderly people in China. In our study, we tried to adopt an empirical approach to estimate the net effect of self-medication behavior on individual patient costs with four waves of data, and explored the heterogeneity of the effect on outpatient, inpatient, total costs, and out-of-pocket costs.

TABLE 5 Parameter estimates from regression equations on OOP costs.

Independent variable	Outpatient OOP				Inpatient OOP			
	Estimate	S.E.	Exp ( $\beta$ )	P	Estimate	S.E.	Exp ( $\beta$ )	P
Self-medication	0.107	0.031	1.113	<0.001	−0.113	0.032	0.893	<0.001
<b>Medical insurance scheme (Ref: None)</b>								
NCMS	−0.065	0.069	0.937	0.343	−0.181	0.082	0.834	0.026
UEBMI	−0.077	0.085	0.926	0.369	−0.236	0.093	0.790	0.011
URBMI	0.179	0.102	1.196	0.078	−0.081	0.108	0.922	0.454
URRBMI	−0.153	0.102	0.858	0.134	−0.139	0.108	0.870	0.197
Multiple/other	−0.142	0.084	0.868	0.092	−0.259	0.094	0.772	0.006

Prior studies showed that cost saving is the main reason for choosing self-medication (49). Additionally, the economic value of self-medication has been fully documented. The Consumer Healthcare Products Association (CHPA) indicated that self-medication reduced the frequency of doctor visits. Without self-medication and OTC (Over-the-Counter) medicines, 90% of consumers would have gone to the doctor instead (50). Each dollar spent on OTC medicines saves the U.S. healthcare system more than USD 7(33), and the availability of self-care medicines generates cost savings of more than USD 146 billion for the healthcare system annually in the US (51). The Association of the European Self-Medication Industry (AESGP) also reported that 1.2 billion minor health issues were self-managed every year with self-care products (35), with responsible self-medication accounting for a large proportion. This condition saved the healthcare systems and national economies EUR 34 billion (35). In Australia, the predicted value of switching 11 categories of current prescription medicines to OTC to promote self-medication resulted in savings of a further \$1.1 billion for the healthcare system and almost \$730 million for Medicare (34).

In terms of inpatient expenditures, comparable results were obtained in our study. We found that respondents who had self-medicated were less likely to use inpatient services, and their inpatient expenses were significantly reduced by 9.4%. Previous research showed that patients in pain who self-medicated with non-prescription medication were associated with significantly fewer hospitalizations experiences (52). Patients with hemophilia who took self-medication without prior consultation with a physician had an 89% reduction in the number of days they were hospitalized (53). To sum up, our results were consistent with fewer hospitalizations and shorter hospital stays. Furthermore, self-medication behaviors were associated with lower inpatient costs.

Although most studies reported that self-medication can reduce outpatient service utilization (50, 54, 55), we drew the unanticipated conclusion. The estimator indicated that self-medication behaviors were significantly associated with a higher

probability of outpatient service utilization but showed no significant association with outpatient expenses. In general, self-medication serves as an alternative to absorb the demand of outpatient services. Patients choose self-medication to avoid visits to medical facilities because of various reasons, but it shows different characteristics among different age groups. A large proportion of the younger group performed self-medication because they felt the disease was too mild to require medical service (56). As regards older groups, the major diseases that led to self-treatment were recurrent and related to aging. Such diseases can often be well controlled by regular over-the-counter medication (57). Variance among groups provided a clue to explaining our unanticipated findings.

One possible explanation for the difference between outpatient and inpatient cases among the middle-aged and elderly population might be health awareness and health literacy. Engaging in self-care activities, such as self-medication, is generally considered as a consequence of health condition awareness (58). Respondents who self-medicated tended to be more health-conscious and more concerned about their own health status. This condition provided them with an advantage in comprehending the importance and methods of early disease detection and treatment (59). Respondents who had taken self-medication implemented better interventions in the early stages of the disease, which reduced the risk of chronic disease progression (60, 61). Possible consequences were an increase in outpatient utilization, due to early interventions, such as disease screening and return visits, and a decrease in inpatient utilization because of the effective control of chronic diseases. Despite these interesting results, the mechanism related to the heterogeneity between outpatient and inpatient cases remains speculative, which is limited by secondary data. Therefore, caution should be warranted in extrapolating the results to all patients. Further studies are required to provide more precise explanations by employing the prospective study design.

As far as the OOP costs were concerned, inpatient respondents showed similar results with total medical

expenditure. Unexpectedly, outpatient OOP costs were significantly increased among respondents who had self-medicated. The results reminded us of the determinants of self-medicating behaviors. In developing countries, the main reasoning behind people self-medicating was a simple sign and symptom of disease (30), which was often associated with primary care utilization. The substitution relationship between self-medication and primary health care utilization provided a convenient approach to minor illnesses or health problems. However, when serious health problems arose, respondents were forced to turn to higher-tier hospitals. This meant the outpatient service utilization of respondents who had taken self-medication was likely inclined to non-primary care providers because of the substitution relationship. In China, visits to non-primary care providers showed higher patient cost-sharing, a policy that encouraged patients to seek primary care (62). Lower reimbursement rates resulted in higher out-of-pocket outpatient costs for the group we focused on.

Another significant aspect that deserved attention was medical insurance. In China, the government has developed a universal medical insurance system. The basic insurance system offered by the Chinese government consists of three schemes: UEBMI, which provides health insurance to formal-sector urban employees and retirees; URBMI, which aims to insure the urban residents not covered by the UEBMI, such as students and the self-employed; and NCMS, which is a voluntary medical insurance scheme targeting rural residents (44). In 2016, the State Council announced that it would integrate the NCMS and URBMI into URBMI (Urban and Rural Resident Basic Medical Insurance) to integrate fragmented medical insurance schemes and reduce inequity (63). We found that all schemes were significantly associated with a higher probability of medical service utilization, whether outpatient or inpatient. Medical insurances provided better financial protection for respondents, which lowered the barriers for individuals to seek healthcare services (64, 65). Thus, healthcare utilization by the insured increased accordingly (66), which was more similar to our results. In terms of out-of-pocket costs, different schemes reflected the heterogeneity. Almost all schemes played a role in reducing OOP costs, but they were not significant in outpatient cases. Three schemes were significantly associated with lower inpatient OOP costs, where the percentage savings for inpatient out-of-pocket expenditures were 21.0% in UEBMI, 16.6% in NCMS, and 22.8% in multiple/other insurances. The deficient reimbursement levels of medical insurance on outpatient care has been a problem in China's social health insurance schemes (44, 67). Meanwhile, the fragmented social health insurance schemes operate in isolation, creating inequalities in the system across insurance programs (68). This situation was reflected in our findings: (1) UEBMI individuals provided the most generous benefit packages (65, 69); (2) A certain gap remains between the actual and expected goals of URRBMI (70), which was integrated

from NCMS and URBMI; (3) Private health insurance (PHI) was an important supplement to the basic health insurance schemes (71).

Our research affirmed the economic value of self-medication among the middle-aged and elderly population in China. Responsible self-medication deserves to be promoted because it delivers significant benefits for both patients and healthcare systems. Given the risks of self-medication (72), reasonable guidance for residents is necessary in the future. Systematic public educational measures, such as public lectures, television, and online social networks, are necessary to reduce the harmful effects of improper self-medication. Regulations on drug instructions should be strengthened by relevant departments to provide accurate and understandable information on rational drug use.

At the same time, further studies are needed to evaluate the impact of self-medication on medical expenditure across different groups, such as children, women, and medical students.

## 5. Limitations

This study was limited in several ways. First, we were unable to judge the rationality of self-medication from the questionnaires that did not contain more details on the subjects' self-medication behavior. Although self-medication would cause adverse outcomes if taken inappropriately. Second, some of the variables were based on self-reporting and might be subject to recall bias, especially regarding medical expenditure. Medical expenditure has placed a significant cost burden on Chinese middle-aged and elderly people, as well as an enormous psychological burden. Therefore, the medical expenditure may have been over-reported to a certain extent (73). Finally, we excluded respondents that had utilized medical services but did not provide specific medical expenditure, which would bias the estimate of the probability of medical service utilization in the selection equations.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <https://opendata.pku.edu.cn/dataverse/CHARLS>.

## Author contributions

ZF and XS contributed to the conception and design of the study. ZZ performed the statistical analysis and wrote the first draft of the manuscript. DF and DZ wrote sections of the manuscript. DD and YL provided constructive suggestions in revising the manuscript. All authors contributed to the manuscript revision, read, and approved the submitted version.



## Funding

This work was supported by the National Natural Science Foundation of China [Grant Nos.: 71804052 and 72274071], Scientific Research Project of Hubei Health Committee [Grant No.: WJ2021Q022], and the National Key Research and Development Program [Grant No.: 2020YFC2006500].

## Acknowledgments

The authors thank the China Health and Retirement Longitudinal Study.

## References

1. World Health Organization. *The role of the pharmacist in self-care and self-medication*. World Health Organization Essential Drugs and Medicines Policy - WHO / EDM. (1998).
2. World Self-Medication Industry. The Story of Self-Care and Self-Medication, 40 years of progress (2010). Available online at: <https://www.wsmi.org/resources/story-self-care-and-self-medication-40-years-progress> (accessed April 28, 2022).
3. Chaturakarn S, Khumros W, Phutrakool P. Self-medication with over-the-counter medicines among the working age population in metropolitan areas of Thailand. *Front Pharmacol*. (2021) 12:726643. doi: 10.3389/fphar.2021.726643
4. Mortazavi SS, Shati M, Khankeh HR, Ahmadi F, Mehravaran S, Malakouti SK. Self-medication among the elderly in Iran: a content analysis study. *BMC Geriatr*. (2017) 17:198. doi: 10.1186/s12877-017-0596-z
5. Rajamma RK, Paswan AK, Pelton LE. Flipping the script: Consumers' propensity for self-medication. *J Market Theory Pract*. (2021) 29:448–62. doi: 10.1080/10696679.2020.1870240
6. Brandao GR, Teixeira L, Araujo L, Paul C, Ribeiro O. Self-medication in older European adults: Prevalence and predictive factors. *Arch Gerontol Geriatr*. (2020) 91:104189. doi: 10.1016/j.archger.2020.104189
7. Carmona-Torres JM, Cobo-Cuenca AI, Recio-Andrade B, Laredo-Aguilera JA, Martins MM, Rodriguez-Borrego MA. Prevalence and factors associated with polypharmacy in the older people: 2006–2014. *J Clin Nurs*. (2018) 27:2942–52. doi: 10.1111/jocn.14371
8. Vahedi S, Jalali FS, Bayati M, Delavari S. Predictors of Self-medication in Iran: A notional survey study. *Iran J Pharm Res*. (2021) 20:348–58. doi: 10.22037/ijpr.2020.113601.14394
9. Gama ASM, Secoli SR. Self-medication practices in riverside communities in the Brazilian Amazon Rainforest. *Rev Bras Enferm*. (2020) 73:e20190432. doi: 10.1590/0034-7167-2019-0432
10. Zhao Y, Ma S. Observations on the prevalence, characteristics, and effects of self-treatment. *Front Public Health*. (2016) 4:69. doi: 10.3389/fpubh.2016.00069
11. Wang R, Ma C, Jiang K, Li M, Ma S. Descriptions of self-treatment for the middle-aged and elderly in Shanxi, China. *PLoS ONE*. (2018) 13:e0198554. doi: 10.1371/journal.pone.0198554
12. Lei XS, Jiang H, Liu CJ, Ferrier A, Mugavin J. Self-Medication Practice and Associated Factors among Residents in Wuhan, China. *Int J Environ Res Public Health*. (2018) 15:69. doi: 10.3390/ijerph15010068
13. Wang Z, Guan X, Zhou Y, Han S, Yao P, Shi L. Prevalence and influence factors of self-medication in Chinese middle-aged and elderly people: evidence from 2011, 2013 and 2015 CHARLS panel data. *J Chin Pharm Sci*. (2019) 28:430–8. doi: 10.5246/jcps.2019.06.042
14. Jerez-Roig J, Medeiros LF, Silva VA, Bezerra CL, Cavalcante LA, Piuvézam G, et al. Prevalence of self-medication and associated factors in an elderly population: a systematic review. *Drugs Aging*. (2014) 31:883–96. doi: 10.1007/s40266-014-0217-x
15. Qato DM, Alexander GC, Conti RM, Johnson M, Schumm P, Lindau ST. Use of prescription and over-the-counter medications and dietary

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- supplements among older adults in the United States. *Jama*. (2008) 300:2867–78. doi: 10.1001/jama.2008.892
16. Francis SA, Barnett N, Denham M. Switching of prescription drugs to over-the-counter status: is it a good thing for the elderly? *Drugs Aging*. (2005) 22:361–70. doi: 10.2165/00002512-200522050-00001
  17. Gao Z, Xu L, Qin W, Zhang J, Zhou J, Hu F, et al. Prevalence and associated factors of self-treatment among the elderly—a comparative study between empty and non-empty nesters in Shandong, China. *Int J Environ Res Public Health*. (2020) 17:7880. doi: 10.3390/ijerph17217880
  18. Klotz U. Pharmacokinetics and drug metabolism in the elderly. *Drug Metab Rev*. (2009) 41:67–76. doi: 10.1080/03602530902722679
  19. Flores VB, Benvegnú LA. Use of medicines by the elderly in Santa Rosa, Rio Grande do Sul State, Brazil. *Cad Saude Publica*. (2008) 24:1439–46. doi: 10.1590/S0102-311X2008000600024
  20. Zawahir S, Lekamwasam S, Halvorsen KH, Rose G, Aslani P. Self-medication Behavior with antibiotics: a national cross-sectional survey in Sri Lanka. *Expert Rev Anti Infect Ther*. (2021) 19:1341–52. doi: 10.1080/14787210.2021.1911647
  21. Bennadi D. Self-medication: A current challenge. *J Basic Clin Pharm*. (2013) 5:19–23. doi: 10.4103/0976-0105.128253
  22. Locquet M, Honvo G, Rabenda V, Van Hees T, Petermans J, Reginster JY, et al. Adverse health events related to self-medication practices among elderly: a systematic review. *Drugs Aging*. (2017) 34:359–65. doi: 10.1007/s40266-017-0445-y
  23. Gong Y, Jiang N, Chen Z, Wang J, Zhang J, Feng J, et al. Over-the-counter antibiotic sales in community and online pharmacies, China. *Bull World Health Organ*. (2020) 98:449–57. doi: 10.2471/BLT.19.242370
  24. Keehan SP, Stone DA, Poisal JA, Cuckler GA, Sisko AM, Smith SD, et al. National health expenditure projections, 2016–25: price increases, aging push sector to 20 percent of economy. *Health Aff (Millwood)*. (2017) 36:553–63. doi: 10.1377/hlthaff.2016.1627
  25. Holle M, Wolff T, Herant M. Trends in the Concentration and Distribution of Health Care Expenditures in the US, 2001–2018. *JAMA Netw Open*. (2021) 4:e2125179. doi: 10.1001/jamanetworkopen.2021.25179
  26. Ayalew MB. Self-medication practice in Ethiopia: a systematic review. *Patient Prefer Adher*. (2017) 11:401. doi: 10.2147/PPA.S131496
  27. Ponte M, Wachs L, Serra A, Othatz L, Souto SM, Wachs A. Self medication and self prescription: relevance in daily medicine. *Drug Safety*. (2014) 37:835.
  28. Wen Y, Lieber E, Wan D, Hong Y, A. qualitative study about self-medication in the community among market vendors in Fuzhou, China. *Health Soc Care Community*. (2011) 19:504–13. doi: 10.1111/j.1365-2524.2011.01009.x
  29. Beyene KGM, Beza SW. Self-medication practice and associated factors among pregnant women in Addis Ababa, Ethiopia. *Trop Med Health*. (2018) 46:10. doi: 10.1186/s41182-018-0091-z
  30. Shaghaghia A, Asadi M, Allahverdipour H. Predictors of self-medication behavior: a systematic review. *Iran J Public Health*. (2014) 43:136–46.

31. Noone J, Blanchette CM. The value of self-medication: summary of existing evidence. *J Med Econ.* (2018) 21:201–11. doi: 10.1080/13696998.2017.1390473
32. Jafari F, Khatony A, Rahmani E. Prevalence of self-medication among the elderly in Kermanshah-Iran. *Glob J Health Sci.* (2015) 7:360–5. doi: 10.5539/gjhs.v7n2p360
33. Consumer Healthcare Products Association. *OTC Medicines Save the U.S. Healthcare System Money.* (2019). Available online at: <https://www.chpa.org/about-consumer-healthcare/infographics/otc-medicines-save-us-healthcare-system-money> (accessed May 14, 2022).
34. Macquarie Centre for the Health Economy. *The Value of OTC Medicines in Australia.* (2014). Available online at: <https://www.chpaaustralia.com.au/Tenant/C0000022/Documents/Research/Value%20of%20OTC%20Medicines%20in%20Australia.pdf>
35. Association of the European Self-Medication Industry. *Self-Care in Europe: Economic and Social Impact on Individuals and Society.* (2021). Available online at: <https://aesgp.eu/articles/aesgp-releases-new-evidence-on-the-economic-and-social-value-of-self-care-in-europe>
36. Zhang P, Jiang H, Chen W. Health shocks and changes in preventive behaviors: Results from the China Health and Retirement Longitudinal Study. *Front Public Health.* (2022) 10:954700. doi: 10.3389/fpubh.2022.954700
37. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort profile: the China Health and Retirement Longitudinal Study (CHARLS). *Int J Epidemiol.* (2014) 43:61–8. doi: 10.1093/ije/dys203
38. Jiang Y, Ni W. Association between supplemental private health insurance and burden of out-of-pocket healthcare expenditure in China: A novel approach to estimate two-part model with random effects using panel data. *Risk Manag Healthc Policy.* (2020) 13:323–34. doi: 10.2147/RMHP.S223045
39. Evashwick C, Rowe G, Diehr P, Branch L. Factors explaining the use of health care services by the elderly. *Health Serv Res.* (1984) 19:357–82.
40. Pan L, Li L, Peng H, Fan L, Liao J, Wang M, et al. Association of depressive symptoms with marital status among middle-aged or older adults in China: Serial mediating effects of sleep time, pain and life satisfaction. *J Affect Disord.* (2022) 303:52–7. doi: 10.1016/j.jad.2022.01.111
41. Lin L, Wang HH, Lu C, Chen W, Guo YY. Adverse childhood experiences and subsequent chronic diseases among middle-aged or older adults in China and associations with demographic and socioeconomic characteristics. *JAMA Netw Open.* (2021) 4:e2130143. doi: 10.1001/jamanetworkopen.2021.30143
42. Zhou J, Fang S. Association between undiagnosed hypertension and health factors among middle-aged and elderly Chinese population. *Int J Environ Res Public Health.* (2019) 16:1214. doi: 10.3390/ijerph16071214
43. Lei X, Smith JP, Sun X, Zhao Y. Gender differences in cognition in China and reasons for change over time: Evidence from CHARLS. *J Econ Ageing.* (2014) 4:46–55. doi: 10.1016/j.joea.2013.11.001
44. Zhang A, Nikoloski Z, Mossialos E. Does health insurance reduce out-of-pocket expenditure? Heterogeneity among China's middle-aged and elderly. *Soc Sci Med.* (2017) 190:11–9. doi: 10.1016/j.socscimed.2017.08.005
45. Buntin MB, Zaslavsky AM. Too much ado about two-part models and transformation? Comparing methods of modeling Medicare expenditures. *J Health Econ.* (2004) 23:525–42. doi: 10.1016/j.jhealeco.2003.10.005
46. Zhao J, Zhao Y, Xiang L, Khanal V, Binns CW, Lee AH, et al. two-part mixed-effects model for analyzing clustered time-to-event data with clumping at zero. *Comput Methods Programs Biomed.* (2020) 187:105196. doi: 10.1016/j.cmpb.2019.105196
47. Hasan MZ, Story WT, Bishai DM, Ahuja A, Rao KD, Gupta S. Does social capital increase healthcare financing's projection? Results from the rural household of Uttar Pradesh, India. *SSM - Populat Health.* (2021) 15:100901. doi: 10.1016/j.ssmph.2021.100901
48. Nosyk B, Montaner JS, Yip B, Lima VD, Hogg RS. Antiretroviral drug costs and prescription patterns in British Columbia, Canada: 1996–2011. *Med Care.* (2014) 52:362–9. doi: 10.1097/MLR.0000000000000097
49. Haque M, Rahman NAA, McKimm J, Kibria GM, Azim Majumder MA, Haque SZ, et al. Self-medication of antibiotics: investigating practice among university students at the Malaysian National Defence University. *Infect Drug Resist.* (2019) 12:1333–51. doi: 10.2147/IDR.S203364
50. Consumer Healthcare Products Association. *OTC Medicines Reduce Doctors Visits.* (2019). Available online at: <https://www.chpa.org/about-consumer-healthcare/infographics/otc-medicines-reduce-doctors-visits>. (accessed May 14, 2022).
51. Consumer Healthcare Products Association. *OTC Medicines Save Billions Annually.* (2019). Available online at: <https://www.chpa.org/about-consumer-healthcare/infographics/otc-medicines-save-billions-annually> (accessed May 14, 2022).
52. Lee LJ, DiBonaventura MD, Kudel I, Schepart AL, Kellstein D. PSY51 - The incremental effect of over-the-counter medications on work productivity and health care resource utilization among adults with pain in the united states. *Value in Health.* (2016) 19:A250. doi: 10.1016/j.jval.2016.03.1074
53. Levine PH, Britten AF. Supervised patient-management of hemophilia: A study of 45 patients with hemophilia A and B. *Annals of internal medicine.* (1973) 78:195–201. doi: 10.7326/0003-4819-78-2-195
54. Millier A, Cohen J, Toumi M. Economic impact of a triptan Rx-to-OTC switch in six EU countries. *PLoS ONE.* (2013) 8:e84088. doi: 10.1371/journal.pone.0084088
55. Rankin PJ, Tsvetkova IV, Estus E, Nah N, Senne B. *Managing Access to Dextromethorphan: Cost Implications of a Potential Over-the-Counter to Prescription-Only Conversion.* (2016). Available online at: <https://www.crai.com/insights-events/publications/managing-access-dextromethorphan-cost-implications-potential-over-counter-prescription/> (accessed May 14, 2022).
56. Flaiti MA, Badi KA, Hakami WO, Khan SA. Evaluation of self-medication practices in acute diseases among university students in Oman. *J Acute Dis.* (2014) 3:249–52. doi: 10.1016/S2221-6189(14)60056-1
57. Jiang Y, Wang Y, Li Y, Wang X, Ma C, Ma S. Prevalence, characteristics, and cost of self-treatment in the middle-aged and elderly: observations from Henan, China. *Public Health.* (2015) 129:597–600. doi: 10.1016/j.puhe.2015.02.005
58. Squiers L, Peinado S, Berkman N, Boudewyns V, McCormack L. The health literacy skills framework. *J Health Commun.* (2012) 17:30–54. doi: 10.1080/10810730.2012.713442
59. Lee SY, Arozullah AM, Cho YI. Health literacy, social support, and health: a research agenda. *Soc Sci Med.* (2004) 58:1309–21. doi: 10.1016/S0277-9536(03)00329-0
60. Galbraith L, Jacobs C, Hemmelgarn BR, Donald M, Manns BJ, Jun M. Chronic disease management interventions for people with chronic kidney disease in primary care: a systematic review and meta-analysis. *Nephrol Dialysis Transplant.* (2017) 33:112–21. doi: 10.1093/ndt/gfw359
61. Welte T, Vogelmeier C, Papi A. COPD early diagnosis and treatment to slow disease progression. *Int J Clin Pract.* (2015) 69:336–49. doi: 10.1111/ijcp.12522
62. Shen M, He W, Li L. Incentives to use primary care and their impact on healthcare utilization: Evidence using a public health insurance dataset in China. *Soc Sci Med.* (2020) 255:112981. doi: 10.1016/j.socscimed.2020.112981
63. Ren Y, Zhou Z, Cao D, Ma BH, Shen C, Lai S, et al. Did the Integrated Urban and Rural Resident Basic Medical Insurance Improve Benefit Equity in China? *Value Health.* (2022) 25:1548–58. doi: 10.1016/j.jval.2022.03.007
64. Ta Y, Zhu Y, Fu H. Trends in access to health services, financial protection and satisfaction between 2010 and 2016: Has China achieved the goals of its health system reform? *Soc Sci Med.* (2020) 245:112715. doi: 10.1016/j.socscimed.2019.112715
65. Zhou Y, Wushouer H, Vuillermin D, Ni B, Guan X, Shi L. Medical insurance and healthcare utilization among the middle-aged and elderly in China: evidence from the China health and retirement longitudinal study 2011, 2013 and 2015. *BMC Health Serv Res.* (2020) 20:654. doi: 10.1186/s12913-020-05522-w
66. Li Y, Malik V, Hu FB. Health Insurance In China: After Declining In The 1990s, Coverage Rates Rebounded To Near-Universal Levels By 2011. *Health Aff (Millwood).* (2017) 36:1452–60. doi: 10.1377/hlthaff.2016.1658
67. Dong W, Zwi AB, Bai R, Shen C, Gao J. Benefits associated with China's social health insurance schemes: trend analysis and associated factors since health reform. *Int J Environ Res Public Health.* (2021) 18:5672. doi: 10.3390/ijerph18115672
68. Liu GG, Vortherms SA, Hong X. China's health reform update. *Annu Rev Public Health.* (2017) 38:431–48. doi: 10.1146/annurev-publhealth-031816-044247
69. Su M, Zhou Z, Si Y, Wei X, Xu Y, Fan X, et al. Comparing the effects of China's three basic health insurance schemes on the equity of health-related quality of life: Using the method of coarsened exact matching. *Health Qual Life Outc.* (2018) 16:41. doi: 10.1186/s12955-018-0868-0
70. Wang Z, Chen Y, Pan T, Liu X, Hu H. The comparison of healthcare utilization inequity between URRBMI and NCMS in rural China. *Int J Equity Health.* (2019) 18:90. doi: 10.1186/s12939-019-0987-1
71. Wang Q, Zhang D, Hou Z. Insurance coverage and socioeconomic differences in patient choice between private and public health care providers in China. *Soc Sci Med.* (2016) 170:124–32. doi: 10.1016/j.socscimed.2016.10.016
72. Hughes CM, McElroy JC, Fleming GF. Benefits and risks of self medication. *Drug Safety.* (2001) 24:1027–37. doi: 10.2165/00002018-200124140-00002
73. Du JL, Yang X, Chen MS, Wang ZH. Socioeconomic determinants of out-of-pocket pharmaceutical expenditure among middle-aged and elderly adults based on the China Health and Retirement Longitudinal Survey. *BMJ Open.* (2019) 9:e024936. doi: 10.1136/bmjopen-2018-024936



## OPEN ACCESS

EDITED BY  
Timotej Jagric,  
University of Maribor, Slovenia

REVIEWED BY  
Rajendra Kadel,  
Public Health Wales NHS Trust, United Kingdom  
Hao Zhang,  
Chongqing Medical University, China  
Chaoyi Huang,  
Chongqing University, China  
Lu Zhang,  
Chengdu University of Traditional Chinese  
Medicine, China  
Shuai Xiong,  
Chengdu University of Traditional Chinese  
Medicine, China

\*CORRESPONDENCE  
Ping Yao  
✉ Yaopingnfu@163.com

SPECIALTY SECTION  
This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 17 October 2022  
ACCEPTED 09 January 2023  
PUBLISHED 26 January 2023

CITATION  
Zhang M and Yao P (2023) Study on the  
evolutionary game of the three parties in the  
combined medical and health-care PPP  
project. *Front. Public Health* 11:1072354.  
doi: 10.3389/fpubh.2023.1072354

COPYRIGHT  
© 2023 Zhang and Yao. This is an open-access  
article distributed under the terms of the  
[Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/).  
The use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in this  
journal is cited, in accordance with accepted  
academic practice. No use, distribution or  
reproduction is permitted which does not  
comply with these terms.

# Study on the evolutionary game of the three parties in the combined medical and health-care PPP project

Min Zhang and Ping Yao\*

College of Economics and Management, Nanjing Forestry University, Nanjing, China

In the context of ageing, the combination of medical and health-care has become a major trend, and the introduction of the PPP model into combined medical and healthcare projects can solve the problem of lack of funds for the development of combined medical and health-care projects. Based on the evolutionary game theory, this paper constructs a three-party evolutionary game model to study the strategy choice of each party in the game process, and also analyses the evolutionary equilibrium strategy and the impact of parameter adjustment on the evolutionary strategy under different situations. The results show that the optimal solution is for the private sector to choose to provide high quality services, for the government to choose to actively regulate and for the public to choose to actively monitor. For each player, the incentives and disincentives influence their behavioural strategies. Based on the above analysis, this paper suggests establishing an independent regulator, broadening public feedback channels, and improving PPP-related laws, as well as innovating project operation methods and improving enterprise operational capabilities.

## KEYWORDS

combined medical and health-care PPP, evolutionary game, government regulation, Matlab simulation, integration of medical and health-care

## 1. Introduction

At this stage, the combination of medical services and elderly care services has become a new mode of supply in the elderly care market. The Opinions on Strengthening Aging Work in the New Era promulgated by the Central Committee of the Communist Party of China and the State Council in November 2021 clearly states, “We should deeply promote the integration of medical care and elderly care, encourage medical institutions to cooperate with elderly care institutions, further integrate and optimize grassroots medical and elderly care resources, and provide medical assistance and rehabilitation and care services for the elderly” (1). The development of combined medical and health-care service system will be a long-term, systematic and comprehensive public health construction work, with huge capital requirements. Relying solely on the government’s financial input cannot fully meet the development capital needs, and the reasonable use of social capital participation is an effective way to solve the problem.

The application of PPP projects in the field of medical and health-care can not only effectively relieve the financial pressure of the government, but also inject fresh blood into the development of combined medical and health-care projects. Regarding the application of health-care PPP in China, as of 19 September 2022, the number of PPP projects in the PPP project pool has reached 10,272, with a total amount of 1,644.7 billion yuan, which to some extent highlights the widespread application of the PPP model in major fields. Among them, there are now a total of 43 combined medical and health-care PPP projects, accounting for only 0.42% of the total number of PPP projects in the pool (2), which indicates that the implementation of combined medical and health-care PPP projects in China is still in its initial stage. Therefore, domestic

experts and scholars mainly focus on the necessity and feasibility of introducing the PPP model in the field of combined health-care (3–14), as well as the countermeasures to the problems of combined medical and health-care PPP projects.

Regarding the necessity of introducing the PPP model in the field of medical and health-care combination, it provides new ideas for the development of medical and health-care combination, as complete public ownership of medical and health-care services would greatly increase the financial burden of government departments, while complete privatization would lead to market failure due to the nature of public goods in medical and health-care services (3). In view of the lack of healthcare resources and elderly resources in remote areas of developing countries, the combined medical and health-care PPP model can provide relatively stable financial support and professional talents, which can effectively solve the difficult problems faced by developing countries (4, 5). In order to study the feasibility of introducing PPP model in the field of medical and health-care combination, some scholars introduced TOT (Transfer-Operate-Transfer) model into combined medical and health-care projects and found that the financing efficiency and construction quality of the projects were significantly improved, thus arguing the feasibility of introducing PPP model in the field of medical and health-care combination (6). In addition, some scholars found that the total benefits of the project were greater than the total costs by measuring in the specific combined medical and health-care PPP projects, thus again arguing the feasibility of introducing PPP projects in the combined medical and health-care field (7).

Regarding the research on the problems and countermeasures in the development of combined medical and health-care PPP projects, some scholars have found the following problems, such as high barriers to social capital participation, inefficient management, and limited channels for operating returns (8, 9). Unequal distribution of resources, single funding channel and lack of talents have become key factors limiting the further development of combined medical and health-care PPP projects (10). In response to the above problems, scholars have provided answers from the government's perspective and social capital's perspective, respectively. From the government's perspective, some scholars believe that laws and regulations in the field of combined medical and health-care PPP should be further established, and the risk-sharing and return mechanisms should be further changed to improve the investment and financing environment (11, 12). From the perspective of social capital, some scholars believe that exploring new profitability channels is important for the development of combined medical and health-care PPP, while proposing the establishment of an effective internal management system so as to attract more talents (13, 14).

The above problems are all focused on the theoretical level, at practical level, the government, as the leader and participant in combined medical and health-care PPP projects, and also the "person in charge" in the minds of the public, is not involved in the specific operation of combined medical and health-care PPP projects, but is more of a regulator. The absence of government in practice may result in existing government monitoring systems that do not effectively capture the value of projects.

To address the issues that arise at the practice level, good governance and regulatory quality become necessary conditions required for the development of combined medical and health-care PPP projects (15). With more and more experts and scholars

conducting in-depth research on PPP model-related issues, the method of evolutionary game is gradually applied to PPP model (16). At present, evolutionary games are mostly applied to transportation and environmental protection PPP projects, and the evolutionary game approach is used to discuss the cooperation mechanism and supervision quality of the projects (16). Unlike transportation and environmental protection PPP projects, where hard indicators can be used to measure the quality of supervision, combined medical and health-care PPP projects mainly provide soft services, so how to regulate combined medical and health-care PPP projects has become a major problem for government departments (16–19). Based on the evolutionary game theory, this paper constructs a three-party evolutionary game model, studies the strategy choice of each party in the game process, analyzes the evolutionary equilibrium strategy under different situations and the influence of the adjustment of parameter on the evolutionary strategy, and puts forward corresponding suggestions and countermeasures from the level of government regulation, in order to design the regulatory mechanism of combined medical and health-care PPP projects and attract social capital to join the healthcare industry. The purpose of this paper is to provide theoretical reference for the government to design the regulatory mechanism of combined medical and health-care PPP projects and to attract social capital to join the elderly industry by choosing the PPP model.

## 2. Hypothesis

It is hypothesized that the three parties in the game, namely the government, the private sector and the public, are all finite rational persons who do not fully understand each other's strategies and efficiency functions, and that the strategies of the three parties in the game are constantly being adjusted until the optimal strategy is found. It is hypothesized that the government department aims to achieve the social interest and the private sector and the public aim to maximize their own interests (20).

The related gains and losses in the private sector are as follows:

It is hypothesized that the probability of the private sector providing a high quality service (no default) is  $x$  and the probability of providing a low quality service (default) is  $1 - x$ . If the private sector chooses to provide high quality services, the minimum benefit based on user fees is  $M_i$ , the cost to be paid is  $CH$ , and the operating subsidy available after government assessment is  $W_e$ . The level of reputation given by the public when the private sector provides high quality services is  $\alpha 1$ . If the private sector provides low quality services, the minimum benefit under user fees is  $M_i$ , the cost to the private sector is  $CL$ , and in conjunction with the above we know that  $CH > CL$ . However, if the private sector is found to be monitored by the government or reported by the public, the private sector is penalized and the resulting loss is  $Ws$ . The level of reputation given by the public when the private sector provides low quality services is  $\alpha 2$ , and in conjunction with the above we know that  $\alpha 1 > \alpha 2$ .

The related gains and losses in the government sector are as follows:



It is hypothesized that the probability of a government department choosing to regulate is  $y$ , and the probability of choosing not to regulate is  $1 - y$ .

If the government chooses to regulate, the fixed benefit is  $F_i$ , the cost to the government is  $C_g$ , and the additional benefit is  $R_g$  (the additional rewards from a higher authority and public recognition for monitoring private sector default), the regulatory to private sector default collection fines is  $W_s$ . The level of reputation given by the public when the government chooses to regulate is  $\beta_1$ .

If the government chooses not to regulate, it will not incur regulatory costs and will not receive additional rewards from a higher authority or fines collected. At this point, if the government is censured by a higher authority or complained by the public for failing to regulate in a timely manner and thus not detecting a private sector default, the loss incurred is  $F_g$ . The level of reputation given by the public in the absence of government oversight is  $\beta_2$ , which, in conjunction with the above, we know that  $\beta_1 > \beta_2$ .

The relevant gains and losses to the public are as follows:

It is hypothesized that the probability of public participation in monitoring the combined medical and health-care PPP project is  $z$ , and the probability of not monitoring is  $1 - z$ .

If the public chooses to monitor, the cost to the public is  $C_p$ , and the rewards from the government is  $R_p$ . When the private sector provides low quality health care services, the public suffers a loss of  $R_1$ , and the compensation for reporting the damage is  $P$ .

If the public chooses not to monitor, they incur no monitoring costs and receive no rewards from government departments. However, if the private sector provides a low quality service at this point, the public suffers a loss of  $R_1$ .

It is hypothesized that all public complaints against the private sector are genuine and valid, and that the government will always be able to detect irregularities (provide low-quality services) in the private sector before the public, provided it takes its regulatory role seriously.

It is hypothesized that if the government chooses to regulate, it will inevitably detect defaults in the private sector, or not if it chooses not to.

The above specific parameters and their meanings are shown in the Table 1.

Based on the above hypothesis, the evolutionary game payment matrix between the government apartment the private sector and the public is shown in the Table 2.

### 3. Model analysis

#### 3.1. Theoretical analysis

Game theory is the study of the decision-making behavior of intelligent decision-makers in situations of interest. Game theory, also known as response theory, is a branch of modern mathematics and an important part of operations research (21). In practical terms, there are a number of conflicting or related subjects, known as decision makers or game players, who are able to make decisions on

TABLE 1 Parameters and meaning of game behavior.

Parameters	Meaning
$M_i$	Minimum benefits to the private sector based on user fees
$CH$	The cost to the private sector of choosing to provide quality services
$We$	Operating subsidies available to the private sector following government assessment of quality service delivery
$\alpha_1$	Level of reputation given by the private sector when providing high quality services under public scrutiny
$CL$	The cost to the private sector of choosing to provide low-quality services
$Ws$	Losses arising from government oversight or public reporting of low-quality services provided by the private sector
$\alpha_2$	Level of reputation given by the private sector when providing low quality services under public scrutiny
$F_i$	Government sector fixed income
$R_g$	Additional benefits gained by government departments choosing to regulate
$C_g$	Cost of active government regulation
$\beta_1$	Government departments actively regulate the level of reputation given to the government when under public scrutiny
$R_p$	Rewards given by government departments to people who actively monitor
$F_g$	Penalties for government failure to regulate in a timely manner so that violations by the private sector that were not detected by the public are discovered
$\beta_2$	Government departments do not actively regulate the level of reputation given to the government by public scrutiny
$C_p$	Costs incurred when the public actively participates in monitoring
$R_1$	Damage to the public when the private sector provides low-quality services
$P$	Compensation for the public in case of damage due to reporting

their own. Game theory is the abstraction of real problems and the creation of corresponding mathematical models to analyze, predict and even intervene in the decisions or behavior of individuals. These models may be out of touch with reality, but they make it easier to interpret actual competitive situations or social dilemmas such as conflict and cooperation than complex real-life situations (21).

In 1950, the American mathematician Nash (22) introduced an important concept in game theory, the Nash Equilibrium. That is, when the individuals involved in the game are in Nash equilibrium, no individual can gain more by unilaterally changing his or her strategy. In practice, however, the assumptions of perfect rationality and perfect information of the participating individuals are difficult to satisfy. In 1973, ecologists Smith and Price published their famous paper "The Logic of Animal Conflict" (23), which combined biological evolution and classical game theory and proposed the Evolutionary Stable Strategy (ESS) based on the study of eco-evolutionary phenomena. Evolutionary Stable Strategy (ESS) is an important concept in evolutionary game theory, which also marks the birth of evolutionary game theory (23).

Evolutionary game theory embodies the idea of biological evolution, the so-called 'survival of the fittest', and the Nash



TABLE 2 Government, private sector, and public payment-revenue matrix 3 results.

Game participants				Government regulators	
				supervision $y$	No supervision $1 - y$
Private sector	No violation $x$	Public	Participation $z$	$Mi + We + \alpha 1 - CH,$ $Fi + Rg + \beta 1 - Cg - Rp,$ $Rp - Cp$	$Mi + We + \alpha 1 - CH,$ $Fi + \beta 2 - Rp,$ $Rp - Cp$
			No participation $1 - z$	$Mi + We - CH,$ $Fi + Rg - Cg,$ $0$	$Mi + We - CH,$ $Fi,$ $0$
	violation $1 - x$	Public	Participation $z$	$Mi + \alpha 2 - CL - Ws,$ $Fi + Rg + Ws + \beta 1 - Cg - Rp$ $Rp - Cp - R1 + P$	$Mi + \alpha 2 - CL,$ $Fi + \beta 2 - Rp - Fg,$ $Rp - Cp - R1 + P$
			No participation $1 - z$	$Mi - CL - Ws,$ $Fi + Rg + Ws - Cg,$ $-R1$	$Mi - CL,$ $Fi,$ $-R1$

equilibrium of classical game theory is reflected in evolutionary stable strategies (ESS) in evolutionary games. A strategy is evolutionarily stable if all individuals in the group adopt a certain strategy and no mutation strategy adopted by a small group of other individuals can invade the group (21).

### 3.2. Analysis of the stability of the private sector strategy

The expected benefits of providing high quality services or providing low quality services in the private sector, as well as the average expected benefits are:

$$\begin{aligned}
 Y_{11} &= yz(Mi + We + \alpha 1 - CH) + (1 - y)z(Mi + We + \alpha 1 - CH) \\
 &\quad + y(1 - z)(Mi + We - CH) \\
 &\quad + (1 - y)(1 - z)(Mi + We - CH) \\
 Y_{12} &= yz(Mi + \alpha 2 - CL - Ws) + (1 - y)z(Mi + \alpha 2 - CL) \\
 &\quad + y(1 - z)(Mi - CL - Ws) + (1 - y)(1 - z)(Mi - CL) \\
 \overline{Y1} &= xY_{11} + (1 - x)Y_{12}
 \end{aligned}$$

The replication dynamics equation for the private sector is:

$$\begin{aligned}
 Y(x) &= dx/dt = x(Y_{11} - \overline{Y1}) = x(x - 1) \\
 &\quad [CH - CL - We - z(\alpha 1 - \alpha 2) - yWs]
 \end{aligned}$$

The first-order derivatives of  $x$  and the set  $G(y)$  are:

$$\begin{aligned}
 d(Y(x))/dx &= (2x - 1)[CH - CL - We - z(\alpha 1 - \alpha 2) - yWs] \\
 G(y) &= CH - CL - We - z(\alpha 1 - \alpha 2) - yWs
 \end{aligned}$$

From the stability theorem of the differential equation, it follows that the probability of the private sector choosing to provide high quality services is in a steady state must satisfy:  $Y(x) = 0$  and  $d(Y(x))/dx < 0$ . Since  $\partial G(y)/\partial y < 0$ ,  $G(y)$  is a decreasing function with respect to  $y$ . Thus, when  $y = [CH - CL - We - z(\alpha 1 - \alpha 2)]/Ws =$

$y^*$ ,  $G(y) = 0$ , at which point  $d(F(x))/dx \equiv 0$ , the private sector cannot determine a stabilization strategy. When  $y < y^*$ ,  $G(y) > 0$ , at this time  $d(Y(x))/dx|_x = 0 < 0$ , at this time,  $x = 0$  is the evolutionary stabilization strategy for the private sector. Conversely when  $y > y^*$ ,  $G(y) < 0$ ,  $d(Y(x))/dx|_x = 1 < 0$ , at this point,  $x = 1$  is the evolutionary stable strategy for the private sector. The evolutionary phase diagram of the private sector's strategy is shown in Figure 1.

### 3.3. Analysis of the stability of government sector strategies

The expected benefits of government sector regulation, non-regulation and the average expected benefits are:

$$\begin{aligned}
 Y_{21} &= xz(Fi + Rg + \beta 1 - Cg - Rp) + x(1 - z)(Fi + Rg - Cg) \\
 &\quad + (1 - x)z(Fi + Rg + Ws + \beta 1 - Cg - Rp) \\
 &\quad + (1 - x)(1 - z)(Fi + Rg + Ws - Cg) \\
 Y_{22} &= xz(Fi + \beta 2 - Rp) + x(1 - z)Fi \\
 &\quad + (1 - x)z(Fi + \beta 2 - Rp - Fg) + (1 - x)(1 - z)Fi \\
 \overline{Y2} &= yY_{21} + (1 - y)Y_{22}
 \end{aligned}$$

The replication dynamics equation for the government sector is:

$$\begin{aligned}
 Y(y) &= dy/dt = y(Y_{21} - \overline{Y2}) = y(y - 1) \\
 &\quad [Cg - Rg - z(\beta 1 - \beta 2) - (1 - x)zFg - (1 - x)Ws]
 \end{aligned}$$

The first order derivatives of  $y$  and the set  $J(z)$  are, respectively:

$$\begin{aligned}
 d(Y(y))/dy &= (2y - 1)[Cg - Rg - z(\beta 1 - \beta 2) \\
 &\quad - (1 - x)zFg - (1 - x)Ws] \\
 J(z) &= Cg - Rg - z(\beta 1 - \beta 2) - (1 - x)zFg - (1 - x)Ws
 \end{aligned}$$

From the stability theorem of the differential equation, it follows that the probability of a government department choosing to regulate

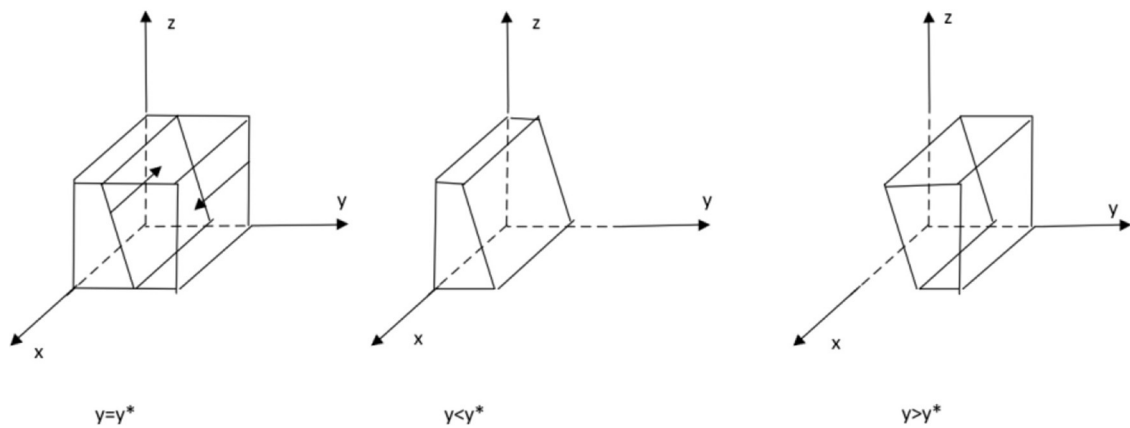


FIGURE 1  
Phase diagram of the evolution of private sector strategies.

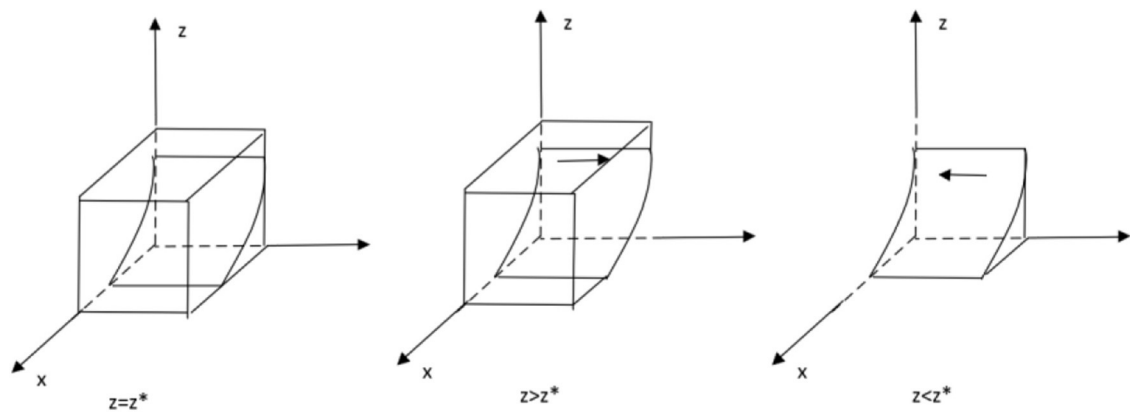


FIGURE 2  
Phase diagram of the evolution of government sector strategies.

must be in a steady state:  $Y(y) = 0$  and  $d(Y(y))/dy < 0$ . Because  $\partial J(z)/\partial z < 0$  therefore  $J(z)$  is a decreasing function with respect to  $z$ . Therefore when  $z = [Rg - Cg + (1-x)Ws]/[(x-1)Fg - (\beta_1 - \beta_2)] = z^*$ ,  $J(z) = 0$ . at this point  $d(Y(y))/dy \equiv 0$ , the government department cannot determine a stabilization strategy. When  $z < z^*$ ,  $J(z) > 0$ , at this point  $d(Y(y))/dy|_{y=0} < 0$ , at this point,  $y = 0$  is the evolutionary stability strategy for the government sector. Conversely when  $z > z^*$ ,  $J(z) < 0$ ,  $d(Y(y))/dy|_{y=1} < 0$ , at this point,  $y = 1$  is the evolutionary stability strategy of the government sector. The evolutionary phase diagram of the government sector's strategy is shown in the following Figure 2.

### 3.4. Public strategy stability analysis

The expected benefits of public scrutiny, no scrutiny and the average expected benefits are:

$$Y_{31} = xy(Rp - Cp) + x(1-y)(Rp - Cp) + (1-x)y(Rp - Cp - R1 + P)$$

$$Y_{32} = (1-x)y(-R1) + (1-x)(1-y)(-R1) \\ \bar{Y}_3 = zY_{31} + (1-z)Y_{32}$$

The replication dynamics equation for the public is:

$$Y(z) = dz/dt = z(Y_{31} - \bar{Y}_3) = z(z-1)[Cp - Rp - P + Px]$$

The first order derivative of  $z$  and the set  $D(x)$  are:

$$d(Y(z))/dz = (2z-1)[Cp - Rp - P + Px] \\ D(x) = Cp - Rp - P + Px$$

It follows from the stability theorem of the differential equation that the probability of the public choosing to monitor must be in a steady state if it is to satisfy:  $Y(z) = 0$  and  $d(Y(z))/dz < 0$ . Because  $\partial D(x)/\partial x > 0$  therefore  $D(x)$  is an increasing function with respect to  $x$ . Therefore, when  $x = (P + Rp - Cp)/P = x^*$ ,  $D(x) = 0$ , at this point  $d(Y(z))/dz \equiv 0$ , the public cannot determine a stabilization strategy.

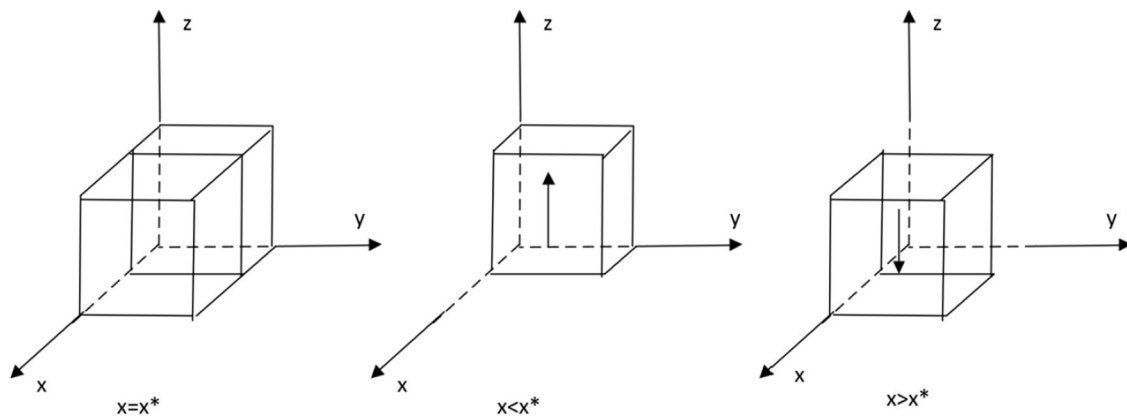


FIGURE 3  
Phase diagram of the evolution of the public's strategy.

When  $x > x^*$ ,  $D(x) > 0$ , at which point  $d(Y(z))/dz|_{z=0} < 0$ , at which point  $z = 0$  is the evolutionary stabilization strategy for the public. Conversely, when  $x < x^*$ ,  $D(x) < 0$ ,  $d(Y(z))/dz|_{z=1} < 0$ , and at this point,  $z = 1$  are the public's evolutionary stable strategies. The evolutionary phase diagram of the public's strategy is shown in the following Figure 3.

### 3.5. Stability analysis of the equilibrium point of a tripartite evolutionary game system

The equilibrium point of the system can be obtained from  $Y(x) = 0$ ,  $Y(y) = 0$ ,  $Y(z) = 0$  as  $E1(0, 0, 0)$ ,  $E2(1, 0, 0)$ ,  $E3(0, 1, 0)$ ,  $E4(0, 0, 1)$ ,  $E5(1, 1, 0)$ ,  $E6(1, 0, 1)$ ,  $E7(0, 1, 1)$ ,  $E8(1, 1, 1)$ . The Jacobian matrix of the three-party evolutionary game system is:

$$J = \begin{bmatrix} J1 & J2 & J3 \\ J4 & J5 & J6 \\ J7 & J8 & J9 \end{bmatrix} = \begin{bmatrix} \partial Y(x)/\partial x & \partial Y(x)/\partial y & \partial Y(x)/\partial z \\ \partial Y(y)/\partial x & \partial Y(y)/\partial y & \partial Y(y)/\partial z \\ \partial Y(z)/\partial x & \partial Y(z)/\partial y & \partial Y(z)/\partial z \end{bmatrix}$$

$$= \begin{bmatrix} (2x-1)[CH-CL-We-z(\alpha_1-\alpha_2)-yWs] & -x(x-1)Ws & -x(x-1)(\alpha_1-\alpha_2) \\ y(y-1)(zFg+Ws) & (2y-1)[Cg-Rg-z(\beta_1-\beta_2)-(1-x)zFg-(1-x)Ws] & y(y-1)[-(\beta_1-\beta_2)-(1-x)Fg] \\ z(z-1)P & 0 & (2z-1)[Cp-Rp-P+Px] \end{bmatrix}$$

The analysis of the equilibrium points is shown in Table 3.

## 4. Simulation analysis

In order to verify the validity of the evolutionary stability analysis, the model was assigned to a realistic situation and simulated using Matlab 2022a software. Regarding the assignment of values, first, according to the equilibrium point analysis in Table 2, it is known that (1,1,1) is a stable point, and in order to satisfy the equilibrium condition, all three eigenvalues of (1,1,1) need to be negative, that is, to satisfy  $Cp - Rp < 0$ ,  $\beta_2 - \beta_1 + Cg - Rg < 0$ ,  $\alpha_2 - \alpha_1 + CH - CL - We - Ws < 0$ . Secondly, reference to the established literature

reveals that in order to simplify the operations of the simulation analysis, the values are chosen for ease of handling, provided that the three inequalities mentioned above are satisfied (21–23). The values are assigned as follows:  $Cp = 10$ ,  $Rp = 15$ ,  $\beta_1 = 30$ ,  $\beta_2 = 5$ ,  $Cg = 30$ ,  $Rg = 20$ ,  $\alpha_1 = 20$ ,  $\alpha_2 = 10$ ,  $CH = 70$ ,  $CL = 30$ ,  $We = 30$ ,  $WS = 80$ ,  $Fg = 100$ ,  $P = 300$ . With the above assignments, the impact of certain parameters on the process and outcome of the evolutionary game is analyzed.

### 4.1. Private sector sensitivity analysis

The effect of  $We$  on the process and outcome of the evolutionary game is analyzed. The simulation results of assigning  $We$  to  $We = 30, 50, 70$ , respectively, and replicating the system of dynamic equations evolving 50 times over time are shown in Figure 4. Figure 4 shows that as the system evolves to a point of stability, an increase in government subsidies to private sector operations accelerates the rate of evolution of the private sector to provide high quality services. That is, as  $We$  increases, the rate at which  $x$  converges

to “1” increases (The  $y$ - $x$  cross section shows that the higher the value of  $We$ , the closer the value of  $x$  is to “1” when the same value of  $y$  is taken). This suggests that government subsidies to the private sector in the combined medical and health-care PPP development process are an important motivation for the private sector's choice to provide high quality services. The above findings are generally consistent with the reality that the higher the subsidy given by the government, the stronger the willingness of the private sector to provide high quality services. The above conclusions are statistically significant, but since the analysis conducted is a simulation, which is more of a measure of the methodology, it lacks a certain degree of comparison with reality.

TABLE 3 Equilibrium point stability analysis.

Balancing point	Jacobian matrix eigenvalues	Symbols	Stability
	$\lambda_1, \lambda_2, \lambda_3$		
$E1(0, 0, 0)$	$CL - CH + We, P - Cp + Rp, Rg - Cg + Ws$	$(\times, +, \times)$	Unstable
$E2(1, 0, 0)$	$Rg - Cg, Rp - Cp, CH - CL - We$	$(\times, +, \times)$	Unstable
$E3(0, 1, 0)$	$Cg - Rg - Ws, P - Cp + Rp, CL - CH + We + Ws$	$(\times, +, +)$	Unstable
$E4(0, 0, 1)$	$Cp - P - Rp, \alpha 1 - \alpha 2 - CH + CL + We, \beta 1 - \beta 2 - Cg + Fg + Rg + Ws$	$(-, +, +)$	Unstable
$E5(1, 1, 0)$	$Cg - Rg, Rp - Cp, CH - CL - We - Ws$	$(\times, +, -)$	Unstable
$E6(1, 0, 1)$	$Cp - Rp, \beta 1 - \beta 2 - Cg + Rg, \alpha 2 - \alpha 1 + CH - CL - We$	$(-, +, -)$	Unstable
$E7(0, 1, 1)$	$Cp - P - Rp, \beta 2 - \beta 1 + Cg - Fg - Rg - Ws, \alpha 1 - \alpha 2 - CH + CL + We + Ws$	$(-, -, +)$	Unstable
$E8(1, 1, 1)$	$Cp - Rp, \beta 2 - \beta 1 + Cg - Rg, \alpha 2 - \alpha 1 + CH - CL - We - Ws$	$(-, -, -)$	ESS

$$Cp - Rp < 0, \beta 2 - \beta 1 + Cg - Rg < 0, \alpha 2 - \alpha 1 + CH - CL - We - Ws < 0.$$

The private sector aims to maximize its own interests, and higher operating subsidies can be used by the private sector to cover the high costs of providing high quality services, but in reality, government funds are limited and the amount of operating subsidies expected by the private sector cannot be fully met. The government should provide appropriate incentives to the private sector when conditions permit, in order to promote the provision of high quality services and sustainable development of combined medical and health-care PPP projects.

The effect of  $Ws$  on the process and outcome of the evolutionary game is analyzed. The simulation results of assigning  $Ws$  to  $Ws = 40, 80, 120$ , respectively, and replicating the system of dynamic equations evolving 50 times over time are shown in Figure 5. Figure 5 shows that as the system evolves to a point of stability, an increase in the default penalty imposed by the government on the private sector accelerates the rate of evolution of the private sector in providing quality services. That is, as  $Ws$  increases, the rate at which  $x$  converges to “1” increases (The  $y$ - $x$  cross section shows that the higher the value of  $Ws$ , the closer the value of  $x$  is to 1 when the same value of  $y$  is taken). This suggests that the government should increase the penalties for private sector default in the combined medical and health-care PPP development process, as higher penalties will deter the private sector from stepping over the “red line” of default, and encourage the private sector to provide high quality services. The private sector aims to maximize its own interests, and if the operating subsidy provided by the government does not cover the cost of providing high quality services, the private sector may choose to provide low quality services in order to maximize its own interests.

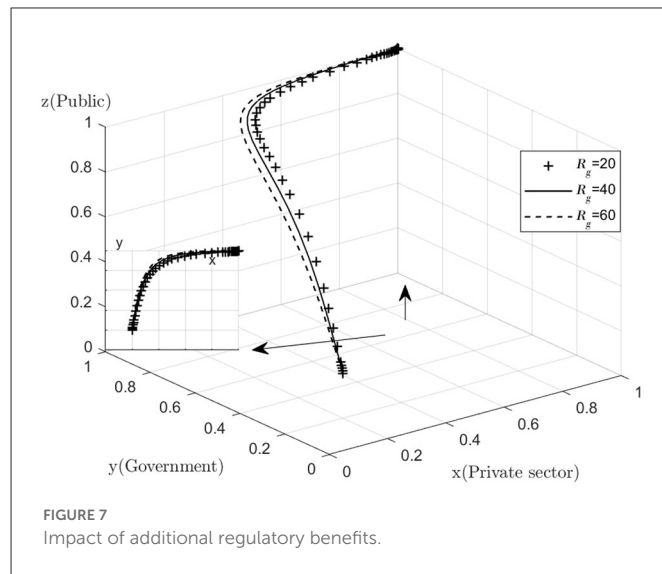
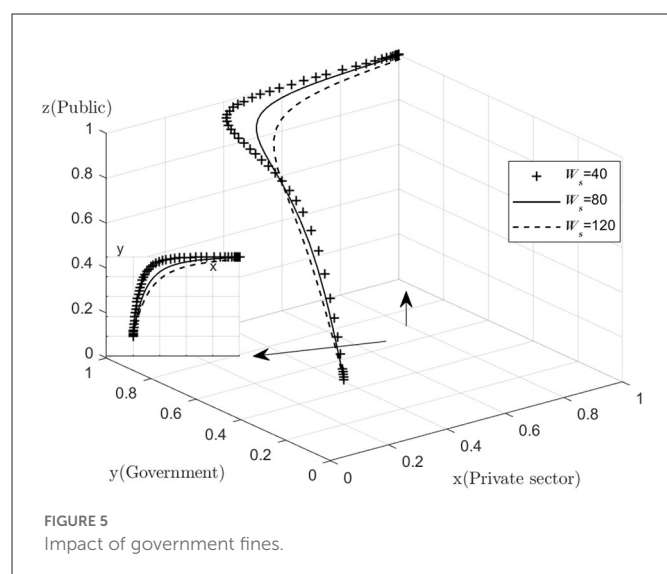
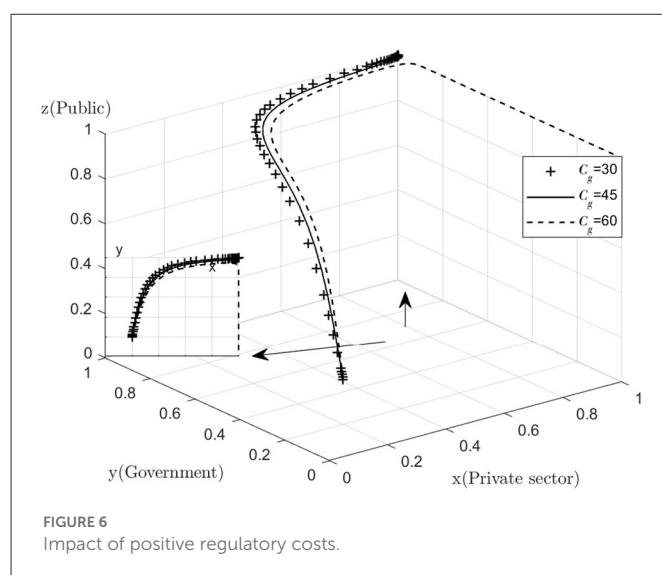
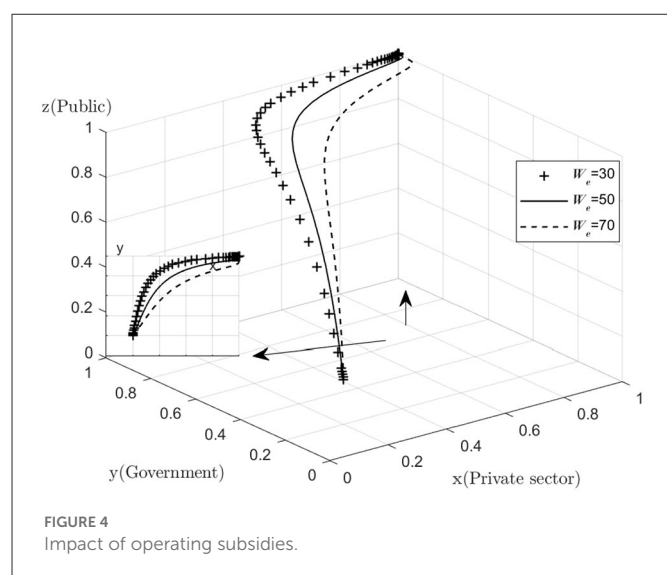
In the light of the above sensitivity analysis on operating subsidies, the government should offer the private sector a combination of incentives and deterrents by increasing the private sector's operating subsidies where possible, and by setting high penalties for non-compliance so that the private sector is both satisfied with the subsidies and deterred by the severity of the penalties.

## 4.2. Government sensitivity analysis

Analyze the effect of  $Cg$  on the process and outcome of the evolutionary game. The simulation results for replicating the system

of dynamic equations evolving 50 times over time by assigning  $Cg$  to  $Cg = 30, 45, 60$ , respectively, are shown in Figure 6. Figure 6 shows that, as the system evolves to a point of stability, the decrease in the cost of active government regulation speeds up the evolution of government departments from “non-regulation” to “regulation.” That is, as  $Cg$  decreases,  $y$  converges to “1” at a faster rate (The  $y$ - $x$  cross section shows that for the same value of  $x$ , the lower the value of  $Cg$ , the closer the value of  $y$  is to “1”). This shows that in the process of combined medical and health-care PPP development, as the cost of regulation decreases, the willingness of governments to choose to regulate is significantly enhanced. Since the government's main demand is to pursue social interests and maximize its own interests, if the cost of regulation is too high and the additional benefits of regulation are lower than the cost of regulation, the government may reduce its willingness to actively regulate. If the combined medical and health-care PPP project is left unregulated for a long period of time, there is no guarantee that the private sector will choose to provide high quality services in order to maximize their own interests, resulting in a low quality of operation of the combined medical and health-care PPP project. If the public finds that the government is not actively regulating, they may give the government a lower level of reputation and the government's reputation will be damaged. In the long run, the combined medical and health-care PPP project may end up as a failure with minimal overall social utility. However, for a number of reasons, the government is unable to significantly reduce the cost of regulation in the short term while ensuring the quality of regulation, so the government needs to consider the overall interests of society and its own reputation and insist on active regulation.

Analyze the effect of  $Rg$  on the process and outcome of the evolutionary game. The simulation results for replicating the system of dynamic equations evolving 50 times over time by assigning  $Rg$  to  $Rg = 20, 40, 60$ , respectively, are shown in Figure 7. Figure 7 shows that, as the system evolves to a point of stability, the increase in the additional benefits of active government regulation speeds up the evolution of government departments from “no regulation” to “regulation.” That is, as  $Rg$  increases, the rate at which  $y$  converges to “1” increases (The  $y$ - $x$  cross section shows that for the same value of  $x$ , the higher the value of  $Rg$ , the higher the value of  $y$  tends to “1”). This suggests that the willingness of the government to choose to engage in active regulation has increased significantly as the additional benefits gained from active government regulation increase. If the additional benefits of regulation are too small to compensate for the high cost



of active regulation, the government may be less willing to actively regulate. If the public finds that the government is not actively regulating, they may give the government a lower level of reputation, which may result in the government's reputation being damaged. However, for many reasons, the regulatory subsidies received by the government will not increase significantly in the short term, so the government needs to consider more about the overall interests of society and its own credibility level and insist on active regulation.

### 4.3. Public sensitivity analysis

With regard to the sensitivity analysis of the public, as the changes in quantities  $C_p, R_p$  are too subtle. Therefore, the graph does not show a significant difference, but a common sense analysis shows that the decrease in the cost of active monitoring and the increase in the reward for active monitoring will help the public to increase their willingness to actively monitor. The public's goal is to maximize their own interests, and those who will monitor the combined medical

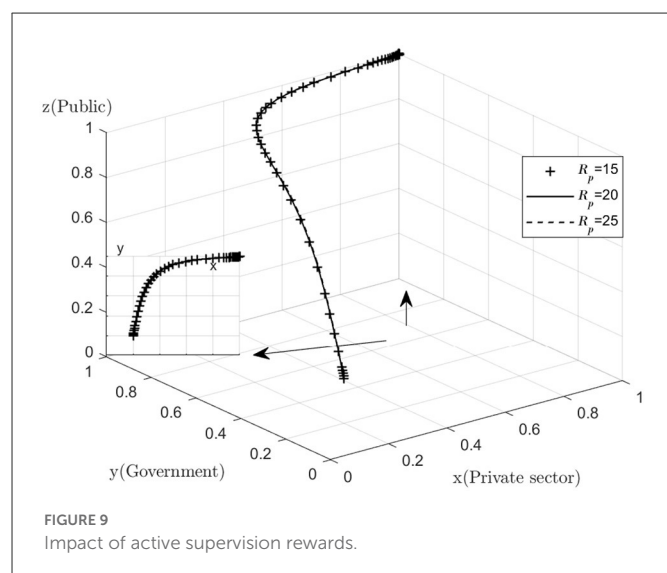
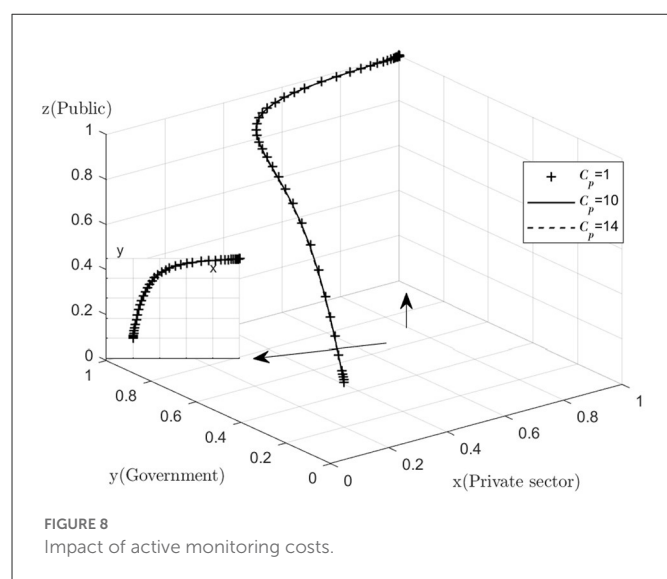
and health-care PPP project are mostly consumers of the combined medical and health-care PPP project and their relatives, and it is the quality of the combined medical and health-care PPP project that they care most about. No matter how the value of  $C_p, R_p$  is varied, the difference in the final operating results is always small (Figures 8, 9).

## 5. Discussion

The most desirable combination of strategies for the three parties evolutionary game is (1, 1, 1), where the private sector provides high quality services, the government actively regulates and the public actively participates in monitoring. The following is an analysis of the respective evolutionary outcomes of the three parties.

The results of the private sector simulations show that the rate at which the private sector evolves toward "1" is determined by a combination of government subsidies  $W_e$  for high quality services and government fines  $W_s$  for low quality services. The private sector, aiming to maximize its own interests, if the government subsidies its operations sufficiently, or penalizes it sufficiently, or both, the





private sector is likely to choose to provide high quality services as an incentive and as a deterrent. In the case of the private sector, the government should be able to give the private sector both incentives and deterrents, while at the same time recognizing the deterrent effect of the penalties.

In combined medical and health-care PPP projects, the private sector often adopts two approaches to improve existing operations in order to increase the project's operating returns: the first is to improve the quality of health care services through internal optimization so that operating costs can be reduced, and the second is to reduce the quality of health care services to achieve a reduction in costs and thereby make a profit (24). The first approach requires significant resources to improve internal management practices and pioneer technological innovation while maintaining the current service prices, while the second approach is opportunistic and may lead to a loss of interest for the public. The more subtle the public's perception of changes in the quality of the services provided by combined medical and health-care PPP project, the less scope there is for the private sector to make profits by cutting quality while keeping the price of the services the same.

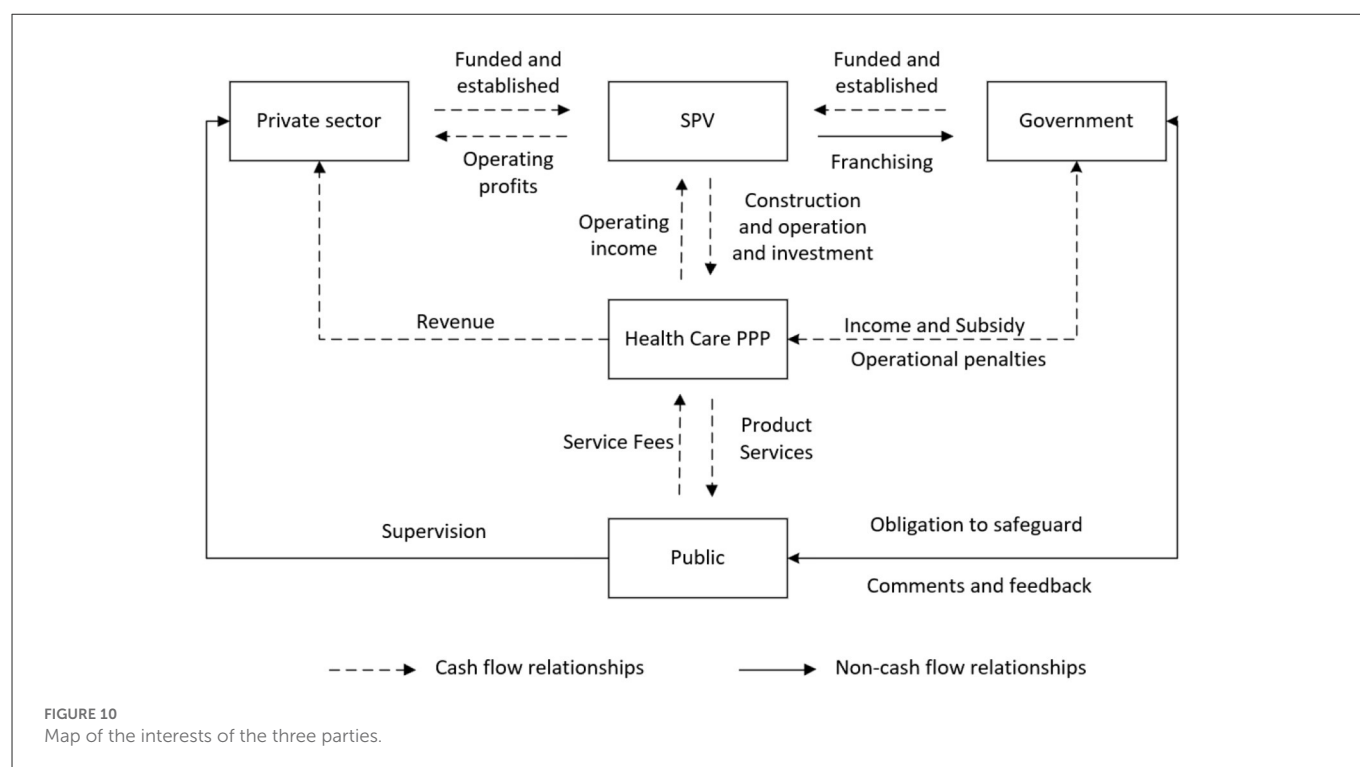
The simulation results for the government show that the cost of active government regulation  $C_g$  and the additional subsidies received by the government for active regulation  $R_g$  together determine the rate at which the government's evolutionary strategy evolves toward "1." If the cost of regulation is too high or if the subsidies received from active regulation are far from covering the cost of active regulation, the government's willingness to actively regulate will decline.

Under the combined medical and health-care PPP model, although government departments can improve the incompleteness of information by taking a small percentage of shares in the SPV (Special-Purpose-Vehicle), their role is limited after all. The threshold of expertise in the combined medical and health-care sector is high, and government departments need to continuously invest more resources and actively supervise in order to fully access the true operation of combined medical and health-care PPP projects.

Most combined medical and health-care PPP have an operational cycle of 15–20 years, while most local administrators are in office for only 5 years. This time mismatch may result in a situation where one administrator leaves the risks to the next, triggering intergenerational injustice. In the traditional GDP (Gross Domestic Product)-led promotion mechanism, basic projects can effectively incentivize local administrators with easily measurable results (25), yet by the time the project enters the operational phase, the local government department to which the combined medical and health-care PPP project belongs will have long since changed. As a result, the distorted incentive of administrative promotion has more or less inhibited the motivation of government departments to actively regulate.

Although it is not possible to determine changes in the state of evolution directly from the results of the public's simulation, it is important to recognize both the costs  $C_p$  and the rewards  $R_p$  of active public monitor. If the cost of monitoring is too high, this may also reduce the willingness of the public to monitor to a certain extent.

Combined medical and health-care PPP projects are inherently complex, and in most cases faced with the dilemma of involving multiple actors in management. By participating in monitoring and providing feedback, the public can identify gaps in the management and quality of services provided by the government and the private sector. The public is in a weaker position in the game than the government and the private sector, and although they can report or defend their rights against poor quality services through online disclosure platforms, but often with a longer waiting period. This has led to two types of negative behavior: firstly, some members of the public prefer to accept low quality health-care services rather than spend time and money to defend their rights, and secondly, the occurrence of extreme behavior such as "medical malpractice," which has a negative impact on the good functioning of public order and may also affect the health and well-being of individuals, may be followed by the rest of the public if not dealt with properly. Therefore, there is a high probability that the public will choose to actively monitor the situation, but the cost of defending their rights after the monitoring becomes a key factor in whether the public will carry out the monitoring to the end. At this point, appropriate motivations from the government may stimulate the public's willingness to defend their rights, prompting them to carry out their rights to the end, and then promote the development of combined medical and health-care PPP projects in the direction of quality.



## 6. Case studies

The Hongjiang People's Hospital Tongxin Medical and Health-Care Centre PPP Project is located in Hongjiang, Huaihua City, Hunan Province. The project is operated under the ROT (Rehabilitate-Operate-Transfer) model, in which the Hongjiang People's Hospital is authorized by the Hongjiang Municipal Government and appointed to co-finance the project company with the private sector, also known as SPV. The Hongjiang Municipal Government and the SPV signed the PPP Project Contract, granting the SPV the concession to undertake the construction, operation, maintenance and renewal and replacement of the project during the cooperation period.

The project is a profit-making medical and health-care project. During the cooperation period, the project company is responsible for operating the project for 30 years to recover the investment and obtain reasonable income. At the same time, the government will regulate and assess the operation and maintenance of the project during the partnership period, and discipline the project company to ensure the quality of service through performance assessment. The public also monitors the actions of the government, the private sector and the SPV company to ensure that their interests are maximized. The following diagram shows the relationship between the interests of the three parties involved in the PPP project for the Tongxin Medical and Health-Care Centre of the Hongjiang People's Hospital (Figure 10).

## 7. Conclusions and recommendations

This paper investigates the behavioral strategies of the three parties in the process of PPP regulation of health-care integration,

and analyzes the evolutionary stabilization strategies of the three parties by constructing an evolutionary game model. The above simulation results show that there are two ways to increase the willingness of the private sector to provide high quality services, either by increasing the amount of government subsidies to the private sector or by increasing the level of government penalties to the private sector. Moreover, the motivation for government departments to regulate depends heavily on the cost of regulation or the benefits of regulation. At the same time, the ability of the public to regulate combined medical and health-care PPP projects depends largely on incentives. The three parties' ultimate ideal situation is that the private sector provides high quality services, the government actively regulates, and the public actively participates in monitoring. This paper enriches the study of game behavior strategies among multiple subjects in the field of health care combination, and lays the foundation for subsequent game studies.

At present, the government has put forward relevant regulations on possible problems in regulation, such as requiring that both construction and operation costs of projects borne by the government should be paid based on the results of performance assessment, and that the portion of construction costs involved in performance assessment should not be <30%. In order to further improve the quality of regulation of combined medical and health-care PPP projects and promote the sustainable development of combined medical and health-care PPP projects, this paper puts forward the following recommendations:

- (1) Establish an independent regulator, broaden public feedback channels and improve PPP-related laws (26). Establish a regulatory body that is independent of the government and the private sector and runs through the entire life cycle of

combined medical and health-care PPP projects (27). The regulator will have independent regulatory and approval functions, and can impose uniform administrative penalties on the private sector and local governments for dereliction of duty. The existing public feedback channels can be broadened, and a PPP credit platform can be established for the whole society, in the form of an app or public number as a carrier, and the private sector can be included in the credit “blacklist” for dereliction of duty, thus increasing the cost of their opportunism.

- (2) Innovate project operation methods and enhance the operational capacity of enterprises. At present, most of the combined medical and health-care PPP models in the market are newly built, and there is a large backlog of stock projects (28). The institutional inertia of the BOT (Build-Operate-Transfer) model, which has been used more often in the past for combined medical and health-care PPP projects, has led to the private sector’s main source of profit being the construction phase, lacking the incentive to innovate in form. Therefore, government departments can encourage the private sector to carry out combined medical and health-care PPP projects in the form of TOT (Transfer-Operate-Transfer), LOT (Lease-Operate-Transfer) and ROT (Rehabilitate-Operate-Transfer), and further revitalize existing health-care resources by integrating and transforming them (29).

Although this paper has studied the evolutionary game of the three parties players in the PPP of combined medical and health-care, it is less relevant to the actual situation because it is a simulation analysis, and further integration with actual cases and introduction of algorithmic models into the field of health-care combination can be considered in the future (30, 31). Meanwhile, this paper only studies the interest relationship between the government, the private sector and the public. In the future, intermediate organizations can be introduced to form a quadrilateral interest relationship and conduct a quadrilateral evolutionary game study.

## References

1. Central Committee of the Communist Party of China State Council. *Opinions on Strengthening the Work of the Elderly in the New Era*. Available online at: <https://www.lawinfochina.com/display.aspx?id=37240&lib=law&SearchKeyword=&SearchCKeyword=> (accessed on November 18, 2021).
2. Wang YJ. *Research on the Choice of Financing Model of “Integrated Medical Care” PPP Project Based on Cloud Model*. (2021). Harbin, China: Harbin University of Commerce.
3. Song Y, Bian Y. Discussions on Application of Public Private Partnerships in Healthcare: Case Study from the Development Kiang Wu Hospital. *Med Philosoph*. (2012) 33:54–5.
4. Goldman M, Compton C, Mittleman B B. Public-private partnerships as driving forces in the quest for innovative medicines. *Clin Transl Med*. (2013) 2:1–3. doi: 10.1186/2001-1326-2-2
5. Dai Y, Sun H, Zhou L. Study on medical service supply public-private partnership mode: Based on the view of public economics. *J Central South University (Medical Science)*. (2015) 40:214–21. doi: 10.11817/j.issn.1672-7347.2015.02.017
6. Yang YX. *Research on the PPP Mode Introduced into the Field of Medical Treatment in China*. Ningbo, China: Ningbo University (2019).
7. Zhang L. Research on PPP model to promote the development of China’s pension institutions. *Guangdong Univ For Stud*. (2018).
8. Yang LJ, Chen KY. Study on Financing and Operation Mechanism of Medical-nursing Combined PPP Projects. *Health Econ Res*. (2021) 38:48–52. doi: 10.14055/j.cnki.33-1056/f.2021.06.032
9. Zhang C, Yan YL. Study on the Combination of Medicine and caring under PPP mode—Based on Social Exchange Theory. *Health Econ Res*. (2019) 46:45–7. doi: 10.14055/j.cnki.33-1056/f.2019.08.013
10. Hao T, Shang Q, Li J. Research on the effective supply path of combined medical and nursing care services under PPP model. *Macrocon Res Macrocon*. (2018) 11:44–53. doi: 10.16304/j.cnki.11-3952/f.2018.11.004
11. Wang SG, Zhang LD, Wang X. Analysis of Constraints on the Development of Social Aged Care Services and Path Selection—Harbin City as an Example. *Sub Natl Fiscal Res*. (2018) 11:79–84.
12. Mou CL. PPP. Mode and countermeasure analysis about medical-nursing combined service developed by social strength. *Northwest Popul J*. (2018) 39:105–11. doi: 10.15884/j.cnki.issn.1007-0672.2018.02.014
13. He SK. Research on the problems and governance paths of the social capital participating in the program of the combination of medical treatment and elderly care. *Contemp Econ Manage*. (2018) 40:53–9. doi: 10.13253/j.cnki.ddjjgl.2018.11.008
14. Che ZY, Zhu WL, Zhang X, Bin CM. Research on the development dilemma and countermeasures of the integration of medical and health care under PPP model - taking Hefei and Bengbu cities of Anhui Province as examples. *Southern Entrepreneur*. (2018) 02:206–7.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

MZ: conceptualization, methodology, formal analysis, and writing—original draft. PY: study supervision. Both authors contributed to the article and approved the submitted version.

## Funding

The article was funded by the Social Science Foundation of Jiangsu Province—Research on the Cooperation Mechanism between Jiangsu Social Capital and the Government in the Context of Rural Revitalization Strategy (No. 19EYB009).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher’s note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

15. Sabry M I. Good governance, institutions and performance of public private partnerships. *Int J Public Sector Manage.* (2015). doi: 10.1108/IJPSM-01-2015-0005
16. Yue XH, Lin YM. Evolutionary Game and Simulation Analysis on Quality of Elderly Care Service PPP Projects under Government Supervision in China. *Soc Secur Stud.* (2020) 06:3–14.
17. Chao XL, Mao SL. Advantages of cooperation, operation mode and regulatory design: Analysis of the PPP model for institutional care in Province F. *Theor Invest.* (2017) 03:171–6.
18. Han XP, Chen M. Problems and countermeasures in the operation of PPP model of elderly care in China. *Econ Rev J.* (2018) 04:81–6.
19. Xu H, Yue QY. The Development Model and Path Optimization of PPP for the Aging Service Industry. *Fin Econ.* (2018) 05:119–32.
20. Teng Y, Pang B, Wei J, Ma L, Yang H, Tian Z. Behavioral decision-making of the government, farmer-specialized cooperatives, and farmers regarding the quality and safety of agricultural products. *Front Public Health.* (2020) 10:920936. doi: 10.3389/fpubh.2022.920936
21. Liu MM. *Research on Evolutionary Game Behavior of Collaboration Network.* Jinan, China: Shandong Normal University (2021).
22. Nash Jr J F. Equilibrium points in n-person games. *Proc Natl Acad Sci.* (1950) 36:48–9. doi: 10.1073/pnas.36.1.48
23. Smith J, Price G R. The logic of animal conflict. *Nature.* (1973) 246:15–8. doi: 10.1038/246015a0
24. Hart O. Incomplete contracts and public ownership: Remarks, and an application to public University. (2021). *Econ J.* (2003) 113:C69–76. doi: 10.1111/1468-0297.00119
25. Zhou LA. Administrative subcontract. *Chin J Sociol.* (2014) 34:1–38. doi: 10.15992/j.cnki.31-1123/c.2014.06.001
26. Huang CY. China's practical wisdom: Assumption of liability for endangering public health in bankruptcy proceedings—A case study of the Changchun Changsheng Biotechnology vaccine incident and the Johnson & Johnson baby powder incident. *Front Public Health.* (2022) 10:1003330. doi: 10.3389/fpubh.2022.1003330
27. Liao WD, Liao JN. On the predicament and optimization path of ppp pension industry based on collaborative governance. *Jiangxi Soc Sci.* (2020) 40:212–21+256.
28. Yue, XH, Lin, YM. Study on the evolutionary game relationship among three parties in the regulation of quality of elderly PPP services. *J Jiangxi Univ Fin Econ.* (2019) 2019:71–80. doi: 10.1155/2019/9641429
29. Song LC, Yang J. Research on the stakeholders behavior in PPP projects of the combination of medical treatment and elderly care based on triple evolutionary game theory. *J Eng Manage.* (2020) 34:79–84. doi: 10.13991/j.cnki.jem.2020.03.015
30. Zhang H, Zhang N, Wu W, Zhou R, Li S, Wang Z, et al. Machine learning-based tumor-infiltrating immune cell-associated lncRNAs for predicting prognosis and immunotherapy response in patients with glioblastoma. *Brief Bioinform.* (2022) 23:bbac386. doi: 10.1093/bib/bb ac386
31. Zhang N, Zhang H, Wu W, Zhou R, Li S, Wang Z, et al. Machine learning-based identification of tumor-infiltrating immune cell-associated lncRNAs for improving outcomes and immunotherapy responses in patients with low-grade glioma. *Theranostics.* (2022) 12:5931. doi: 10.7150/thno.74281



## OPEN ACCESS

## EDITED BY

Timotej Jagric,  
University of Maribor, Slovenia

## REVIEWED BY

Rajendra Kadel,  
Public Health Wales NHS Trust, United Kingdom  
Shen Weiteng,  
Zhejiang Wanli University, China

## \*CORRESPONDENCE

Jin Ke  
✉ kejin981129@gmail.com

<sup>†</sup>These authors share first authorship

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 16 November 2022

ACCEPTED 18 January 2023

PUBLISHED 10 February 2023

## CITATION

Li W, Ke J and Sun F (2023) Long-term care  
insurance and multidimensional poverty of  
middle-aged and elderly: Evidence from China.  
*Front. Public Health* 11:1100146.  
doi: 10.3389/fpubh.2023.1100146

## COPYRIGHT

© 2023 Li, Ke and Sun. This is an open-access  
article distributed under the terms of the  
[Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/).  
The use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in this  
journal is cited, in accordance with accepted  
academic practice. No use, distribution or  
reproduction is permitted which does not  
comply with these terms.

# Long-term care insurance and multidimensional poverty of middle-aged and elderly: Evidence from China

Wenxiu Li<sup>1†</sup>, Jin Ke<sup>2\*†</sup> and Fei Sun<sup>3</sup>

<sup>1</sup>School of Economics and Trade, Guangdong University of Finance, Guangzhou, China, <sup>2</sup>School of Economics and Management, South China Normal University, Guangzhou, China, <sup>3</sup>School of Social Work, Michigan State University, East Lansing, MI, United States

**Introduction:** This paper examined the impact of public long-term care insurance (LTCI) pilots in China on the multidimensional poverty status of middle-aged and older adults.

**Methods:** Using panel data from the China Health and Retirement Longitudinal Survey, we utilized LTCI pilots conducted in different cities from 2012 to 2018 and assessed the impact of LTCI using a difference-in-differences strategy.

**Results:** We found that the implementation of LTCI reduces the multidimensional poverty of middle-aged and older adults and their likelihood of future multidimensional poverty. LTCI coverage was also associated with a reduction in the likelihood that middle-aged and older adults in need of care fall into income poverty, living consumption poverty, health poverty, and social participation poverty.

**Discussion:** From a policy perspective, the findings of this paper suggest that the establishment of an LTCI system can improve the poverty of middle-aged and older adults in several ways, which has important implications for the development of LTCI systems in China and other developing countries.

## KEYWORDS

long-term care insurance, multidimensional poverty, middle-aged and elderly, difference-in-differences model, China

## 1. Introduction

The causes of poverty are complex and multifaceted, with one of the most overlooked being the need for care due to physical disability and handicap (1). According to research conducted in developing countries, people with disabilities and their families are poorer and more likely to fall into poverty than families without a disabled person (2–4). People with disabilities and their families, on average, face additional direct costs (e.g., medical expenses), indirect costs (e.g., informal care), and opportunity costs (e.g., labor supply) than families without a disabled person, making them more vulnerable to poverty or chronic poverty (5). The vast majority of care services are provided and paid for by families and individuals (6). Informal caregiving within the family can be extremely costly in terms of both time and money, and affect unpaid caregivers' physical and mental health (7). Primary caregivers' employment status and work hours may suffer as a result of caring for their parents (8). However, only 6% of the world's population has access to government-sponsored long-term care assistance (6). Skilled formal care from professional caregivers is expensive in both developed and developing countries. When the price of care is solely determined by the market, individuals in need of care can quickly fall into a poverty trap due to costly care. In 1995, Germany pioneered the world's first long-term care social insurance system based on the care assistance system, providing specialized long-term care insurance (LTCI), which has greatly alleviated the poverty of the disabled. In China, the first public LTCI program pilots began in 2016. The purpose of this study is to examine the poverty reduction effects of a public LTCI program recently piloted in China.



For China, the number of disabled older adults (including those with mild, moderate, and severe disabilities based on ADL scores) expected to rise from 43.75 million in 2020 to 91.4 million in 2050, with growth rates of 108, 104, and 120% for older adults with mild, moderate, and severe disabilities, respectively, in 2050 compared to 2020, and total care costs are expected to rise from ¥538 billion in 2020 to ¥8,530.8 billion in 2050 (9). The traditional model of informal care provided by families in China is unsustainable as the proportion of nuclear families rises. Family members are tethered to provide care for relatives with disabilities, making it difficult for them to find work and miss out on development opportunities, leaving families in financial distress. The most common type of poverty for people with disabilities and their families is “poverty due to disability.”

However, a single monetary indicator does not fully reflect the poverty status of the individual. Poverty does not only mean low income, but also a lack of individual capability. Sen (10) defines a person's capability as the combination of possible functioning that a person is capable of achieving, and functioning reflects a wide range of things or states that a person considers worth doing or achieving, including both the basic functions such as maintaining health, obtaining adequate nutrition, and avoiding disease, as well as complex functions such as happiness, self-esteem, and being able to participate in social activities. The loss of these functions is a manifestation of poverty and is closely related to progress in achieving social justice (11). Therefore, a multidimensional perspective is needed to investigate the capability deprivation of people with disabilities, and a multidimensional poverty theory based on the capability study approach provides this perspective. This theory contributes to the investigation of inequalities in the deprivation of capability among people with disabilities, as well as providing a comprehensive framework for investigating the negative effects suffered by people with disabilities (12). According to multidimensional poverty theory, income deprivation cannot be used as a consensual indicator variable to adequately capture the degree of individual deprivation in real-world contexts where markets are imperfect or non-existent. Individual deprivation must be considered in terms of multiple functional dimensions to properly measure individual poverty.

Previous studies have broadly selected dimensions from the following to measure the multidimensional poverty level of people with disabilities: Income, consumption, material wellbeing, social participation, health, psychological wellbeing, education, and employment are all factors to consider (4, 5, 12, 13). The additional direct, indirect, and opportunity costs that people with disabilities and their families must bear have a negative impact on their income and consumption (14). Difficulty in accessing basic life materials, such as sanitation and clean water, is also an important dimension of the capability deprivation of the poor. The physical mobility constraint of people with disabilities also leads to partial and complete loss of their social interaction and social mobilization, which often means weakened and discrete social networks, and the mobility constraint is an important cause of people's poverty (15). Furthermore, people with disabilities frequently face social exclusion in areas such as health care, education, employment, and social participation (16). People with disabilities tend to have poorer health and are more likely to be depressed compared to people without disabilities (17, 18).

The poverty alleviation system of the Chinese government has been based on the multidimensional poverty theory, which focuses on five aspects of poverty alleviation: food, clothing, education, medical care, and housing. The “poverty alleviation by improving health care” policy is designed to protect the people in poverty the right to health, preventing poverty from being caused by illness, and preventing poverty from returning due to illness. In the context of this policy, to alleviate the “poverty due to disability” problem, the number of LTCI pilot cities in China increased from Qingdao to 49 cities from 2012 to 2021, with over 140 million participants. At the moment, individual contributions, financial subsidies, and the transfer of existing public health insurance fund balances are the primary sources of funding for the LTCI fund. For people with varying degrees of disability, the LTCI program offers a variety of care service plans and medical care coverage. The LTCI program offers three types of services: home care, institutional care, and hospital care, with home care offering two types of services: basic life care and usual clinical care.

For those who already receive LTCI services, LTCI may contribute to poverty reduction in multiple dimensions. For the household income dimension, LTCI has an impact on household income through two main impact paths. The first pathway is that LTCI can reduce care and medical expenditures. Lu et al. (19) find that LTCI led to significant reductions in individual hospital care and medical expenditures in Qingdao. Feng et al. (20) show that LTCI led to significant reductions in individual hospital care and medical expenditures in Shanghai. Kim and Lim (21) suggest that subsidies for formal care can reduce expenditures for the least able elderly in Korea. The reduction in care and medical expenses has increased household income. The second pathway is that LTCI can reduce the care burden and increase the labor supply of family caregivers. In Japan, LTCI reduces the burden on family caregivers and has a significant positive spillover effect on the labor supply to family caregivers (22, 23). Similarly, Shinya and Nakamura (24) find that LTCI can increase the female labor supply by reducing the burden of informal caregiving. The reduced burden of family caregiving and the increased labor supply of informal caregivers brought about an increase in family income. Rudiger and Seiler (25) find that LTCI causes a change in the income of some people who needed long-term care, causing them to no longer require social assistance. For the living consumption dimension, LTCI has a positive effect on living consumption (i.e., living expenses including clothing, food, housing, transportation, entertainment, communication, etc., excluding medical and educational expenses). In the same way that other public health insurance has a consumption-boosting effect (26), LTCI can promote living consumption by reducing care and medical expenditures and increasing household income. Similarly, on the material wellbeing dimension, LTCI can improve material wellbeing (e.g., sanitation, clean water) by lowering care and medical expenditures and increasing household income. For the health, psychological wellbeing, and social participation dimensions, previous studies on LTCI in developed countries found that it is associated with improved health status and lower mortality among those who are covered (27, 28). The diverse service formats of Chinese public LTCI programs may also help improve the health status and psychological wellbeing of the population covered by LTCI. Lei et al. (29) find that LTCI coverage improved the health status of the covered population in China and reduced mortality, as well as improved depression. Improvements in health status and

psychological wellbeing may also increase the frequency of social activities (30). Care services provided by LTCI may also help increase the frequency of social activities (31). For those who have not yet received LTCI services but are enrolled in LTCI, LTCI may promote living consumption and improve material wellbeing by reducing the anticipated financial burden from expected long-term care needs (32). Furthermore, LTCI may improve their health outcomes by alleviating the psychological burden associated with anticipated long-term care needs or the caregiving burden on the current care recipient's family caregiver (29).

The potential poverty-reducing efforts of Chinese public LTCI programs remain unknown. In this study, we examine the poverty reduction efforts of LTCI on middle-aged and older adults covered by the program, which are of particular interest to policy makers. Many developing countries that have plans to implement LTCI can also benefit from the experience of China's LTCI pilot.

Using panel data from the China Health and Retirement Longitudinal Survey (CHARLS), this paper contributes to the literature in the following ways. First, few studies have linked LTCI to poverty and focused on the impact of LTCI on poverty. With the perspective of multidimensional poverty, we assess the multidimensional poverty status of middle-aged and older adults across six dimensions: income, living consumption, material wellbeing, health, psychological wellbeing, and social participation, and evaluate the impact of LTCI on the multidimensional poverty status of middle-aged and older adults using a difference-in-differences (DID) strategy based on LTCI pilots launched in different cities in China from 2012 to 2018. We also analyze the heterogeneity of the impact of LTCI on multidimensional poverty based on the differences in LTCI systems in each pilot city to provide useful references for optimizing the LTCI system in China in more detail. Second, in order to more comprehensively assess the poverty reduction effect of LTCI, we construct multidimensional poverty vulnerability (MPV), a forward-looking indicator of poverty, and evaluate the impact of LTCI on it. Third, as one of the few studies evaluating the impact of the LTCI pilot, this paper provides evidence that the implementation of LTCI reduced multidimensional poverty and multidimensional poverty vulnerability among middle-aged and older adults. These findings are important for a complete cost-benefit analysis of LTCI and have policy relevance for other middle-income countries and developing countries.

## 2. Institutional background

To ensure affordable long-term care services for people in need, the Chinese central government issued guidelines in July 2016 to establish an LTCI system, conducted the first public LTCI pilots in 15 cities, and identified two provinces (i.e., Jilin and Shandong Provinces) as key provinces, which can choose cities within their provinces (other than the 15 cities mentioned above) as LTCI pilots.<sup>1</sup> Individual cities among the 15 initial pilot cities (e.g., Qingdao and Changchun) had previously launched LTCI pilots, and Weifang in Shandong Province had also launched an LTCI pilot in January 2015. In addition to the 15 first LTCI pilot cities and the self-defined LTCI

pilot cities of the two key provinces, individual cities (e.g., Jiaxing) conducted their LTCI pilots in 2016–2017 (see Figure 1).

The LTCI program relies on three basic medical insurance programs in China to expand its coverage: the Urban Employee Basic Medical Insurance (UEBMI), the Urban Resident Basic Medical Insurance (URBMI), and the Urban-Rural Resident Basic Medical Insurance (URRBMI). URBMI and New Rural Cooperative Medical Insurance (NRCMI) merged to form URRBMI, but URBMI remains in some cities. In 2020, UEBMI, URBMI, and URRBMI have covered more than 95% of the population. Residents who are already enrolled in basic health insurance will likely be automatically enrolled in LTCI, depending on the actual situation in the pilot cities.

The LTCI programs in most pilot cities were funded by basic medical insurance funds, and in some cities, the pilot programs were also supported by financial subsidies (e.g., Suzhou, Nantong) or welfare lottery funds (e.g., Shihezi). Individual cities may require individual contributions (e.g., Anqing requires an annual individual contribution of 20 RMB) or employer contributions (e.g., Shangrao requires an employing unit contribution of 5 RMB per employee per year) for funding.

Most cities require at least 6 months of long-term severe disability to receive benefits, but some cities (e.g., Nantong, Suzhou) allow people with moderate disabilities to receive LTCI benefits. The criteria for disability assessment are also not consistent. The majority of pilot cities assessed disability using the Barthel ADL index, while some pilot cities used localized assessment criteria (e.g., Suzhou, Chengdu).

Home care, full-time institutional care, and full-time hospital care are the three main types of services provided by the LTCI program. LTCI's expense reimbursement rates are all above 70%. In most cases, the actual treatment payment rate for people receiving LTCI benefits is usually determined by the service type. Home care benefits are covered at a higher rate than institutional or hospital care (e.g., LTCI pays 90% of the cost for those who choose home care in Guangzhou, with a payment ceiling of up to 115 RMB/person/day. However, LTCI pays 75% of the cost for those who choose institutional care, with a payment ceiling of up to 120 RMB/person/day.).

Although the LTCI program has only been in place for a short time, it is rapidly expanding in China. By 2020, there were 108,353,000 LTCI participants, among whom 835,000 people received benefits. There were 4,845 LTCI designated care service institutions, and 191,000 care service personnel. In 2020, LTCI fund income was 19.61 billion yuan (or \$2.9 billion), fund expenditure was 13.14 billion yuan (or \$1.93 billion), and per capita subsidies were 15,700 RMB (or \$2,310). On top of the original LTCI pilot cities, the Chinese central government expanded the LTCI pilot cities in May 2020, adding 14 new cities as LTCI pilots, making every province in the country have at least one LTCI pilot city. In September of that year, the Chinese central government increased the number of LTCI pilot cities to 49 and announced a plan to create a policy framework for a unified LTCI system by 2025.

## 3. Data and variables

### 3.1. China Health and Retirement Longitudinal Survey

This study used secondary data from the China Health and Retirement Longitudinal Survey (CHARLS), a large interdisciplinary

<sup>1</sup> Specific policy documents are available on the official website of the Chinese Ministry of Human Resources and Social Security: [http://www.mohrss.gov.cn/wap/zc/zcwj/201607/t20160705\\_242951.html](http://www.mohrss.gov.cn/wap/zc/zcwj/201607/t20160705_242951.html).

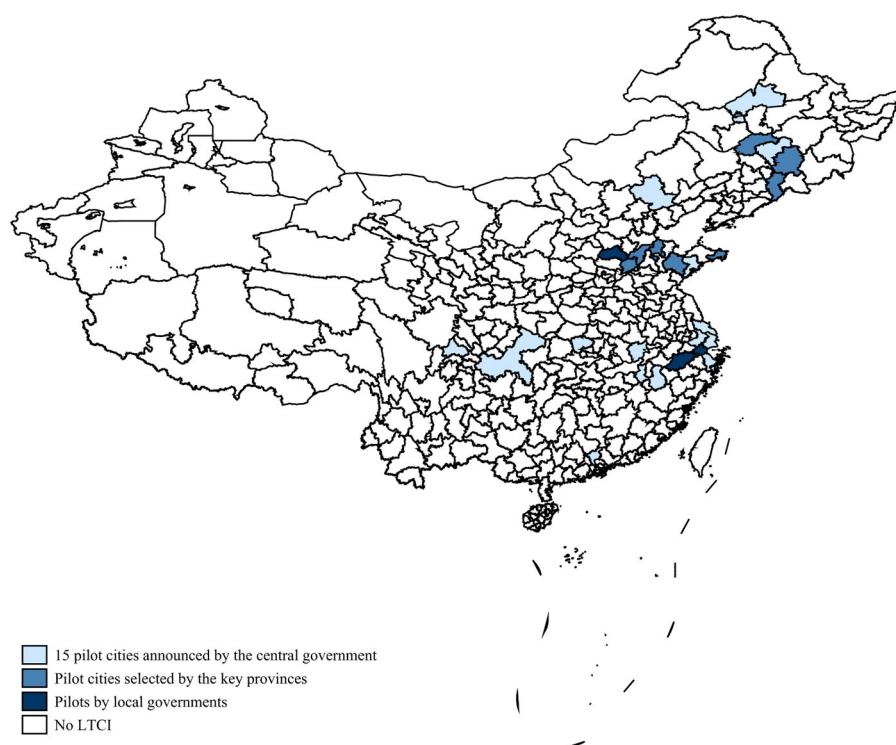


FIGURE 1

LTCI pilot cities (China, 2012–18). Self-collected by the author from publicly available policy documents at all levels of government. For details, see [Appendix B](#).

survey project hosted by Peking University's National Development Institute, implemented by Peking University's China Social Science Survey Center, and funded by the National Institute on Aging in the United States, the World Bank, and the National Natural Science Foundation of China (34). CHARLS aims to collect individual and household-level data on the Chinese population aged 45 and over, as well as their spouses. In 2011, CHARLS conducted a national baseline survey, and respondents were followed up every 2 years. CHARLS conducted survey interviews in 150 counties and 450 communities (or villages) in 28 provinces (autonomous regions and municipalities directly under the central government) across China in 2013, 2015, and 2018, with a total of 19,000 respondents in 12,400 households covered by 2018. Zhao et al. (34) provided more detailed information on the CHARLS sampling procedure, data quality, attrition, and response rates.

We primarily used CHARLS data from 2011, 2013, 2015, and 2018 (the latest available) for the following reasons. First, the main beneficiaries of LTCI are middle-aged and elderly people, and its poverty reduction effort is primarily reflected in the elderly group, and CHARLS is a survey data specifically for it over 45 years old and their spouses, which meets the research criteria of this paper. Second, this paper focuses on the poverty reduction effort of LTCI, and the CHARLS questionnaire contains typical questions that can represent each dimension of poverty, providing data support for this study. Third, in this study, Qingdao, the first city subject to the LTCI policy intervention, began the pilot in 2012, and subsequent cities began the pilot at various points in time. The four data waves allow the difference-in-differences (DID) approach to be used to study the differences before and after the policy pilot's implementation. The use

of a household follow-up survey format for CHARLS also facilitates control for unobservable variables. Finally, our primary study sample is a four-period unbalanced panel of 36,439 surveyed middle-aged and older adults (11,162 individuals in 2011, 10,441 in 2013, 7,801 in 2015, and 7,035 in 2018) from 123 cities. The mean age of the sample was 61 years ( $SD = 9.226$ ) and the median age was 60 years, which corresponds to the beneficiary population of LTCI.

## 3.2. Outcome variables

### 3.2.1. Index of multiple deprivation

Poverty is a multidimensional concept. Measuring poverty from a multidimensional perspective is necessary not only to more accurately assess the breadth and depth of poverty, but also to provide better targeted and effective disaggregated relief measures for the poor (35).

The “dual cut-off” approach proposed by Alkire and Foster (36) is the current mainstream approach to measuring multidimensional poverty. The first cut-off determines whether the sample is deprived in each dimension, while the second cut-off determines whether the sample is in multidimensional poverty status based on the number of dimensions in which the sample is deprived. The method specifically measures multidimensional poverty through the following steps.

In the first step, let  $W$  represent the  $n \times m$  dimensional matrix and let the matrix element  $y_{ij} \in W^{n,m}$  represent the values obtained by  $n$  individuals in  $m$  different dimensions. Any element  $y_{ij}$  in  $y$  represents the value taken by an individual  $i$  in dimension  $j$ ,  $i \in (1, 2, \dots, n)$ ,

$j \in (1, 2, \dots, m)$ . The row vector  $y_i = (y_{i1}, y_{i2}, \dots, y_{im})$  includes the values taken by individual  $i$  in all dimensions. Similarly, the column vector  $y_j = (y_{1j}, y_{2j}, \dots, y_{mj})$  represents the distribution of values taken by different individuals in dimension  $j$ .

The second step is to discern the poverty status of individuals on unidimensional and multidimensional dimensions. Let  $Z = (Z_1, Z_2, \dots, Z_m)$  be the deprivation threshold matrix, and denote by  $Z_j$  ( $Z_j > 0$ ) the threshold value at which an individual is deprived in the dimension  $j$ . If the welfare level of individual  $i$  in dimension  $j$  is less than the deprivation threshold  $Z_j$ , the individual is judged to be poor under dimension  $j$ . The discriminative process is shown below:

$$G_{ij}^{\partial} \begin{cases} \left(\frac{z_j - y_{ij}}{z_j}\right)^{\partial}, y_{ij} < z_j \\ 0, y_{ij} \geq z_j \end{cases} \quad (1)$$

When  $\partial$  takes a value of 0, the matrix  $G_{ij}^{\partial}$  discriminates whether individual  $i$  is in poverty in dimension  $j$  (i.e., when  $G_{ij}^{\partial} = 1$ , it means that individual  $i$  is in poverty in dimension  $j$ , and the opposite when  $G_{ij}^{\partial} = 0$ ). When  $\partial = 1$  and  $y_{ij} < z_j$ ,  $G_{ij}^{\partial}$  can represent the proportional gap in deprivation suffered by individual  $i$  in dimension  $j$ .

Further introducing the determination of individual multidimensional poverty, each element of the matrix  $G_{ij}^{\partial}$  represents the poverty status of individual  $i$  in a single dimension, defining  $k$  as the deprivation dimension threshold used to identify whether individual  $i$  is in multidimensional poverty,  $C_i$  as the multidimensional deprivation score of individual  $i$ ,  $C_i = \sum_{j=0}^k w_j G_{ij}^{\partial}$ .  $w_j$  is the weight of dimension  $j$  in the multidimensional poverty measure, which indicates the relative importance of each dimension. In general, the “dual cut-off” method uses the dimensional equal weight method. When  $C_i \geq k$ , individual  $i$  is judged to be in multidimensional poverty, but not in it if the opposite is true.

The third step is to calculate the index of multiple deprivation (IMD). The index of multiple deprivation  $IMD$  and average deprivation share  $A$  are calculated as follows:

$$A = \sum_{i=1}^n C_i(k)/qm \quad (2)$$

$$H = q/n \quad (3)$$

$$IMD = \sum_{i=1}^n C_i(k)/nm \quad (4)$$

$q$  denotes the number of people in multidimensional poverty at the deprivation dimension threshold  $k$ .  $C_i(k)$  denotes the value of  $C_i$  at the deprivation dimension threshold  $k$ . The incidence of poverty is  $H$ ,  $A$  denotes the average deprivation share, and  $IMD$  is the index of multiple deprivation. Given the deprivation dimension threshold  $k$ , the index of multiple deprivation  $IMD$  is determined by both the incidence of poverty  $H$  and the average deprivation share  $A$  (i.e.,  $IMD = H \times A$ ).

### 3.2.2. Construction dimensions of IMD

We identified 6 dimensions and 11 indicators to measure the index of multiple deprivation: income (one indicator), consumption (one indicator), material wellbeing (four indicator), social participation (one indicator), health (two indicator), psychological wellbeing (two indicators; see Table 1).

We chose indicators for measuring multidimensional poverty based on data availabilities, comparability, and representativeness. Comparability implies that dimension selection must be comparable across countries or internationally, and representativeness requires that indicator selection can represent the main characteristics of local poverty (37).

The first dimension selected is income. An assessment of the effectiveness of multidimensional poverty alleviation in China shows that long-term poverty alleviation targeting net income per capita contributes significantly to long-term multidimensional poverty alleviation among Chinese rural residents as a whole (38). This suggests that income continues to have a significant impact on poverty in rural China.

The second dimension is identified as living consumption. Living consumption takes on a different meaning compared to income in China, where the welfare coverage for the population is relatively limited compared to those in welfare states (e.g., universal health care) and where there is a tradition of high savings rates, as people often save on living expenses to cope with uncertainty. Moreover, living consumption is closely related to individual welfare, but monetary income does not guarantee a specific consumption basket due to imperfections in market functioning and consumer preference patterns (39). Therefore, in the Chinese context, it is necessary to include the living consumption dimension in a multidimensional poverty measurement system.

Four indicators from the material wellbeing dimension are included in our study. Cooking fuel, sanitation, and drinking water are all important issues for rural China's poverty, and these three indicators meet the official United Nations International Children's Emergency Fund (UNICEF) definition of an acceptable sanitation threshold. People who suffer from indoor air pollution as a result of cooking with wood, straw, or coal, do not have access to safe drinking water, and do not have access to flushable toilets are classified as poor. Our measure of material wellbeing also includes household living space per capita. One indicator of poverty in urban China is crowded living spaces.

The fourth dimension is health. To assess the health dimension, we used two indicators: self-rated health and the presence of chronic diseases. Health is a basic capability, and good health is linked to human development and social justice (40). In China, poverty caused by disease accounts for up to 40% of the poor population. Improving the health of the poor also helps them to escape from poverty through their work and reduces the likelihood of them falling back into poverty due to illness.

Finally, we included an indicator of social participation: whether they had engaged in social activities (e.g., socializing with friends, playing mahjong, chess, cards, or going to the community room) in the past month. People with disabilities who need care may face difficulties with social exclusion and participation in social activities (41, 42). Furthermore, social exclusion may have an impact on the mental health of people with disabilities (43). As a result, we included the psychological wellbeing dimension, which we measured using two indicators: life satisfaction and CES-D depression self-assessment scores.

We used the dimensional equal-weighting approach used in most studies, with the weights of each dimension set to be equal (i.e., the indicator weights under each dimension account for 1/6), and the weights of each indicator contained within the same dimension are also equal. Furthermore, there is no defined criterion for



TABLE 1 Dimensions of poverty and indicators of deprivation.

Dimension	Indicators	Deprivation cut-off
Income	Annual household income per capita	Annual per capita income below the absolute poverty line set by the central government (based on the constant price of 2300 RMB in 2011) = 1; else = 0
Living consumption	Household per capita daily living expenses	Household per capita daily living expenses below World Bank daily living consumption Poverty Line = 1; else = 0
Material wellbeing	Cooking fuel	Use of straw, firewood or coal as the main domestic fuel = 1; else = 0
	Drinking water	Non-tap water or filtered water for drinking or cooking = 1; else = 0
	Flushing toilet	Toilet can't flush = 1; else = 0
	Household living area per capita	Household living area per capita is <12 square meters = 1; else = 0
Social participation	Social activity	No social activity in the past month = 1; else = 0
Health	Self-reported health	Self-reported health is fair or bad = 1; else = 0
	Chronic disease	Have a chronic disease = 1; else = 0
Psychological wellbeing	Life satisfaction	Life satisfaction is not very satisfied or not at all satisfied = 1; else = 0
	CES-D score	CES-D depression self-assessment score $\geq 20$ = 1; else = 0

Source: Zhao et al. (33).

(1) The CHARLS questionnaire inquired about the number of people living in each household as well as the total annual household income. Total annual household income includes both wage and investment income from household members. Pensions, wages, and allowances make up annual wage income. After-tax income from industrial and commercial projects, rent, income from financial assets (e.g., funds, stocks, etc.), and income from agriculture comprise investment annual income. Divide the total annual household income by the number of household members to get the annual per capita household income. The threshold is determined by the central government's absolute poverty line (measured in constant 2011 prices). (2) The World Bank daily living consumption poverty line is \$1.25 (2005 PPP) in 2011–2013 and \$1.90 (2011 PPP) in 2015–2018. The World Bank daily living consumption poverty line is used as the deprivation cutoff for household per capita daily living expenses in this paper. Household living expenses are the sum of various household expenses such as clothing, food, housing, transportation, communication, and entertainment, but exclude medical and education expenses. (3) The Chinese government does not currently have a uniform standard for the minimum guaranteed housing area per capita, and the minimum guaranteed housing area per capita in each city varies between 10 and 15 square meters. We use 12 square meters as the deprivation cut-off for Household living area per capita. Household living area per capita is calculated by dividing the total household living area by the number of people living in the house. (4) The CHARLS questionnaire includes the Center for Epidemiological Survey, Depression Scale (CES-D). According to the scale, an individual is considered to have depressive symptoms if the CES-D score is  $\geq 20$ . Therefore, we set the CES-D score  $\geq 20$  as the deprivation cut-off.

multidimensional poverty thresholds, so we set the multidimensional poverty threshold at 1/3 based on the experience of most studies (44, 45), which means we use  $k = 1/3$  to calculate the IMD. Furthermore, if more than half of the indicators in each dimension of multidimensional poverty are poor, we consider the individual to be poor in that dimension and assign a value of 1, otherwise 0. The IMD structure constructed in this paper and the sensitivity analysis of the impact of different weighting structures on IMD are detailed in Appendix A.

We decomposed the IMD according to the two classification criteria of treatment group cities, control group cities, and whether or not they are covered by LTCI within the treatment group cities according to the research design of this paper. Poverty incidence is  $\sim 3\%$  lower in the treatment group cities than in the control group cities, as shown in Figure 2, but this may be due to the non-randomized and selective nature of the policy pilot, and thus this concern must be mitigated in subsequent robustness tests. The incidence of poverty ( $H$ ) among those already covered by LTCI is much lower than among those not covered by LTCI, but the magnitude of the LTCI poverty reduction effect and whether the existence of this effect is robust and plausible still needs further empirical testing.

### 3.2.3. Measurement of multidimensional poverty vulnerability

Poverty vulnerability, like poverty, should be a multidimensional concept and structure, and estimates of poverty vulnerability based only on the economic dimension are an important limitation

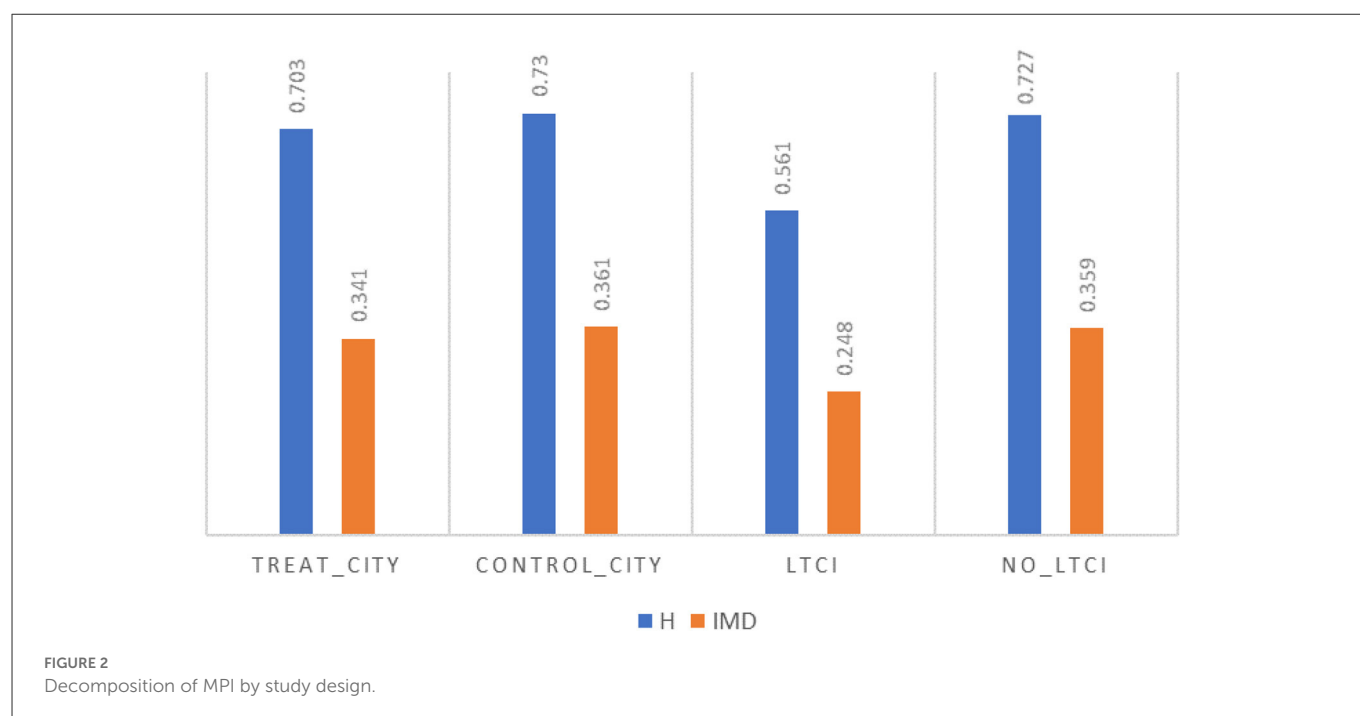
to the scope of poverty (46). Azeem et al. (47) discovered that ex post economic poverty indicators are more prone to bias in identifying poor groups, and it is necessary to broaden the discussion beyond economic poverty to include multidimensional poverty and multidimensional poverty vulnerability. Multidimensional poverty vulnerability is a forward-looking indicator that depicts the dynamics of multidimensional poverty by measuring the likelihood of future multidimensional poverty among individuals. Feeny and McDonald (48) used a feasible generalized least squares (FGLS) method to estimate the MPV of Melanesian households and discovered that MPV is more prevalent than multidimensional poverty.

We use the feasible generalized least squares (FGLS) method to estimate MPV based on Feeny and McDonald (48). A high vulnerability to multidimensional poverty indicates that individuals are still highly likely to experience multidimensional poverty again in the future. We estimate the MPV using the following estimator:

$$\hat{V}_{MPI_i} = \Pr(MPI_i > k|X_i) = \Phi\left(\frac{X_i\hat{\beta}_{FGLS} - k}{\sqrt{X_i\hat{\theta}_{FGLS}}}\right) \quad (5)$$

where  $\hat{V}_{MPI_i}$  is the estimated probability value of the occurrence of multidimensional poverty for individual  $i$  in the future, IMD is the multidimensional deprivation score of individual  $i$ ,  $\Phi$  is the normal distribution cumulative density function,  $X_i\hat{\beta}_{FGLS}$  and  $X_i\hat{\theta}_{FGLS}$  are expected and fluctuating consistency estimates of multidimensional poverty for individuals in the future period, respectively.





### 3.3. Key independent variables

The first independent variable is LTCI coverage, which measures whether or not individuals are enrolled in LTCI. It was determined based on the policy document, which indicates when the pilot city started the LTCI pilot and who was covered in that city. Our dataset includes individuals surveyed in 15 LTCI pilot cities, 12 of which are the first batch of LTCI pilot cities identified by the central government. The LTCI programs in all 15 pilot cities cover groups that are already enrolled in UEBMI, with four covering URRBMI enrollees and one covering coverage for URBMI enrollees. LTCI coverage is an independent variable with intervention coded as 1 and not covered as 0. [Appendix B](#) contains specific information on when the LTCI pilot cities launched the program and which groups were served.

The duration of LTCI coverage (i.e., the difference between the survey interview date and the LTCI project start date in each pilot city) is the second independent variable, coded as 0 if the individual was not covered by LTCI.

### 3.4. Descriptive statistics

[Table 2A](#) presents descriptive statistics for the entire sample, treatment and control group. The *t*-test indicates the level of significance of the comparison between groups. The results of the simple DID estimation for each outcome variable are given in the last column. The simple DID analysis showed that individuals in the treatment group showed improvements in multidimensional poverty, income poverty, living consumption poverty, material wellbeing poverty, social participation poverty, health poverty, and psychological wellbeing poverty.

To account for potential confounders, we included age, gender, marital status, hukou status (i.e., registered residence status), level of

education, full-time employment, basic old-age insurance, retirement support, three indicators of health insurance, hospitalization status, and inpatient out-of-pocket expenses in the demographic and socioeconomic covariates. Furthermore, we controlled for several household-by-year variables, including household debt, number of household members, number of household durables, and household education & training expenses. As shown in [Table 2A](#), the post-treatment population in treatment group cities was slightly older, more urban residents, had higher levels of education, higher levels of household capital, fewer people with full-time jobs, preferred to use pensions or retirement salaries for retirement, had smaller families, and tended to have basic pension insurance as well as the three types of basic medical insurance. [Table 2B](#) presents the characteristics of each variable studied.

## 4. Analytical strategies

To assess the impact of LTCI on multidimensional poverty among middle-aged and older adults, we applied a DID strategy controlling for individual fixed effects (FE) to panel data from 2011 to 2018. The treatment group in this study was middle-aged and older adults in the pilot city who were covered by LTCI, while the control group was middle-aged and older adults who were not covered by LTCI. The following equation is estimated:

$$y_{cjt} = \alpha_1 LTCI_{cjt} + \alpha_2 X_{cjt} + \alpha_3 w_{cjt} + \sigma_t + \tau_i + \varepsilon_{cjt} \quad (6)$$

where  $y_{cjt}$  denotes the outcome variable for individual  $i$  living in the city  $c$  in year  $t$ , including the IMD and indicators of income poverty, living consumption poverty, material wellbeing poverty, social participation poverty, health poverty, and psychological wellbeing poverty derived from the decomposition of the IMD by dimension.

The key independent variable  $LTCI_{cjt}$  has two set forms. One form is  $Treat_{c_i} \times Post_t$ , where  $Post_t$  is a dichotomous variable that

TABLE 2A Summary statistics (2011–2018 panel).

	Full	Treatment group (LTCl pilot cities)		Control group (non-LTCl pilot cities)				$\Delta\Delta$
		Pre-treat	Post-treat	2011	2013	2015	2018	
Observations	36,439	4,034	107	11,162	10,441	7,801	7,035	
<b>Outcome variables</b>								
Index of multiple deprivation								
IMD	0.418 (0.167)	0.406 (0.166)	0.336 (0.151)***	0.384 (0.162)	0.423*** (0.169)	0.446*** (0.158)	0.432*** (0.172)	−0.067*** [0.024]
Single dimensional poverty (poverty = 1; otherwise = 0)								
Income poverty	0.521 (0.500)	0.481 (0.500)	0.112*** (0.317)	0.418 (0.493)	0.540*** (0.498)	0.720*** (0.449)	0.438*** (0.496)	−0.120*** [0.038]
Living consumption poverty	0.345 (0.475)	0.330 (0.470)	0.196*** (0.399)	0.281 (0.450)	0.381*** (0.486)	0.319*** (0.466)	0.422*** (0.494)	−0.161* [0.089]
Material wellbeing poverty	0.717 (0.450)	0.755 (0.430)	0.897*** (0.305)	0.647 (0.478)	0.594*** (0.491)	0.644 (0.479)	0.680*** (0.466)	−0.074 [0.045]
Social participation poverty	0.638 (0.481)	0.614 (0.487)	0.607 (0.491)	0.651 (0.477)	0.745* * * (0.436)	0.724*** (0.447)	0.772*** (0.419)	−0.052 [0.054]
Health poverty	0.726 (0.446)	0.729 (0.445)	0.710 (0.456)	0.733 (0.442)	0.717*** (0.450)	0.713*** (0.453)	0.742 (0.437)	−0.066 [0.052]
Psychological wellbeing poverty	0.154 (0.361)	0.139 (0.346)	0.131 (0.339)	0.175 (0.380)	0.147*** (0.354)	0.124*** (0.330)	0.166* (0.372)	0.002 [0.038]
<b>Individual demographic covariates</b>								
Age	61.075 (9.226)	60.971 (8.967)	64.421*** (8.691)	59.090 (9.483)	60.871*** (9.303)	62.012*** (9.034)	63.408*** (8.154)	
Gender (male = 1; female = 0)	0.481 (0.500)	0.480 (0.500)	0.542 (0.501)	0.482 (0.500)	0.479 (0.500)	0.481 (0.500)	0.484 (0.500)	
Marital status (married = 1; unmarried, divorced and widowed = 0)	0.869 (0.338)	0.880 (0.325)	0.879 (0.328)	0.876 (0.330)	0.872 (0.334)	0.861*** (0.346)	0.862*** (0.345)	
Hukou status (urban residents = 1; rural residents = 0)	0.181 (0.385)	0.203 (0.402)	0.598*** (0.493)	0.227 (0.419)	0.202*** (0.401)	0.134*** (0.341)	0.129*** (0.336)	
Level of education								
No formal education (illiterate) = 1	0.255 (0.436)	0.229 (0.420)	0.112*** (0.317)	0.255 (0.436)	0.259 (0.438)	0.272*** (0.445)	0.230*** (0.421)	
Did not finish primary school but capable of reading or writing = 2	0.193 (0.395)	0.232 (0.422)	0.178 (0.384)	0.175 (0.380)	0.182 (0.386)	0.201*** (0.401)	0.229*** (0.420)	
Sishu/home school = 3	0.004 (0.061)	0.003 (0.059)	—	0.005 (0.071)	0.004 (0.062)	0.004 (0.064)	0.001 (0.029)	
Graduate from elementary school = 4	0.227 (0.419)	0.239 (0.427)	0.252 (0.436)	0.221 (0.415)	0.223 (0.416)	0.234** (0.423)	0.238** (0.426)	
Graduate from middle school = 5	0.208 (0.406)	0.196 (0.397)	0.168 (0.376)	0.214 (0.410)	0.210 (0.407)	0.197*** (0.398)	0.211*** (0.408)	
Graduate from high school = 6	0.075 (0.263)	0.071 (0.257)	0.187*** (0.392)	0.080 (0.271)	0.078 (0.268)	0.066*** (0.247)	0.072*** (0.259)	
Graduate from vocational school = 7	0.022 (0.146)	0.024 (0.153)	0.075*** (0.264)	0.027 (0.161)	0.025 (0.155)	0.018*** (0.133)	0.014*** (0.115)	
Graduate from two/three year college/associate degree = 8	0.012 (0.107)	0.005 (0.068)	0.028*** (0.166)	0.017 (0.130)	0.015 (0.121)	0.007*** (0.081)	0.004*** (0.062)	
Graduate from 4 year college/bachelor's degree = 9	0.005 (0.068)	0.001 (0.027)	—	0.008 (0.086)	0.005** (0.072)	0.002*** (0.047)	0.002*** (0.040)	

(Continued)

TABLE 2A (Continued)

	Full	Treatment group (LTCI pilot cities)		Control group* (non-LTCI pilot cities)				△△
		Pre-treat	Post-treat	2011	2013	2015	2018	
Full-time employment (have full-time job = 1; no full-time job = 0)	0.668 (0.471)	0.667 (0.471)	0.383*** (0.488)	0.687 (0.464)	0.672** (0.470)	0.694 (0.461)	0.603*** (0.489)	
Have basic old-age insurance	0.651 (0.477)	0.649 (0.477)	0.935*** (0.248)	0.286 (0.452)	0.812*** (0.391)	0.764*** (0.425)	0.863*** (0.344)	
Retirement support								
Relying on children for retirement = 1	0.655 (0.475)	0.579 (0.494)	0.140*** (0.349)	0.669 (0.471)	0.635*** (0.481)	0.673 (0.469)	0.643*** (0.479)	
Relying on savings for retirement = 2	0.039 (0.193)	0.038 (0.190)	0.009 (0.097)	0.041 (0.199)	0.042 (0.201)	0.042 (0.202)	0.027*** (0.161)	
Relying on pension or retirement salary for retirement = 3	0.255 (0.436)	0.325 (0.468)	0.822*** (0.384)	0.229 (0.420)	0.283*** (0.450)	0.243** (0.429)	0.264*** (0.441)	
Relying on commercial pension insurance for retirement = 4	0.004 (0.060)	0.003 (0.057)	—	0.005 (0.069)	0.003* (0.058)	0.004 (0.060)	0.002*** (0.048)	
Relying on other for retirement = 5	0.048 (0.215)	0.055 (0.228)	0.028 (0.166)	0.056 (0.230)	0.037*** (0.189)	0.039*** (0.193)	0.064** (0.244)	
Have UEBMI	0.099 (0.298)	0.050 (0.217)	0.579*** (0.496)	0.117 (0.322)	0.117 (0.321)	0.072*** (0.258)	0.072*** (0.259)	
Have URBMI	0.043 (0.203)	0.066 (0.248)	0.159*** (0.367)	0.045 (0.208)	0.052** (0.221)	0.042 (0.200)	0.028*** (0.165)	
Have URRBMI	0.037 (0.190)	0.093 (0.290)	0.262*** (0.442)	0.012 (0.111)	0.020*** (0.142)	0.019*** (0.138)	0.122*** (0.327)	
Hospitalization (hospitalized in the past year = 1; else = 0)	0.129 (0.335)	0.126 (0.332)	0.168 (0.376)	0.091 (0.287)	0.129*** (0.335)	0.146*** (0.354)	0.171*** (0.376)	
Log (inpatient out-of-pocket expenses + 1)	0.293 (1.545)	0.238 (1.400)	0.331 (1.525)	0.151 (1.110)	0.268*** (1.478)	0.377*** (1.741)	0.462*** (1.934)	
Household-level covariates								
Log (household debt + 1)	1.421 (3.523)	1.031 (3.040)	1.197 (3.451)	0.811 (2.733)	1.914*** (3.962)	1.600*** (3.706)	1.457*** (3.594)	
Number of household members	3.502 (1.847)	3.345 (1.682)	2.262*** (0.757)	3.590 (1.818)	4.978*** (1.738)	2.517*** (1.165)	2.262*** (0.759)	
Number of household durables	4.603 (2.184)	4.685 (2.183)	5.140** (2.230)	4.246 (2.161)	4.928*** (2.340)	4.679*** (2.097)	4.601*** (1.982)	
Household education and training expenses	1.344 (2.985)	1.253 (2.888)	1.510 (3.335)	0.380 (1.560)	2.024*** (3.499)	1.543*** (3.174)	1.642*** (3.266)	

Standard deviations are in parentheses. The last column clusters standard errors at the city level, which are listed in square brackets. t-tests are used to compare pre-treatment and post-treatment within the treatment group cities, as well as a pairwise comparison of individuals in the control group cities in 2011 with 2013, 2015, and 2018.

\* $p < 0.10$ .

\*\* $p < 0.05$ .

\*\*\* $p < 0.01$ .

is 0 before city  $c$  starts the LTCI pilot and 1 after it starts the LTCI pilot, and  $Treat_{cit}$  is a dummy variable for individual treatment status, defined according to the LTCI coverage group and individual basic health insurance status in the pilot city.  $\tau_i$  explains all time-invariant factors that may affect the outcome variables. Another form of  $LTCI_{cit}$  is the duration of LTCI coverage, which is defined by the specific time of implementation of the LTCI program in each pilot city and the date of interview of the surveyed individuals.

$X_{cit}$  is a vector of individual time-varying characteristics associated with demographic and socioeconomic characteristics,

and  $w_{cit}$  is a set of household-by-year controls, as described in Table 2A.  $\sigma_t$  is a year-fixed effect and  $\varepsilon_{cit}$  is a random error term. Standard errors are clustered at the city level to account for possible correlations between middle-aged and older adults in the same city.

Because our data set does not allow us to directly observe whether individuals are served by LTCI, the coefficient  $\alpha_1$  is an estimate of the net effect of expanding LTCI coverage, averaged across covered middle-aged and older adults who do or do not yet receive LTCI services.

TABLE 2B Descriptive statistics (full sample).

Variables	N	Mean	SD	Min	Med	Max
<b>Outcome variables</b>						
Index of multiple deprivation						
IMD	36,439	0.418	0.167	0	0.417	1
Single dimensional poverty (poverty = 1; otherwise = 0)						
Income poverty	36,439	0.521	0.500	0	1	1
Living consumption poverty	36,439	0.345	0.475	0	0	1
Material wellbeing poverty	36,439	0.717	0.450	0	1	1
Social participation poverty	36,439	0.638	0.481	0	1	1
Health poverty	36,439	0.726	0.446	0	1	1
Psychological wellbeing poverty	36,439	0.154	0.361	0	0	1
<b>Individual demographic covariates</b>						
Age	36,439	61.08	9.226	45	60	108
Gender	36,439	0.481	0.500	0	0	1
Marital status	36,439	0.869	0.338	0	1	1
Hukou status	36,439	0.181	0.385	0	0	1
<b>Level of education</b>						
No formal education (illiterate)	36,439	0.255	0.436	0	0	1
Did not finish primary school but capable of reading or writing	36,439	0.193	0.395	0	0	1
Sishu/home school	36,439	0.00400	0.0610	0	0	1
Graduate from elementary school	36,439	0.227	0.419	0	0	1
Graduate from middle school	36,439	0.208	0.406	0	0	1
Graduate from high school	36,439	0.0750	0.263	0	0	1
Graduate from vocational school	36,439	0.0220	0.146	0	0	1
Graduate from 2/3 year college/associate degree	36,439	0.0120	0.107	0	0	1
Graduate from 4 year college/bachelor's degree	36,439	0.00500	0.0680	0	0	1
Full-time employment	36,439	0.668	0.471	0	1	1
Have basic old-age insurance	36,439	0.651	0.477	0	1	1
<b>Retirement support</b>						
Relying on children for retirement	36,439	0.655	0.475	0	1	1
Relying on savings for retirement	36,439	0.0390	0.194	0	0	1
Relying on pension or retirement salary for retirement	36,439	0.254	0.435	0	0	1
Relying on commercial pension insurance for retirement	36,439	0.00400	0.0600	0	0	1
Relying on other for retirement	36,439	0.0480	0.215	0	0	1
Have UEBMI	36,439	0.0990	0.298	0	0	1
Have URBMI	36,439	0.0430	0.203	0	0	1
Have URRBMI	36,439	0.0370	0.190	0	0	1
Hospitalization	36,439	0.129	0.335	0	0	1
Log (inpatient out-of-pocket expenses + 1)	36,439	0.293	1.545	0	0	11.98
<b>Household-level covariates</b>						
Log (household debt + 1)	36,439	1.421	3.523	0	0	18.76
Number of household members	36,439	3.502	1.847	1	3	16
Number of household durables	36,439	4.603	2.184	0	5	18
Household education and training expenses	36,439	1.344	2.985	0	0	12.76

The issue of concern is the problem of sample selection bias. To avoid sample selection bias, we borrowed an idea from Imbens and Wooldridge (49) and combined the propensity score matching (PSM) method with DID regression. This method is also known as PSM-DID. First, we calculated propensity scores using a logit model (i.e., to estimate the probability of entering the treatment group given a set of observable characteristics including demographic and socioeconomic covariates, and household-level covariates). Second, based on the estimated propensity scores, we estimated DID for individuals who met the common support hypothesis, and individuals who did not meet the common support hypothesis were excluded from the DID analysis. We used a matching strategy of year-by-year matching as well as six nearest neighbor matching. All observable features were better balanced after matching, and the propensity score distributions were more similar for both groups (see Appendix Tables D4, D5; Appendix Figure D4).

Another issue of concern to us is the small sample size of the treatment group. Theoretically, a smaller proportion of treatment groups relative to control groups does not pose a significant problem for estimation in the data structure of this paper, and DID estimation does not require that the treatment and control groups' relative proportions meet a specific criterion. The only purpose of the control group is to provide a counterfactual for the treatment group. The sample size of the treatment group in Moser and Voena (50)'s classic study is only 4.6%. In the robustness test, we attempt to design a test procedure and use the synthetic difference-differences (SDID) method to verify that the small sample proportion of the treatment group does not affect the robustness of the paper's findings.

## 5. Results

### 5.1. Main effects of LTCI

Table 3 reports the estimated impact of LTCI coverage on IMD. Each column in the table corresponds to the results of a separate regression. The first column shows that the LTCI coverage significantly reduces multidimensional poverty. In column 2, the DID estimates vary slightly in magnitude based on samples that meet the common support assumption, but the direction remains the same as in column 1. The coefficient of the interaction term of Treat and Post is  $-0.09$  is statistically significant at the level of 0.01, which indicates that IMD decreased 21.53% after the implementation of LTCI. In Columns 3 and 4, we also study the effect of LTCI coverage duration. Column 3 shows that LTCI duration has a significant negative effect on IMD. In column 4, based on samples that meet the common support assumption, we find that the coefficient of LTCI duration is  $-0.044$  is statistically significant at the level of 0.01, which indicates that IMD decreased 10.53% for one more year of LTCI coverage.

We further analyzed the effect of LTCI on each dimension of poverty. The regression results in Column 2 of Table 4 are based on samples that meet the common support assumption that LTCI coverage is associated with a 27.7% reduction in the likelihood of income poverty and a 12.2% reduction in the likelihood of health poverty. For living consumption poverty, the estimate is negative and significant in the first column ( $p = 0.041$ ), but statistically insignificant in the second column. Column 4 in Table 4 estimates the effect of LTCI coverage time on each dimension of poverty based on the sample that meets the common support assumption. According to

the findings, one more year of LTCI coverage reduces the likelihood of income poverty by 11.9% and subsistence consumption poverty by 9.6%. This implies that as the duration of LTCI coverage increases, it will have a poverty-reducing effect on the living consumption dimension. In contrast, the estimates for health poverty are not statistically significant, indicating that LTCI coverage does not reduce poverty in the health dimension over time.

Middle-aged and older adults who already have LTCI coverage are only eligible for LTC services if they have an ADL hardship condition. Although CHARLS does not have direct information on individuals' service status for the LTCI program, we added an interaction term in Table 5 between LTCI coverage and whether the individual surveyed had ADL difficulties in 11 areas (i.e., dressing, bathing, eating, getting in and out of bed, going to the bathroom, controlling bowel movements, doing chores, cooking, shopping, managing money, and taking medication). We examined the difference in the LTCI poverty reduction effect between subgroups with and without LTC demand in the group already covered by LTCI using this interaction term. In our dataset, 14.98% of the population had ADL difficulties. The coefficient of the interaction term can be interpreted as the differential effect of LTCI on middle-aged and older adults with LTC needs relative to those without LTC needs.

The first two columns in each row of Table 5 indicate the interaction DID estimates of LTCI coverage without and with LTC need, respectively. The last two columns show the interaction DID estimates of LTCI duration without and with LTC need. For multidimensional poverty status, the effect of LTCI on improving the multidimensional poverty status of middle-aged and elderly people with LTC needs is significantly greater than that of middle-aged and elderly people without LTC needs, and the covered population with LTC needs may be the actual recipients of LTCI benefits. For middle-aged and older adults with LTC needs, the effect of LTCI coverage on the reduced likelihood of income poverty occurrence is significantly stronger than for those without LTC needs. In the long run, LTCI would reduce the likelihood of income poverty by 12.4% for middle-aged and older adults without LTC needs for one more year of LTCI coverage, while the estimates for middle-aged and older adults with LTC needs were not statistically significant. This phenomenon may be attributed to the fact that LTCI coverage may have a "peace of mind" effect on middle-aged older adults even if they do not receive benefits (51), or that these middle-aged and older adults without LTC needs are more likely to be informal caregivers who benefit from LTCI's reduced informal caregiving burden (29).

For living consumption poverty, LTCI coverage only reduced the likelihood of living consumption poverty by 40.2% for middle-aged and older adults with LTC needs, while the estimate for middle-aged and older adults without LTC needs was not statistically significant. Estimates for the duration of LTCI coverage showed that one more year of LTCI coverage had a significantly greater effect on reducing the likelihood of living consumption poverty for middle-aged and older adults with LTC needs than for middle-aged and older adults without LTC needs. For social participation poverty, LTCI coverage only reduces the likelihood of social participation poverty among middle-aged and older adults with LTC needs in the long run, with one more year of LTCI coverage being associated with a 3.2% reduction in the likelihood of social participation poverty among middle-aged and older adults with LTC needs.



TABLE 3 Effect of LTCl on IMD.

	Coefficient on treat $\times$ post		Coefficient on LTCl_duration	
	DID	DID with matching	DID	DID with matching
	(1)	(2)	(3)	(4)
Treat $\times$ post	−0.064*** (0.023)	−0.090*** (0.034)		
LTCl_duration			−0.032*** (0.012)	−0.044*** (0.015)
Age	−0.000 (0.001)	0.004 (0.003)	−0.000 (0.001)	0.004 (0.003)
Gender	0.022 (0.022)	−0.101 (0.063)	0.022 (0.022)	−0.101 (0.063)
Marital status	0.014* (0.008)	−0.004 (0.025)	0.014* (0.008)	−0.004 (0.025)
Hukou status	−0.015 (0.022)	−0.035 (0.046)	−0.014 (0.022)	−0.033 (0.046)
Level of education [Reference group: No formal education (illiterate)]				
Did not finish primary school but capable of reading or writing	−0.012 (0.008)	−0.022 (0.018)	−0.012 (0.008)	−0.022 (0.018)
Sishu/home school	−0.071** (0.029)	—	−0.071** (0.029)	—
Graduate from elementary school	−0.024*** (0.009)	−0.051** (0.020)	−0.024*** (0.009)	−0.051** (0.020)
Graduate from middle school	−0.022* (0.012)	−0.043* (0.026)	−0.022* (0.012)	−0.044* (0.026)
Graduate from high school	0.008 (0.019)	0.001 (0.032)	0.007 (0.019)	0.000 (0.032)
Graduate from vocational school	−0.002 (0.022)	−0.037 (0.039)	−0.002 (0.022)	−0.034 (0.039)
Graduate from 2/3 year college/associate degree	0.005 (0.024)	−0.131** (0.059)	0.005 (0.024)	−0.127** (0.059)
Graduate from 4 year college/bachelor's degree	−0.040 (0.050)	—	−0.040 (0.050)	—
Full-time employment	−0.005 (0.003)	0.006 (0.007)	−0.005 (0.003)	0.006 (0.007)
Have basic old-age insurance	−0.015*** (0.003)	−0.006 (0.009)	−0.015*** (0.003)	−0.006 (0.009)
Retirement support (Reference group: Relying on children for retirement)				
Relying on savings for retirement	−0.003 (0.006)	−0.005 (0.028)	−0.003 (0.006)	−0.005 (0.028)
Relying on pension or retirement salary for retirement	0.003 (0.004)	0.017* (0.009)	0.003 (0.004)	0.017** (0.009)
Relying on commercial pension insurance for retirement	0.020 (0.016)	—	0.020 (0.016)	—
Relying on others for retirement	0.023*** (0.005)	0.022 (0.018)	0.023*** (0.005)	0.022 (0.018)
Have UEBMI	−0.012* (0.006)	−0.007 (0.017)	−0.012* (0.006)	−0.009 (0.017)
Have URBMI	0.001 (0.007)	0.060*** (0.019)	0.001 (0.007)	0.060*** (0.019)
Have URRBMI	0.002 (0.008)	0.025** (0.011)	0.002 (0.008)	0.025** (0.011)
Hospitalization	−0.001 (0.003)	−0.006 (0.008)	−0.001 (0.003)	−0.007 (0.008)
Log (Inpatient out-of-pocket expenses + 1)	0.001 (0.001)	0.004 (0.003)	0.001 (0.001)	0.004 (0.003)
Log (Household debt + 1)	0.000 (0.000)	0.002* (0.001)	0.000 (0.000)	0.002* (0.001)
Number of household members	0.005*** (0.001)	0.006* (0.003)	0.005*** (0.001)	0.006* (0.003)
Number of household durables	−0.008*** (0.001)	−0.002 (0.002)	−0.008*** (0.001)	−0.002 (0.002)
Household education and training expenses	−0.005*** (0.000)	−0.005*** (0.001)	−0.005*** (0.000)	−0.005*** (0.001)
_cons	0.459*** (0.052)	0.288 (0.183)	0.459*** (0.052)	0.288 (0.183)
Observations	36,439	11,896	36,439	11,896
Adj-R <sup>2</sup>	0.320	0.274	0.320	0.274
Individual FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Robust standard errors are clustered at the city level. \*\*\*, \*\*, and \* denote 1, 5, and 10% significance level, respectively. All regressions control for year FE, individual FE, demographic and socioeconomic covariates, and household-level covariates, and the specific covariates controlled for are detailed in Table 2A.

TABLE 4 Effect of LTCI on poverty in each dimension.

	Coefficient on treat $\times$ post		Coefficient on LTCI duration	
	DID	DID with matching	DID	DID with matching
	(1)	(2)	(3)	(4)
Income poverty	−0.107*** (0.038)	−0.277*** (0.079)	−0.055*** (0.019)	−0.119*** (0.036)
Observations	36,439	11,896	36,439	11,896
Adj- $R^2$	0.291	0.256	0.291	0.256
Living consumption poverty	−0.167** (0.081)	−0.129 (0.120)	−0.098*** (0.035)	−0.096** (0.041)
Observations	36,439	11,896	36,439	11,896
Adj- $R^2$	0.261	0.231	0.261	0.232
Material wellbeing poverty	−0.066 (0.043)	−0.026 (0.033)	−0.022 (0.016)	−0.015 (0.024)
Observations	36,439	11,896	36,439	11,896
Adj- $R^2$	0.363	0.408	0.363	0.408
Social participation poverty	−0.047 (0.052)	−0.023 (0.061)	−0.020 (0.026)	−0.023 (0.030)
Observations	36,439	11,896	36,439	11,896
Adj- $R^2$	0.228	0.268	0.228	0.269
Health poverty	−0.066 (0.050)	−0.122* (0.066)	−0.029 (0.026)	−0.026 (0.040)
Observations	36,439	11,896	36,439	11,896
Adj- $R^2$	0.215	0.096	0.215	0.095
Psychological wellbeing poverty	−0.000 (0.037)	−0.010 (0.061)	0.006 (0.023)	0.014 (0.041)
Observations	36,439	11,896	36,439	11,896
Adj- $R^2$	0.299	0.303	0.299	0.303
Individual FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y

Robust standard errors are clustered at the city level. \*\*\*, \*\*, and \* denote 1, 5, and 10% significance level, respectively. All regressions control for year FE, individual FE, demographic and socioeconomic covariates, and household-level covariates, as specified in Table 3.

For health poverty, coverage of LTCI has a significantly greater effect on reducing the likelihood of health poverty occurring in the middle-aged and elderly population without LTC needs than in the middle-aged and elderly population with LTC needs. One possible explanation is that in addition to the “peace of mind” effect of LTCI coverage and the fact that these middle-aged and elderly people without LTC needs may be informal caregivers, the reduced likelihood of health poverty due to the reduced caregiving burden, the rich community services provided by the LTCI pilot (e.g., regular medical checkups, home visits, etc.) reduce the likelihood of health poverty among middle-aged and older adults without LTC needs. For middle-aged and elderly people with LTC needs, their health status may not be good for a long time, and they may have chronic diseases that are difficult to cure, so the effect of basic LTCI services on the health of this group may be very limited. In the long term, one more year of LTCI coverage will reduce the likelihood of health poverty among the middle-aged and elderly population with LTC needs by 2.6%.

In the sensitivity analysis, we used methods such as converting unbalanced panels to balanced panels, replacing the outcome variables using logit models, converting time-varying DID estimates to ordinary DID estimates, and using the second batch of LTCI pilot cities as the control group. Furthermore, we conducted a

sensitivity analysis for different deprivation dimension thresholds  $k$  and discovered that different  $k$  does not affect the results of this paper. The simplicity of the IMD construction makes it flawed. The IMD assumes that the dimensions are independent of one another, but they are not. For example, the material wellbeing dimension influences the health dimension. The IMD cannot more precisely target a specific poor group, it does not change when a good is transferred from poor to non-poor households. As a result, IMD cannot more precisely identify individuals who are closest to escaping poverty or who are most in need of assistance. We use the correlation-sensitive poverty index (CSPI) constructed by Rippin (52), also known as the multidimensional inequality index, to conduct a sensitivity analysis that addresses the shortcomings of the IMD. The unique structure of the CSPI allows it to overcome the shortcomings of the IMD. The CSPI does not require that the dimensions be independent of each other and can identify the neediest groups. We found similar results (see Appendix C).

## 5.2. Robustness tests

The DID estimation premise assumes that when the policy is not implemented, the trends of change in the treatment

TABLE 5 Effect of LTCI with LTC need and without LTC need.

Dependent variables	DID with matching			
	(1)		(2)	
	Coefficient on treat × post × no LTC need	Coefficient on treat × post × have LTC need	Coefficient on LTCI duration × no LTC need	Coefficient on LTCI duration × have LTC need
IMD	−0.083*** (0.031)	−0.158*** (0.059)	−0.043*** (0.014)	−0.052* (0.028)
Income poverty	−0.275*** (0.094)	−0.294* (0.158)	−0.124** (0.050)	−0.091 (0.076)
Living consumption poverty	−0.099 (0.112)	−0.402*** (0.144)	−0.084** (0.040)	−0.153*** (0.056)
Material wellbeing poverty	−0.021 (0.044)	−0.074 (0.233)	−0.011 (0.017)	−0.031 (0.128)
Social participation poverty	−0.018 (0.063)	−0.072 (0.054)	−0.022 (0.034)	−0.032* (0.017)
Health poverty	−0.124* (0.072)	−0.100** (0.045)	−0.026 (0.047)	−0.026* (0.014)
Psychological wellbeing poverty	−0.008 (0.054)	−0.033 (0.226)	0.014 (0.035)	0.017 (0.102)

Robust standard errors are clustered at the city level. \*\*\*, \*\*, and \* denote 1, 5, and 10% significance level, respectively. All regressions control for year FE, individual FE, demographic and socioeconomic covariates, and household-level covariates, as specified in Table 3.

and control groups should be parallel. We use the event study method to see if the parallel trend assumption holds, and we find no evidence of heterogeneity in the trends of change between the treatment and control groups before treatment (see Appendix Figure D1). Furthermore, to strengthen the credibility of the parallel trend hypothesis, we used Abadie SDID reweighting regression for validation. The Abadie SDID reweighting regression is a reweighting technique that can be used to deal with the imbalance of characteristics between the treatment and control groups, which can make the conclusion somewhat plausible even if the parallel trend hypothesis is not fully satisfied (53). Thus, the technique increases the credibility of the parallel trend hypothesis. The results of the Abadie SDID reweighted regression make the parallel trend hypothesis of this paper more plausible (see Appendix Table D1).

Furthermore, We devised a test procedure to ensure that the robustness of the findings in this paper is not compromised by the treatment group's small proportion of the sample size. We took 10% of the samples from the control group each time as a new control group, combined with the treatment group to perform a regression according to Equation (6), repeated this regression 1,000 times, and plotted the density distribution of the regression coefficient  $\alpha_1$  for these 1,000 regressions. We find that the baseline regression coefficients are very close to the median of the density function, confirming that the conclusions of this paper are not affected by the small proportion of sample size in the treatment group (see Appendix Figure D2).

Further, we use the synthetic difference-differences (SDID) method to verify that the small sample proportion of the treatment group does not affect the robustness of the paper's findings. Usually, we can use the synthetic control method (SCM) to assess policy treatment effects when the treatment group contains only one individual or very few individuals. Arkhangelsky et al. (54) combine the SCM with DID to form the SDID, which can find control group individuals similar to the treatment group by individual weights and also find the post-policy treatment period by time weights and assign them larger individual and time weights, respectively. The SDID estimation results show that the small proportion of the sample in the treatment group does not affect the robustness of the findings in this paper (see Appendix Table D2).

Another concern we have is that the LTCI pilot cities may not be chosen at random. The central or local government decides on LTCI implementation, which may be influenced by some unique characteristics of the city chosen to conduct the LTCI pilot. To alleviate this problem, we control for all observable and unobservable heterogeneity at the city level that does not change over time by controlling for city-level fixed effects, which have been absorbed by individual fixed effects. We further incorporate city-year interactions to control for the effects of urban characteristics over time and still find the conclusions of this paper to be robust (see Appendix Table D3). Furthermore, we used a placebo test to ensure that this possible nonrandomization has no negative impact on the robustness of the findings in this paper. We conducted a placebo test by randomly selecting several cities as pseudo-treatment group cities. The results of the placebo test suggest that this possible non-randomness in the selection process of LTCI pilot cities does not have a deleterious effect on the robustness of our study findings (see Appendix Figure D3).

Goodman-Bacon et al. (55) show that the time-varying DID estimates based on the occurrence of policies at multiple points in time consist of four 2x2 DID estimates, and the final policy treatment effects are obtained by weighting these four  $2 \times 2$  DID estimators. The new treatment group may take the previous treatment group as the control group, which we call the "bad control group." We are concerned that such "bad control groups" may also exist in our time-varying DID estimation, thus biasing the estimation results in this paper. We decompose the time-varying DID estimates in this paper using the Bacon decomposition to verify that the possible presence of the "bad control group" does not affect the robustness of the conclusions in this paper (see Appendix Table D6 and Appendix Figure D5). The results of the Bacon decomposition suggest that the possible presence of the "bad control group" in our DID estimation does not affect the robustness of the findings in this paper.

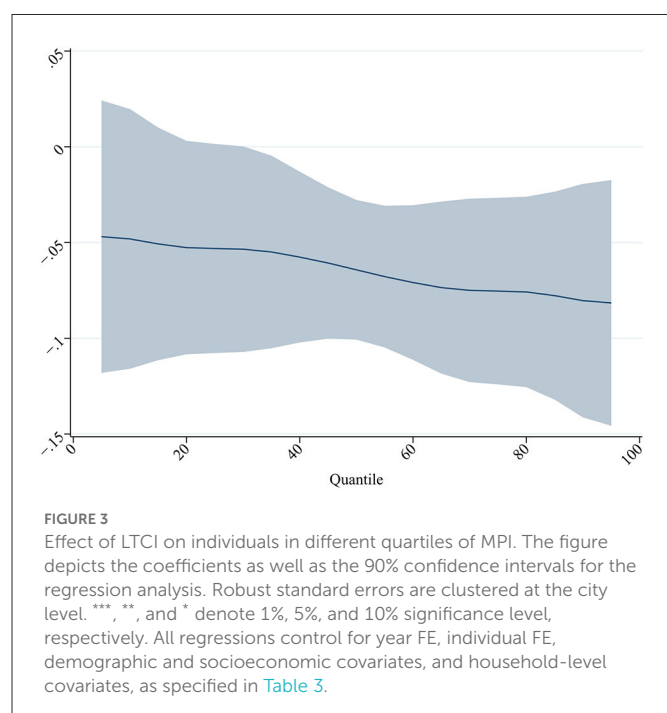
### 5.3. Effect of LTCI on multidimensional poverty vulnerability

We continue to use the estimation strategy of Equation (6) to evaluate the impact of LTCI on MPV. We first tested the hypothesis

TABLE 6 Effect of LTCI on MPV.

	MPV ( $k = 1/3$ )				MPV ( $k = 2/3$ )			
	DID		DID with matching		DID		DID with matching	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<b>Panel A</b>								
Treat $\times$ post	−0.138** (0.059)		−0.211** (0.086)		−0.009*** (0.002)		−0.010*** (0.002)	
Treat $\times$ post $\times$ no LTC need		−0.130** (0.057)		−0.193** (0.079)		−0.008*** (0.002)		−0.009*** (0.002)
Treat $\times$ post $\times$ have LTC need		−0.205** (0.093)		−0.387*** (0.131)		−0.073*** (0.017)		−0.021** (0.009)
<b>Panel B</b>								
Treat duration	−0.076*** (0.029)		−0.101*** (0.035)		−0.005*** (0.001)		−0.005*** (0.001)	
Treat duration $\times$ no LTC need		−0.073** (0.028)		−0.101*** (0.035)		−0.005*** (0.001)		−0.005*** (0.001)
Treat duration $\times$ have LTC need		−0.091** (0.036)		−0.137** (0.052)		−0.007*** (0.002)		−0.007** (0.003)
Observations	36,439	36,439	11,896	11,896	36,439	36,439	11,896	11,896
Adj- $R^2$	0.741	0.741	0.643	0.643	0.414	0.414	0.474	0.958
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Individual FE	Y	Y	Y	Y	Y	Y	Y	Y

Robust standard errors are clustered at the city level. \*\*\*, \*\*, and \* denote 1, 5, and 10% significance level, respectively. All regressions control for year FE, individual FE, demographic and socioeconomic covariates, and household-level covariates, as specified in Table 3.



that the treatment and control groups had similar time trends in MPV before treatment using an event study approach, and the event study analysis results for MPV measured at  $k = 1/3$  and  $k = 2/3$ , respectively, are detailed in Appendix Figures E1, E2. Whether  $k = 1/3$  or  $k = 2/3$ , the pre-reform estimates were all non-significant. This indicates that the trend of MPV in the treatment group does not differ from that of the control group in the pre-reform period.

In contrast, MPV declined significantly in the reform year and even more in the year following the reform year. This finding provides additional evidence that the trend of this effect remains consistent with the true effect.

In Table 6, we estimated the MPV for regression by taking 1/3 and 2/3 for  $k$  (deprivation dimension threshold), respectively. LTCI coverage/duration had a significant negative effect on MPV whether  $k$  was taken as 1/3 or 2/3, implying that LTCI can significantly reduce an individual's likelihood of future multidimensional poverty. The effect of LTCI coverage/duration on MPV was significantly greater in the middle-aged and elderly with LTC needs than in the middle-aged and elderly without LTC needs. Using  $k = 1/3$ , for those middle-aged and older adults with LTC needs, LTCI coverage was associated with a 20.5–38.7 reduction in MPV; for those middle-aged and older adults without LTC needs, LTCI coverage was associated with a 13%–19.3% reduction in MPV.

## 5.4. Heterogeneity

First, we are interested in the heterogeneity of the impact of LTCI on individuals at different quantiles of the IMD. The greater the multidimensional poverty of an individual, the more difficult it is to reduce poverty. If LTCI has a greater effect on poverty reduction for individuals with more severe multidimensional poverty, this implies that LTCI plays a “timely help” role in poverty reduction. We estimated the effect of LTCI on individuals in different quantiles of IMD using quantile regression. The results are shown in Figure 3 and Appendix Table F1.

We find that the quantile estimates for both specifications suggest that LTCI has a greater impact on middle-aged and older adults in

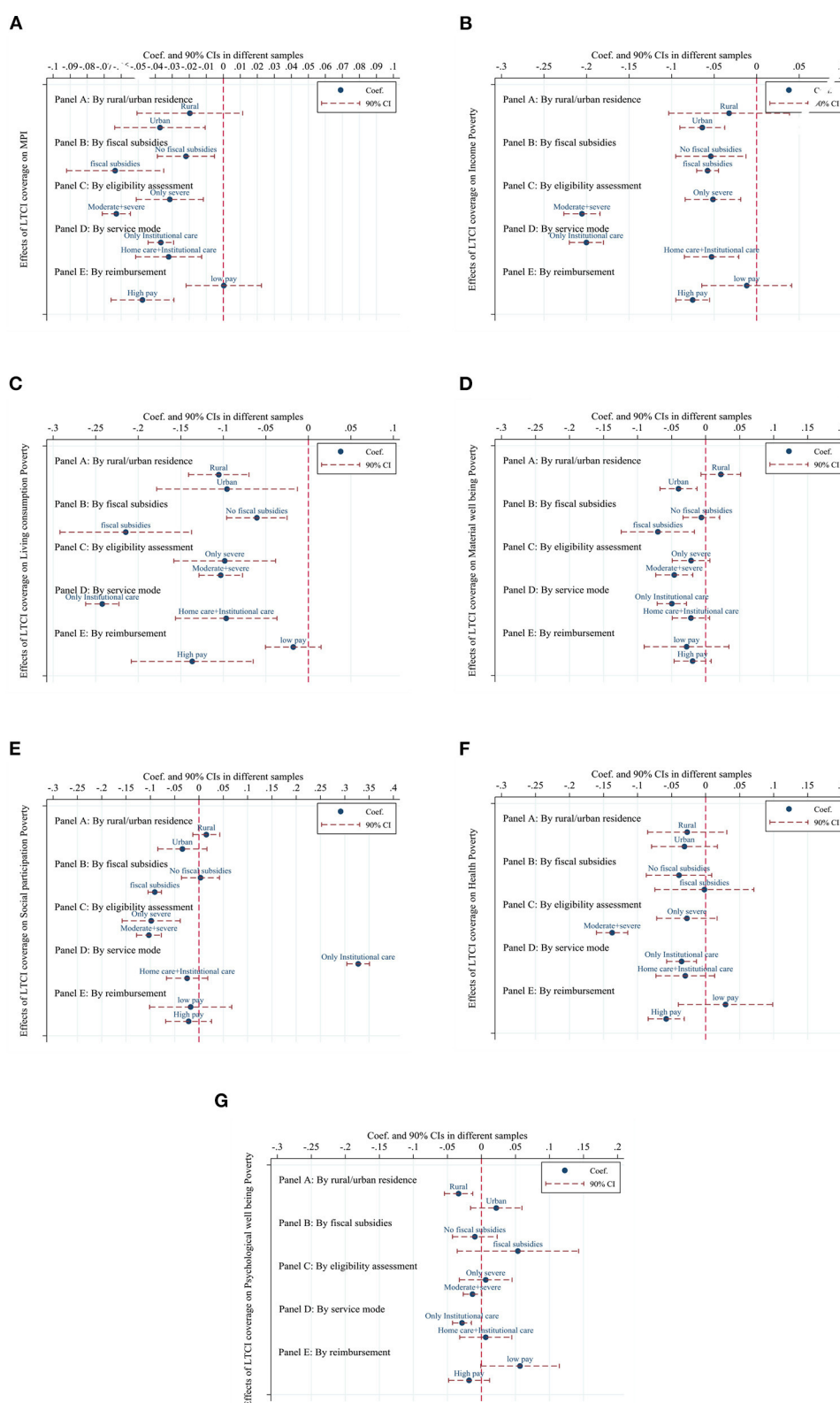


FIGURE 4

Heterogeneous effects of LTCl. The figure depicts the coefficients as well as the 90% confidence intervals for the regression analysis. Robust standard errors are clustered at the city level. \*\*\*, \*\*, and \* denote 1%, 5%, and 10% significance level, respectively. All regressions control for year FE, individual FE, demographic and socioeconomic covariates, and household-level covariates, as specified in Table 3. (A), IMD; (B), Income poverty; (C), Living consumption poverty; (D), Material wellbeing poverty; (E), Social participation poverty; (F), Health poverty; (G), Psychological wellbeing poverty.

the higher quantile of multidimensional poverty. Not only does LTCl significantly reduce multidimensional poverty among middle-aged

and older adults, but it also plays a greater role for the group of middle-aged and older adults who need the most help. One possible



explanation is that, on the one hand, LTCI in China provides different levels of benefit based on the level of disability, and the more severe the disability, the better the LTCI benefit, providing for a reduction in multidimensional poverty for individuals with severe multidimensional poverty who may have received LTCI services. On the other hand, individuals who are covered by LTCI but do not receive LTCI services may be informal caregivers of individuals who have received LTCI services and benefit from the reduction in multidimensional poverty of these individuals who have received LTCI services.

Another interesting question worth investigating is whether the relationship between LTCI and each outcome variable may differ in some dimensions. We interact LTCI duration with the indicators of each subgroup, and the estimated coefficients of each interaction term show the estimated effect of the subgroup with certain observable characteristics. The results are shown in [Figure 4](#) and [Appendix Table F2](#) in the Appendix. The dotted lines in [Figure 4](#) represent the estimated coefficients of the effect of LTCI duration on each subgroup outcome variable, and the dashed lines represent the 90% confidence intervals for each estimate.

In [Figure 4A](#), each graph shows the estimated results for each outcome variable by rural/urban residents. For the rural resident group, LTCI coverage has a significant negative effect on IMD, the likelihood of income poverty, and the likelihood of material wellbeing poverty for urban residents. In the living consumption poverty dimension, LTCI coverage has a significant negative effect on both rural residents and urban residents, but the effect on rural residents is greater than that on urban residents. Furthermore, LTCI coverage only has a significant negative effect on the likelihood of psychological wellbeing poverty for rural residents, and the effect on urban residents is not statistically significant.

In [Figure 4B](#), each graph shows the estimated results for each outcome variable by fiscal subsidies. For the fiscal subsidy group, LTCI coverage has a significant negative effect on IMD, the likelihood of income poverty, the likelihood of living consumption poverty, the likelihood of social participation poverty, and the likelihood of material wellbeing poverty for individuals in pilot cities with fiscal subsidies. Except for the IMD, income poverty and living consumption poverty dimensions, the estimates for the no-subsidy group are not significant in other dimensions. In the income poverty dimension and the living consumption poverty dimension, the LTCI coverage has a significantly larger effect on the group with fiscal subsidies relative to the group without fiscal subsidies.

In [Figure 4C](#), each graph shows the estimated results for each outcome variable by eligibility assessment. The negative effects of LTCI coverage on IMD, the likelihood of income poverty, the likelihood of living consumption poverty, and the likelihood of social participation poverty were significantly greater for the group with moderately disabled and severely disabled people as enrollees than for the group with severely disabled people only as enrollees. In the material welfare poverty and health poverty dimensions, LTCI coverage had statistically insignificant estimates for the group with only the severely disabled as enrollees, while it had a statistically significant negative effect for the group with the moderately disabled and severely disabled as enrollees.

In [Figure 4D](#), each graph shows the estimated results for each outcome variable by service mode. The negative effect of LTCI coverage on IMD, the likelihood of income poverty, and the likelihood of living consumption poverty was significantly greater

for the group with institutional care only as the service model than for the group with home care and institutional care as the service model. In the material wellbeing poverty, health poverty, and psychological wellbeing poverty dimensions, the LTCI coverage was not statistically significant in its estimates for the group with home care and institutional care as a service model, while it had a significant negative effect on the group with institutional care only as a service model. In the social participation poverty dimension, LTCI coverage significantly increased the likelihood of social participation poverty occurring in the group with institutional care only as a service model.

In [Figure 4E](#), each graph shows the estimated results for each outcome variable by reimbursement. Considering LTCI reimbursement rates above 75% and daily payments above 100 RMB as high pay, the pilot cities were divided into high and low-pay groups. The estimates of LTCI coverage on IMD for the low-pay group were not statistically significant, while it had a significant negative effect on IMD for the high-pay group. In the income poverty, living consumption poverty, and health poverty dimensions, the estimates of LTCI coverage were not statistically significant for the low-pay group, while it had a significant negative effect on the high-pay group.

## 6. Discussion and conclusion

As the population ages and the family structure becomes smaller, the function of families to provide informal care services weaken, while demand for formal LTC services rise in China. To explore the feasibility of establishing an LTCI system, the central government launched the LTCI pilot program in 2016. Using longitudinal data based on a national random sample survey, this paper used a DID strategy to assess the effect of LTCI coverage in improving multidimensional poverty status and unidimensional poverty status and in reducing multidimensional poverty vulnerability. As one of the few studies evaluating the impact of the LTCI pilot, this paper provides evidence that the implementation of LTCI reduced multidimensional poverty and multidimensional poverty vulnerability among middle-aged and older adults.

We found that the IMD of middle-aged and older adults decreased significantly 21.53% after the implementation of LTCI and that one more year of LTCI coverage was associated with a significant 10.53% decrease in IMD. LTCI had a greater impact on middle-aged and older adults with higher quartiles of multidimensional poverty. Furthermore, we found that LTCI coverage contributed to a reduction in MPV and that the impact was greater for individuals with LTC needs. These findings provide evidence for the existence of LTCI poverty reduction effects and confirm that LTCI coverage improves multidimensional poverty among covered individuals and reduces their likelihood of future multidimensional poverty.

For income poverty and living consumption poverty, we found that LTCI coverage significantly reduces the likelihood of income poverty among the middle-aged and elderly by 27.7%, and LTCI coverage significantly reduces the likelihood of living consumption poverty among individuals with LTC needs by 40.2%. These effects may stem from the reduction in care and medical expenditures due to LTCI and the increase in the labor supply of informal family caregivers. The literature suggests that public LTCI programs in China are associated with reductions in out-of-pocket medical costs. [Lei et al. \(29\)](#) found a 23.5% reduction in out-of-pocket medical

costs for covered individuals for one more year of LTCI coverage. Lu et al. (19) and Feng et al. (20) similarly found this phenomenon in their studies of LTCI pilots in Shanghai and Qingdao, China. The implementation of public LTCI programs in China has also reduced the caregiving burden of family caregivers, and Lei et al. (29) found that LTCI coverage resulted in a 47% reduction in informal caregiving time. The reduced burden of informal caregiving implies a potential positive spillover effect of LTCI on the labor supply of family caregivers (22). The public LTCI program in China also provides cash subsidies to covered individuals who choose family caregivers for home care.

We also found some evidence that LTCI can improve health poverty and social participation poverty. Coverage of LTCI significantly reduces the likelihood of health poverty by 12.2%, and one more year of LTCI coverage significantly reduces the likelihood of health poverty for individuals with LTC needs by 2.6%. These findings are similar to those of Stabile et al. (27), who found a positive effect of publicly funded home care services in Canada on the self-rated health of welfare recipients. Physical function decline in older adults who are physically frail can be slowed by a randomized, family-based intervention program (56). However, some studies have shown that more LTC services do not have an impact on health outcomes (57). One possible explanation is that China has a high demand for LTC but a chronic lack of LTC services, so LTCI coverage has an impact on health poverty. Additionally, our findings can be compared with those of Lei et al. (29), who discovered that public LTCI programs in China resulted in a 29% increase in the likelihood of self-rated good health status among individuals in need of care. In the social participation poverty dimension, we found that one more year of LTCI coverage reduced the likelihood of occurrence of social participation poverty by 3.2% for individuals with LTC needs. This may be related to improvements in the health status of covered individuals and the care services provided by LTCI.

Furthermore, we focused on the effect of LTCI coverage on different subgroups. LTCI coverage has a much greater reduction effect on the likelihood of living consumption poverty for rural residents than for urban residents, and a statistically significant reduction effect on the likelihood of psychological wellbeing poverty for rural residents only, while it is statistically insignificant for urban residents. However, LTCI coverage only affects IMD, the likelihood of income poverty, and the likelihood of material wellbeing poverty for urban residents, and is not significant for rural residents. These findings may be related to the fact that the LTCI pilot began supplying care services to rural residents, but care resources for rural residents are still undersupplied relative to urban residents (58). We also found that the impact of LTCI coverage on IMD, the likelihood of income poverty, and the likelihood of living consumption poverty was significantly greater in pilot cities that offered only one service model, institutional care, than in pilot cities that offered both institutional care and home care. One possible explanation is that older adults in China prefer home care to institutional care (59), so the burden of informal caregivers in pilot cities that only provide institutional care is lower than in pilot cities that provide both home and institutional care. This explanation also applies to estimates in the material wellbeing poverty dimension. Estimates on the likelihood of health and psychological wellbeing poverty indicate that LTCI coverage has a significant impact only on individuals in pilot cities that only provide institutional care. This could be because institutional care is more specialized in

terms of care circumstances, care equipment, and caregivers than home care. However, we found that LTCI coverage in LTCI pilot cities that provided only institutional care significantly increased the likelihood of socially engaged poverty occurrence. This finding may be related to barriers to social participation among individuals requiring LTC services in institutional care settings. Studies of older residents requiring LTC services in institutional care settings in China have confirmed the existence of this barrier to social participation (60).

Additionally, we found that the impact was greater for LTCI programs that provided fiscal subsidies, included both severe and moderate disability in the granting of benefits, and higher benefit payments. It is important to optimize the existing LTCI system design by assessing the heterogeneity of the effects of LTCI design in different pilot cities to help establish a suitable public LTCI system in China.

There are several limitations in our study. First, the literature suggests that public programs, such as cash transfers, can indirectly affect ineligible individuals in the same area (61). Because specific information on individual access to LTCI benefits is not available, the treatment effects estimated in this paper include both direct effects for direct LTCI beneficiaries and spillover effects for non-direct LTCI beneficiaries who are covered by LTCI programs. Therefore, this paper may have underestimated the impact of the LTCI program on actual beneficiaries. Second, due to data limitations, we do not know which service model was selected by individuals who received LTCI benefits, so the impact of home care, institutional care, and hospital care cannot be estimated separately in this paper. Overall, this study provides empirical evidence for the effectiveness of LTCI in improving multidimensional poverty among middle-aged and elderly people in China. These findings have important policy implications for further optimizing LTCI program design and expanding LTCI pilots in China, as well as for developing LTCI systems in other developing countries with rapidly growing disabling populations and LTC needs.

## Author's note

Disability is one of the major causes of poverty, people with disabilities and their families are more likely to fall into poverty than families without a disabled person. However, the vast majority of care services are provided and paid for by families and individuals, only 6% of the world's population has access to government-sponsored long-term care assistance. When the price of care is solely determined by the market, individuals in need of care can quickly fall into a poverty trap due to costly care. The traditional model of informal care provided by families in China is unsustainable as the proportion of nuclear families rises. Family members are tethered to provide care for relatives with disabilities, making it difficult for them to find work and miss out on development opportunities, leaving families in distress. However, poverty does not only mean low income, but also a lack of capability. Therefore, this paper examines the poverty reduction effects of the public long-term care insurance (LTCI) program piloted in China in recent years from a multidimensional poverty perspective. The findings of this paper suggest that the establishment of an LTCI system can improve the poverty of

middle-aged and older adults in several ways, which has important implications for the development of LTCI systems in China and other developing countries.

## Data availability statement

The datasets [China Health and Retirement Longitudinal Survey (CHARLS)] for this study can be found at: <https://opendata.pku.edu.cn/> (Peking University Open Research Data Platform).

## Author contributions

WL: conceptualization, supervision, and writing—review and editing. JK: conceptualization, methodology, data curation, investigation, software, writing—original draft, and visualization. FS: conceptualization, validation, formal analysis, writing—original draft, and writing—review and editing. All authors contributed to the article and approved the submitted version.

## Funding

This work was supported by the National Natural Science Foundation of China (No. 71873040), the Project of the Service Trade Sustainable Development Research Base of Guangdong (No. 2019WZJD004), and the Project of Innovation and Industrial Development Research Group (No. 2018WCXTD005).

## References

- Del Pozo-Rubio R, Pardo-Garcia I, Escribano-Sotos F. Financial catastrophism inherent with out-of-pocket payments in long term care for households: a latent impoverishment. *Int J Environ Res Public Health*. (2020) 17:295. doi: 10.3390/ijerph17010295
- Filmer D. Disability, poverty, and schooling in developing countries: results from 14 household surveys. *World Bank Econ Rev*. (2008) 22:141–63. doi: 10.1093/wber/lhm021
- Trani J-F, Loeb M. Poverty and disability: a vicious circle? Evidence from Afghanistan and Zambia. *J Int Dev*. (2012) 24:S19–52. doi: 10.1002/jid.1709
- Mitra S, Posarac A, Vick B. Disability and poverty in developing countries: a Multidimensional Study. *World Dev*. (2013) 41:1–18. doi: 10.1016/j.worlddev.2012.05.024
- Pinilla-Roncancio M, Alkire S. How poor are people with disabilities? Evidence based on the global multidimensional poverty Index. *J Disabil Policy Stud*. (2021) 31:206–16. doi: 10.1177/1044207320919942
- OECD. *Enabling Women's Economic Empowerment: New Approaches to Unpaid Care Work in Developing Countries*. Paris: Organisation for Economic Co-operation and Development (2019). doi: 10.1787/ec90d1b1-en
- Brodaty H, Donkin M. Family caregivers of people with dementia. *Dialogues Clin Neurosci*. (2009) 11:217–28. doi: 10.31887/DCNS.2009.11.2/hbrodaty
- Yamada H, Shimizutani S. Labor market outcomes of informal care provision in Japan. *J Econ Ageing*. (2015) 6:79–88. doi: 10.1016/j.jea.2015.02.003
- Zhang L, Fu S, Fang Y. Prediction of the number of and care costs for disabled elderly from 2020 to 2050: a comparison between urban and rural areas in China. *Sustainability*. (2020) 12:2598. doi: 10.3390/su12072598
- Sen A. *Development as Freedom*, 1st ed. Oxford: Oxford University Press (1999).
- Barclay L. Natural deficiency or social oppression? The capabilities approach to justice for people with disabilities. *J Moral Philos*. (2012) 9:500–20. doi: 10.1163/174552412X628823
- Trani J-F, Bakhshi P, Tlapek SM, Lopez D, Gall F. Disability and poverty in morocco and tunisia: a multidimensional approach. *J Hum Dev Capab*. (2015) 16:518–48. doi: 10.1080/19452829.2015.1091808
- Trani J-F, Kuhlberg J, Cannings T, Chakkal D. Multidimensional poverty in Afghanistan: who are the poorest of the poor? *Oxford Dev Stud*. (2016) 44:220–45. doi: 10.1080/13600818.2016.1160042
- Banks LM, Kuper H, Polack S. Poverty and disability in low- and middle-income countries: a systematic review. *PLoS ONE*. (2017) 12:e0189996. doi: 10.1371/journal.pone.0189996
- Gartrell A. “A frog in a well”: the exclusion of disabled people from work in Cambodia. *Disabil Soc*. (2010) 25:289–301. doi: 10.1080/09687591003701207
- Yeo R, Moore K. Including disabled people in poverty reduction work: “nothing about us, without us” *World Dev*. (2003) 31:571–90. doi: 10.1016/S0305-750X(02)00218-8
- Dembo RS, Mitra M, Mckee M. The psychological consequences of violence against people with disabilities. *Disabil Health J*. (2018) 11:390–7. doi: 10.1016/j.dhjo.2018.01.006
- Kavanagh AM, Krnjacki L, Aitken Z, LaMontagne AD, Beer A, Baker E, et al. Intersections between disability, type of impairment, gender and socio-economic disadvantage in a nationally representative sample of 33,101 working-aged Australians. *Disabil Health J*. (2015) 8:191–9. doi: 10.1016/j.dhjo.2014.08.008
- Lu B, Mi H, Yan G, Lim JKH, Feng G. Substitutional effect of long-term care to hospital inpatient care? *China Econ Rev*. (2020) 62:101466. doi: 10.1016/j.chieco.2020.101466
- Feng J, Wang Z, Yu Y. Does long-term care insurance reduce hospital utilization and medical expenditures? Evidence from China. *Soc Sci Med*. (2020) 258:113081. doi: 10.1016/j.socscimed.2020.113081
- Kim HB, Lim W. Long-term care insurance, informal care, and medical expenditures. *J Public Econ*. (2015) 125:128–42. doi: 10.1016/j.jpubeco.2014.12.004
- Fu R, Noguchi H, Kawamura A, Takahashi H, Tamiya N. Spillover effect of Japanese long-term care insurance as an employment promotion policy for family caregivers. *J Health Econ*. (2017) 56:103–12. doi: 10.1016/j.jhealeco.2017.09.011
- Tamiya N, Noguchi H, Nishi A, Reich MR, Ikegami N, Hashimoto H, et al. Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet*. (2011) 378:1183–92. doi: 10.1016/S0140-6736(11)61176-8

## Acknowledgments

We would like to express our gratitude to the Service Trade Sustainable Development Research Base of Guangdong for their assistance with this project.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2023.1100146/full#supplementary-material>

24. Shinya S, Nakamura J. Can formal elderly care stimulate female labor supply? The Japanese experience. *J Jpn Inst Econ.* (2014) 34:98–115. doi: 10.1016/j.jjie.2014.05.006
25. Rudiger D, Seiler D. Changes in income for those in need of long-term care as a result of the introduction of a long-term-care insurance. *Z Gerontol.* (1992) 25:178–85.
26. Bai C-E, Wu B. Health insurance and consumption: evidence from China's new cooperative medical scheme. *J Comp Econ.* (2014) 42:450–69. doi: 10.1016/j.jce.2013.07.005
27. Stabile M, Laporte A, Coyte PC. Household responses to public home care programs. *J Health Econ.* (2006) 25:674–701. doi: 10.1016/j.jhealeco.2005.03.009
28. Sohn M, O'Campo P, Muntaner C, Chung H, Choi M. Has the long-term care insurance resolved disparities in mortality for older Koreans? Examination of service type and income level. *Soc Sci Med.* (2020) 247:112812. doi: 10.1016/j.socscimed.2020.112812
29. Lei X, Bai C, Hong J, Liu H. Long-term care insurance and the well-being of older adults and their families: evidence from China. *Soc Sci Med.* (2022) 296:114745. doi: 10.1016/j.socscimed.2022.114745
30. Ng ST, Tengku-Aizan H, Tey NP. Perceived health status and daily activity participation of older Malaysians. *Asia Pac J Public Health.* (2011) 23:470–84. doi: 10.1177/1010539510374751
31. Siette J, Berry H, Jorgensen M, Brett L, Georgiou A, McClean T, et al. Social participation among older adults receiving community care services. *J Appl Gerontol.* (2021) 40:997–1007. doi: 10.1177/0733464820938973
32. Ariizumi H. Effect of public long-term care insurance on consumption, medical care demand, and welfare. *J Health Econ.* (2008) 27:1423–35. doi: 10.1016/j.jhealeco.2008.07.008
33. Zhao Y, Strauss J, Chen X, Wang Y, Gong J, Meng Q, et al. *China Health and Retirement Longitudinal Study wave 4 User's Guide*. National School of Development, Peking University (2020). p. 5–6.
34. Zhao Y, Hu Y, Smith JP, Strauss J, Yang G. Cohort profile: the china health and retirement longitudinal study (CHARLS). *Int J Epidemiol.* (2014) 43:61–8. doi: 10.1093/ije/dys203
35. Alkire S. Dimensions of human development. *World Dev.* (2002) 30:181–205. doi: 10.1016/S0305-750X(01)00109-7
36. Alkire S, Foster J. Counting and multidimensional poverty measurement. *J Public Econ.* (2011) 95:476–87. doi: 10.1016/j.jpubeco.2010.11.006
37. Alkire S, Fang Y. Dynamics of multidimensional poverty and uni-dimensional income poverty: an evidence of stability analysis from China. *Soc Indic Res.* (2019) 142:25–64. doi: 10.1007/s11205-018-1895-2
38. Zhou D, Cai K, Zhong S. A statistical measurement of poverty reduction effectiveness: using China as an example. *Soc Indic Res.* (2021) 153:39–64. doi: 10.1007/s11205-020-02474-w
39. Thorbecke E. Multidimensional poverty: conceptual and measurement issues. In: Kakwani N, Silber J, editors. *The Many Dimensions of Poverty*. London: Palgrave Macmillan UK (2013). p. 3–19. doi: 10.1057/9780230592407\_1
40. Sen A. Why health equity? *Health Econ.* (2002) 11:659–66. doi: 10.1002/he.762
41. Benoit C, Jansson M, Jansenberger M, Phillips R. Disability stigmatization as a barrier to employment equity for legally-blind Canadians. *Disabil Soc.* (2013) 28:970–83. doi: 10.1080/09687599.2012.741518
42. Meininger HP. Connecting stories: a narrative approach of social inclusion of persons with intellectual disability. *Alter.* (2010) 4:190–202. doi: 10.1016/j.alter.2010.04.001
43. Meyer IH, Schwartz S, Frost DM. Social patterning of stress and coping: does disadvantaged social statuses confer more stress and fewer coping resources? *Soc Sci Med.* (2008) 67:368–79. doi: 10.1016/j.socscimed.2008.03.012
44. Alkire S, Emma Santos M. Measuring acute poverty in the developing world: robustness and scope of the multidimensional poverty Index. *World Dev.* (2014) 59:251–74. doi: 10.1016/j.worlddev.2014.01.026
45. UNDP OPHI. *Global Multidimensional Poverty Index 2021 – Unmasking Disparities by Ethnicity, Caste and Gender*. Oxford: United Nations Development Programme and Oxford Poverty and Human Development Initiative (2021).
46. Chaudhuri S, Jalan J, Suryahadi A. *Assessing Household Vulnerability to Poverty From Cross-Sectional Data: A Methodology and Estimates from Indonesia*. Department of Economics, Columbia University, New York, NY, United States. (2002). doi: 10.7916/D85149GF
47. Azeem MM, Muger A, Schilizzi S. Vulnerability to multi-dimensional poverty: an empirical comparison of alternative measurement approaches. *J Dev Stud.* (2018) 54:1612–36. doi: 10.1080/00220388.2017.1344646
48. Feeny S, McDonald L. Vulnerability to multidimensional poverty: findings from households in melanesia. *J Dev Stud.* (2016) 52:447–64. doi: 10.1080/00220388.2015.1075974
49. Imbens GW, Wooldridge JM. Recent developments in the econometrics of program evaluation. *J Econ Lit.* (2009) 47:5–86. doi: 10.1257/jel.47.1.5
50. Moser P, Voena A. Compulsory licensing: evidence from the trading with the enemy act. *Am Econ Rev.* (2012) 102:396–427. doi: 10.1257/aer.102.1.396
51. Haushofer J, Chemin M, Jang C, Abraham J. Economic and psychological effects of health insurance and cash transfers: evidence from a randomized experiment in Kenya. *J Dev Econ.* (2020) 144:102416. doi: 10.1016/j.jdeveco.2019.102416
52. Rippin N. *A Response to the Weaknesses of the Multidimensional Poverty Index (MPI): The Correlation Sensitive Poverty Index (CSPI) (Briefing Papers No.19/2011)*. German Institute of Development and Sustainability (2011).
53. Abadie A. Semiparametric difference-in-differences estimators. *Rev Econ Stud.* (2005) 72:1–19. doi: 10.1111/0034-6527.00321
54. Arkhangelsky D, Athey S, Hirshberg DA, Imbens GW, Wager S. Synthetic difference-in-differences. *Am Econ Rev.* (2021) 111:4088–118. doi: 10.1257/aer.20190159
55. Goodman-Bacon A. Difference-in-differences with variation in treatment timing. *J Econometrics.* (2021) 225:254–77. doi: 10.1016/j.jeconom.2021.03.014
56. Gill TM, Baker DI, Gottschalk M, Peduzzi PN, Allore H, Byers A. A program to prevent functional decline in physically frail, elderly persons who live at home. *N Engl J Med.* (2002) 347:1068–74. doi: 10.1056/NEJMoa020423
57. Takahashi M. The Behavioral effect of insurance coverage and its health consequences: Evidence from long-term care. *SSRN Elect J.* (2019). doi: 10.2139/ssrn.3352257
58. Wang Y, Li J, Zhang N, Ding L, Feng Y, Tang X, et al. Urban-rural disparities in informal care intensity of adult daughters and daughters-in-law for elderly parents from 1993-2015: evidence from a National Study in China. *Soc Indic Res.* (2022) 160:487–503. doi: 10.1007/s11205-020-02280-4
59. Mi H, Fan X, Lu B, Cai L, Piggott J. Preparing for population ageing: estimating the cost of formal aged care in China. *J Econ Ageing.* (2020) 17:100183. doi: 10.1016/j.jeoa.2018.12.002
60. Pan H, Dury S, Duppen D, Wang R, De Donder L. Motivators and barriers to social participation in two Chinese long-term care institutions: a focus-group study. *Geriatr Nurs.* (2022) 44:90–6. doi: 10.1016/j.gerinurse.2022.01.004
61. Angelucci M, De Giorgi G. Indirect effects of an aid program: how do cash transfers affect ineligible consumption? *Am Econ Rev.* (2009) 99:486–508. doi: 10.1257/aer.99.1.486





## OPEN ACCESS

## EDITED BY

Mariana Dyakova,  
Public Health Wales NHS Trust, United Kingdom

## REVIEWED BY

Arcadio A. Cerda,  
University of Talca, Chile  
Arpo Aromaa,  
National Institute for Health and  
Welfare, Finland

## \*CORRESPONDENCE

Behzad Karamimatin  
✉ bkm\_1344@yahoo.com

## SPECIALTY SECTION

This article was submitted to  
Public Health Policy,  
a section of the journal  
Frontiers in Public Health

RECEIVED 03 September 2022

ACCEPTED 27 January 2023

PUBLISHED 16 February 2023

## CITATION

Soofi M, Kok G, Soltani S, Kazemi-Karyani A,  
Najafi F and Karamimatin B (2023) Willingness  
to pay for a COVID-19 vaccine and its  
associated determinants in Iran.  
*Front. Public Health* 11:1036110.  
doi: 10.3389/fpubh.2023.1036110

## COPYRIGHT

© 2023 Soofi, Kok, Soltani, Kazemi-Karyani,  
Najafi and Karamimatin. This is an open-access  
article distributed under the terms of the  
[Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/).  
The use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in this  
journal is cited, in accordance with accepted  
academic practice. No use, distribution or  
reproduction is permitted which does not  
comply with these terms.

# Willingness to pay for a COVID-19 vaccine and its associated determinants in Iran

Moslem Soofi<sup>1</sup>, Gerjo Kok<sup>2</sup>, Shahin Soltani<sup>3</sup>, Ali Kazemi-Karyani<sup>3</sup>,  
Farid Najafi<sup>3</sup> and Behzad Karamimatin<sup>3\*</sup>

<sup>1</sup>Social Development and Health Promotion Research Center, Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran, <sup>2</sup>Work and Social Psychology Department, Maastricht University, Maastricht, Netherlands, <sup>3</sup>Research Center for Environmental Determinants of Health, Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran

**Introduction:** Understanding the individuals' willingness to pay (WTP) for the COVID-19 vaccine could help design policy interventions to control the COVID-19 pandemic. This study aimed to estimate the individuals' willingness to pay (WTP) for a COVID-19 vaccine and to identify its associated determinants.

**Methods:** A cross-sectional survey was conducted on 526 Iranian adults using a web-based questionnaire. A double-bounded contingent valuation approach was used to estimate WTP for the COVID-19 vaccine. The parameters of the model were estimated based on the maximum likelihood method.

**Results:** A considerable proportion of participants (90.87%) were willing to pay for a COVID-19 vaccine. Based on our discrete choice model, the estimated mean WTP for a COVID-19 vaccine was US\$ 60.13 (CI: 56.80–63.46;  $p < 0.01$ ). Having a higher perceived risk of being contaminated with COVID-19, higher average monthly income, higher education level, pre-existence of chronic diseases, previous experience of vaccination, and belonging to higher age groups were significant determinants associated with WTP for COVID-19 vaccination.

**Conclusion:** The present study indicates a relatively high WTP and acceptance of a COVID-19 vaccine among the Iranian population. Average monthly income, risk perception, education level, the preexistence of chronic disease, and previous vaccination experience increased the likelihood of WTP for a vaccine. Subsidizing the COVID-19 vaccine for the low-income population and raising risk perception among the population should be considered in formulating vaccine-related interventions.

## KEYWORDS

willingness to pay, COVID-19 vaccine, contingent valuation method, Iran, valuation in health, vaccine preferences

## Introduction

The World Health Organization (WHO) announced COVID-19 to be a pandemic on March 11, 2020 (1). According to WHO (2021), until 14 April 2022, 500,186,525 cases of COVID-19 were confirmed globally, resulting in 6,190,349 deaths. As of November 19, 2021, there have been ~7,199,861 confirmed cases of COVID-19 in Iran, with 140,716 deaths (2). COVID-19 has caused disruptions in multiple sectors of human life and potentially could cause persistent symptoms (3, 4).

Hand-washing, mask-wearing, and social distancing are the primary methods for preventing the spread of COVID-19 in most countries. However, their effectiveness is limited, and they have psychological, economic, and societal impacts on people (5). Vaccination is now the most effective way to protect individuals from communicable diseases and provide long-term immunity (6, 7).



In providing an essential health service (e.g., vaccination) to the people, the evaluation of this service by them is one of the most important issues that can be used to measure their acceptance and the success of the program. The question is how much individuals or society as a whole value the COVID-19 vaccine (8). Willingness to Pay (WTP) is the maximum amount of money that a person would be willing to pay for a specific intervention or service. Several studies on the willingness to pay (WTP) for the COVID-19 vaccine have been conducted in various countries worldwide, including Kenya, Malaysia, Ecuador, and Indonesia (9–12). However, gaps in knowledge regarding WTP for COVID-19 vaccination still exist, especially in low- and middle-income countries. Previous studies have shown that a majority of people in some LMICs are still hesitant to get vaccinated against COVID-19, particularly in the Middle East and North Africa (13).

WTP estimation studies enable decision-makers to have a better understanding of individuals' preferences used in designing health policies (14). Information on individuals' WTP also can be helpful in formulating well-designed health interventions for use in target populations (10). Moreover, pharmaceutical companies can use information regarding individuals' WTP for a COVID-12 vaccine to identify a potential vaccine market and pricing strategy (15). In addition, the social valuation of a vaccine is important to assess the benefits of public and private investments required for its development and distribution.

Until April 14, 2022, ~65 % of people around the world had received at least one dose of the COVID-19 vaccine; however, only 15.2 % of people in low-income countries had received at least one dose (16). While the government has provided free access to COVID-19 vaccines, the vaccine manufacturers must be compensated for their costs related to research and development, production and distribution (8). Although the COVID-19 vaccine is available to individuals free of charge in Iran, like in most countries, estimating the individuals' willingness to pay can indicate their propensity for vaccine-related decisions as well as their understanding of the need for vaccination. Thus, the findings of our study can help health planners gain a better understanding of vaccine-related behaviors and be used as a criterion to compensate vaccine developers in developing countries like Iran. Given that many countries are currently involved in COVID-19 and may face another pandemic in the future, estimating the willingness to pay for this pandemic can highlight the challenges of other possible future pandemics and help design control interventions. The goal of this study is to elicit individuals' WTP for a COVID-19 vaccine and its associated determinants in Iran. Our findings may be useful in formulating public health policies on the COVID-19 vaccine.

## Methods

### Study design and sample

A cross-sectional survey among the Iranian adult population aged 18 and above was conducted. Due to the difficulties of conducting a face-to-face survey at the time of the COVID-19 pandemic, the method of an online survey was used. To determine sample size, we used single population proportion formula by considering a 95% level of confidence, a 5% sampling error or precision limit, and a

proportion of individuals who are willing to pay for the COVID-19 vaccine 50%.

The minimum sample size was determined to be 385. However, in order to reduce sample error, the final sample size was increased ( $N = 526$ ). Individuals participated voluntarily through convenience sampling. We sent the web-based questionnaire to individuals via Telegram and WhatsApp. They were requested to forward the questionnaire link to their contacts. We informed participants that their participation in the study is entirely voluntary; thus, they are free to leave at any time, and their completion of the questionnaire represents their informed consent to participate in the study. WhatsApp and Telegram were chosen because these social media platforms are used by the majority of Iranians across socioeconomic groups. As a result, we were able to access the general population both from low and high socioeconomic groups, which is important for WTP studies.

### Survey instrument

The survey instrument was developed by the research team including public health professionals (e.g., a health economist, a social psychologist, etc.). The study tool consisted of a set of binary questions developed to estimate WTP. It also consisted of questions on sociodemographic factors, the perceived risk of being infected with COVID-19, having existing chronic diseases, self-rated overall health status, and COVID-19 vaccination intention. Sociodemographic factors included age, sex, marital status, average monthly income, level of education, and living area (urban/ rural). The average monthly income was categorized as: <IRR 30 million (<US\$ 714.28); IRR 30–60 million (US\$ 714.28–US\$ 1,428.57); and more than IRR 60 million (>US\$ 1,428.57). The questions that were used for measuring intention to uptake the COVID-19 vaccine and perceived risk were: “If a safe and effective vaccine against COVID-19 is available, how likely are you to get that?” and “How do you rate your chances of getting COVID-19?”, respectively. The questionnaire was validated qualitatively using expert opinion. In addition, a pilot survey of 50 participants was conducted to identify problematic questions, assess the bid values' validity, and finalize the instrument.

### Econometric estimation and eliciting WTP

To elicit WTP, the contingent valuation approach in its double-bounded dichotomous choice format was used. It allows efficient use of participants' information. It is considered an appropriate method since it is statistically more efficient in estimating the variance of the parameter, resulting in a more precise confidence interval (17–20).

To elicit participants' WTP, they were first asked if they were willing to pay an initial price for a COVID-19 vaccine. If the respondent answered no (yes) to the initial price, they were asked if they were willing to pay a lower (higher) price for the vaccine. Particularly, respondents were asked, “Are you willing to pay 1.5 million Iranian Rials (IRR) (equivalent to US\$ 35.71 using an exchange rate of 1 US\$ = IRR 42,000) for the COVID-19 vaccine?”. If the respondent replied “yes” to this bid, then, the initial price was doubled to IRR 3 million (US\$ 71.43) and if the respondent replied “no” to this bid, then, the initial price was halved to IDR 750,000 (US\$

17.85). In this way, two answers were recorded for each individual. Based on the responses to double-bounded dichotomous questions, the WTP can be estimated in four types of possible intervals:

- “yes-yes”, where, US\$  $71.43 \leq \text{WTP} < \infty$ ,
- “yes-no”, where, US\$  $35.71 \leq \text{WTP} < \text{US\$ } 71.43$ ,
- “no-yes”, where, US\$  $17.85 \leq \text{WTP} < \text{US\$ } 35.71$ , and
- “no-no”, where,  $0 \leq \text{WTP} < \text{US\$ } 17.85$

The econometric estimation assumes that WTP can be modeled as follow:

$$\text{WTP}_i(z_i, u_i) = z_i'\beta + u_i \text{ and } u_i \sim N(0, \sigma^2) \quad (1)$$

where  $z_i$ ,  $\beta$  and  $u_i$  represent a vector of explanatory variables, represent a vector of parameters, and an error term, respectively.

The following function was maximized to estimate the parameters of the model:

$$\sum_{i=1}^N \left[ d_i^{yy} \ln \left( \Phi \left( z_i' \frac{\beta}{\sigma} - \frac{71.43}{\sigma} \right) - \Phi \left( z_i' \frac{\beta}{\sigma} - \frac{35.71}{\sigma} \right) \right) + d_i^{yy} \ln \left( \Phi \left( z_i' \frac{\beta}{\sigma} - \frac{71.43}{\sigma} \right) \right) + d_i^{ny} \ln \left( \Phi \left( z_i' \frac{\beta}{\sigma} - \frac{35.71}{\sigma} \right) - \Phi \left( z_i' \frac{\beta}{\sigma} - \frac{17.85}{\sigma} \right) \right) + d_i^{nn} \ln \left( 1 - \Phi \left( z_i' \frac{\beta}{\sigma} - \frac{17.85}{\sigma} \right) \right) \right] \quad (2)$$

Furthermore,  $d_i^{yy}$ ,  $d_i^{ny}$ ,  $d_i^{nn}$ , and  $d_i^{nn}$  are indicator variables that take the value of one or zero, depending on the relevant case for each individual, implying that a given individual contributes the likelihood function's logarithm in only one of its four parts. Following Lopez-Feldman  $\beta$  and  $\sigma$  were estimated using the maximum likelihood method (21).

## Results

### Descriptive results

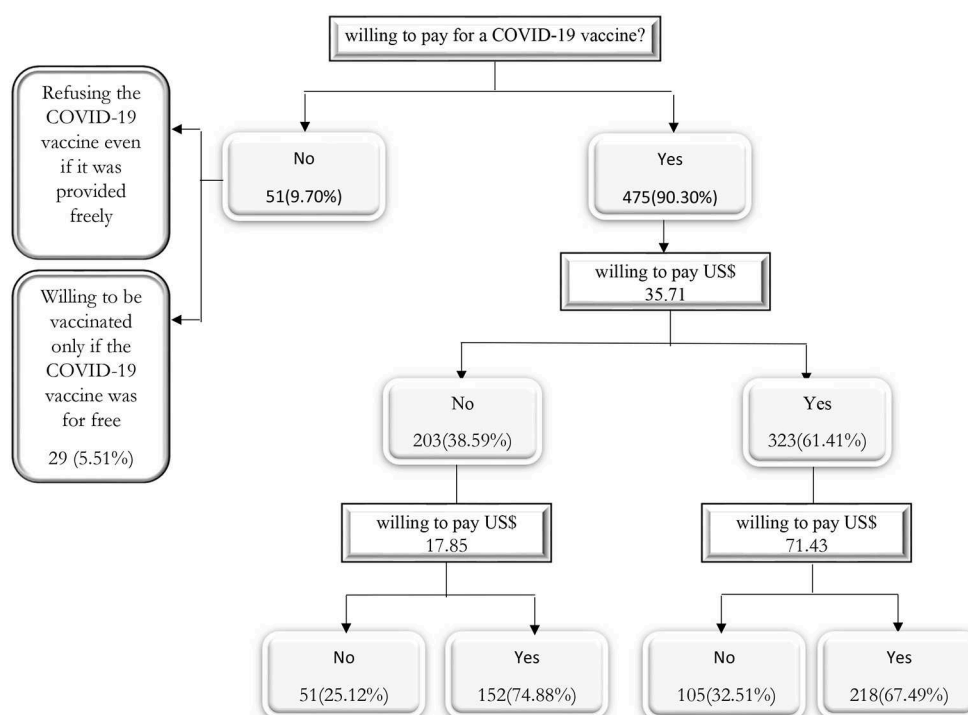
Data from 526 individuals were analyzed. The mean age of respondents was 39.11 (SD±11.63). More than half (55.32%) of the respondents were men, 42.78% had a postgraduate degree, 29.28% belonged to the age group of 30-39 and most of the participants (87.07) lived in urban areas. 12.36% of respondents stated that they had previous vaccination experience prior to the pandemic, 59.70 % had a high level of intention to uptake the COVID-19 vaccine and 23.57 of participants had a low level of risk perception (Table 1).

Of the sample, 378 (71.86%) participants were willing to pay for a COVID-19 vaccine. The remaining 148 (28.14%) individuals stated that they were unwilling to pay for a COVID-19 vaccine, of which 79 (15.02%) individuals stated that they would refuse the COVID-19 vaccine even if it was given to them for free, and 69 (13.12 %) individuals stated they would only be vaccinated if the vaccine was free. In addition, 218 (41.44 %) of participants stated that they would pay both the initial bid and the higher second bid, while 105 (19.96 %) participants stated that they would pay the initial bid but not the higher second bid (Figure 1).

TABLE 1 Characteristics of the participants, cross-sectional survey, 2021.

Variables	N (%)
<b>Sex</b>	
Male	291 (55.32)
Female	235 (44.68)
<b>Age group</b>	
18–29 years	124 (23.57)
30–39 years	154 (29.28)
40–49 years	142 (27.00)
50 years or more	106 (20.15)
<b>Marital status</b>	
Married	345 (65.59)
Single/Widowed/Divorced	181 (34.41)
<b>Education level</b>	
High school or less	87 (16.54)
Bachelor degree	214 (40.68)
Postgraduate degree	225 (42.78)
<b>Place of residence</b>	
Urban	458 (87.07)
Rural	68 (12.93)
<b>Average monthly income (Million IRR<sup>a</sup>)</b>	
<30	88 (16.73)
30–60	165 (31.37)
>60	273 (51.90)
<b>Self-rated general health</b>	
Poor/ Fair	127 (24.14)
Good	210 (39.92)
Very good	189 (35.93)
<b>Pre-existing condition-respondent</b>	
Yes	42 (7.98)
No	484 (92.02)
<b>Level of risk perception</b>	
Low	124 (23.57)
Moderate	186 (35.36)
High	216 (41.06)
<b>Having previous vaccination experience</b>	
Yes	65 (12.36)
No	461 (87.64)
<b>Level of intention to uptake COVID-19 vaccine</b>	
High	314 (59.70)
Moderate	100 (19.01)
Low	112 (21.29)

<sup>a</sup>US\$ = 42,000 Iranian Rials (IRR).



**FIGURE 1**  
Summary of statistics of the responses to the double-bounded dichotomous choice questions.

## Analytical results

The results show that higher educational level, higher income, belonging to older age groups, higher level of risk perception, and having previous vaccination experience are all statistically associated with a higher probability of willingness to pay for a COVID-19 vaccine (Table 2).

Table 3 shows the estimated mean WTP for the basic and expanded model. The basic model is based on the assumption that there are no control variable variables. The expanded model depicted the best-fit model when control variables were taken into account. The results indicated that the mean of the WTP for the COVID-19 vaccine for the basic and expanded model was 60.08 US\$ (CI 95%: 56.13–64.04) and 60.13 US\$ (CI 95%: 56.80–63.46), respectively. The estimated WTP was statistically significant in both models.

## Discussion

In this study, we estimated the WTP for a hypothetical COVID-19 vaccine and examined its associated determinants in Iran. To our knowledge, this is the first study that estimated the WTP for a COVID-19 vaccine using the contingent valuation method in Iran. We found that most of the respondents (95.81%) were willing to accept a COVID-19 vaccine. These acceptability estimates are similar to those from other countries including Kenya (9), Ecuador (11), Malaysia (12), and Indonesia (10) which reported vaccine acceptability rates >90%. The estimated acceptance rate is higher than those reported from other countries such as Saudi Arabia and Turkey, which reported acceptability rates of ~64 and 80%,

respectively (22, 23). In addition, our study demonstrated that the majority (90.30%) of respondents were willing to pay for a COVID-19 vaccine. This finding is higher than those reported in Indonesia (10), Bangladesh (24), Chile (25), and Ecuador (11). Based on our double-bounded dichotomous model, it was estimated that the participants' WTP is US\$ 60.1. This finding is comparable in magnitude to those found by studies conducted in Indonesia (10) and Kenya (9). In a study by Carlos E. Carpio et al. in Kenya individuals' mean WTP for the vaccine was estimated to be ranged from USD 49.81 to USD 68.25 (9). On the other hand, the estimated mean WTP for Iran is larger than those found in other studies (12, 24, 26). For example, the estimated mean WTP in our study is about 2 times and 3 times higher than those found in the Malaysian and Brazilian studies that reported a mean WTP of US\$ 30.70 and US\$ 22.18, respectively (12, 14). However, the estimated mean WTP in our study is low when compared to that of previous studies conducted in Chile, Ecuador, and the US (8, 11, 25, 27). These differences in WTP values could be attributed to differences in the methods used, each country's economic, health, and cultural conditions, and the status of the COVID-19 pandemic at the time of data collection. We estimated individuals' WTP for a COVID-19 vaccine in Iran during the early stages of the disease, and it is now expected to be higher than the amount estimated in this study due to an increase in the number of infected cases, a higher contagion rate, the rapid spread of the disease, global involvement, and a reduction in economic activity (25). Moreover, some of the other influencing factors such as national vaccination policy, vaccine critics' voices, health education messages, severe health consequences of the disease, concerns over adverse effects, etc. had not yet reached their peak impact. These factors can also affect the willingness to pay for the vaccine.

TABLE 2 The effect of explanatory variables on the WTP of individuals for COVID19 vaccine.

Variables	Coefficient	Standard. Error	z	P-value
<b>Sex</b>				
Male	0.41621	3.31732	0.13	0.9
<b>Age group</b>				
30–39 years	−4.0312	4.52596	−0.89	0.373
40–49 years	13.8375	5.15931	2.68	0.007
50 years or more	13.8995	5.78919	2.4	0.016
<b>Marital status</b>				
Married	−0.4929	3.6696	−0.13	0.893
<b>Education level</b>				
Bachelor degree	−0.0221	4.88624	0	0.996
Postgraduate degree	13.5354	5.28502	2.56	0.01
<b>Place of residence</b>				
Urban	3.72871	4.88291	0.76	0.445
<b>Average monthly income (Million IRRa)</b>				
30–60	5.48579	4.75045	1.15	0.248
>60	19.8117	5.08157	3.9	0.000
<b>Self-rated general health</b>				
Good	8.29659	4.11755	2.01	0.044
Very good	15.9019	4.38084	3.63	0.000
<b>Pre-existing condition</b>				
Yes	19.0934	6.83717	2.79	0.005
<b>Level of risk perception</b>				
Moderate	7.35458	4.28919	1.71	0.086
High	15.646	4.37045	3.58	0.000
<b>Having previous vaccination experience</b>				
Yes	16.4942	5.48025	3.01	0.003
_cons	12.2261	7.19541	1.7	0.089
<b>Sigma</b>				
_cons	32.1637	1.64028	19.61	0

Sample: 526, Log likelihood = −642.85, Wald chi2(16) = 168.36, Prob > chi<sup>2</sup> = 0.0000.

TABLE 3 Estimation of double-bounded discrete choice models and willingness-to-pay (WTP) estimates for the basic and expanded model<sup>a</sup>, 2021.

	Mean WTP (\$)	Standard. Error	P-value	Confidence interval 95%
Basic model	60.08	2.01	0.000	56.13–64.04
Expanded model	60.13	1.70	0.000	56.80–63.46

<sup>a</sup>Values are in US dollars.

Individuals with a higher risk perception were more likely to pay for a COVID-19 vaccine, according to our findings. Similarly, previous research found that if a person perceived high risk of contracting the disease, she/he would be more willing to pay for the vaccine (10, 28, 29). In Indonesia, for example, having a higher perceived risk has been associated with higher WTP for the COVID-19 vaccine (10). Another study in Vietnam found that low-risk individuals paid less than those who rated themselves as

moderate- or high-risk (29). The level of risk perception should be given more attention in public health policy because it is among the most important modifiable determinants of WTP (10). Because this is an important determinant of vaccine acceptance, a well-designed intervention to raise individuals' perceived risk for COVID-19 is required to increase a positive attitude toward vaccination (30). As a result, it is crucial to improve people's awareness well about the COVID-19 pandemic and the importance of the vaccine (29). It

should be noted that at this time that the pandemic has passed several peaks in terms of morbidity, mortality and etc., it is expected that the risk perception of individuals should be affected and there may be a higher level of risk perception among the population (25).

According to our findings, participants with a higher average monthly income were more likely to pay for a COVID-19 vaccine. This is consistent with previous studies that found a significant relationship between income and willingness to pay for a COVID-19 vaccine (8, 12, 25). A positive association between income and WTP is used as a justification to subsidize vaccination for the poorest groups. Subsidizing the cost of the COVID-19 vaccine may increase vaccine uptake in terms of public health policy, while higher-income groups may be able to pay for it (9, 25).

Our findings show that high-educated individuals are more likely to pay for the COVID-19 vaccine. This finding is in line with the previous studies that found education as a significant determinant of WTP for the COVID-19 vaccine (12, 25). For example, Wong et al. found that higher education levels resulted in a higher WTP for the COVID-19 vaccine. This finding suggests that vaccination campaigns should target people with a low educational level, as they are less likely to intend to receive a vaccine. A possible explanation is that their health literacy and education levels are likely to be lower, and they may be unaware of the risk of the disease (31).

We have not found a significant association between sex and place of residence with WTP for the covid-19 vaccine, while some studies have reported a significant relationship between these factors and WTP. It should be noted that WTP is influenced by a number of factors, including sociodemographic features and individuals' attitudes and beliefs. These characteristics are not always related to WTP in the same way in different communities (32).

The pre-existing condition also was an important factor that had a positive significant association with WTP for the COVID-19 vaccine. This is consistent with the finding of studies conducted in Chile and the USA (8, 27). One possible explanation is that people with chronic illness have a higher perceived risk due to their condition and health education programs. In addition, in public health policies, these people have been given priority in receiving the vaccine (33). So, these may improve their risk perception and their understanding of the need for vaccines.

Another interesting result from our study is that having previous experiences with vaccination was positively and statistically significantly associated with WTP for the COVID-19 vaccine. A possible explanation for this might be that people who have been vaccinated before have lost some of their fear of the adverse effects of the vaccine.

An important finding was that ~10% of those willing to be vaccinated stated that they were unwilling to pay for the COVID-19 vaccine. Of which, near to half would refuse the COVID-19 vaccine even if it was provided for free. The remaining half stated that they were willing to be vaccinated only if the vaccine was provided freely. Therefore, any policy interventions that are designed should consider these groups as well (25).

There are some limitations to this study. First, we used an online survey as well as convenience sampling to collect the data. This may result in sampling bias, thus, results may not be fully representative of the Iranian population. Second, we conducted this study before the COVID-19 vaccine became available in Iran with a hypothetical vaccine. Therefore, in practice, findings may now differ.

In addition, periodic vaccinations may be required, which in turn will affect the willingness to pay. However, we believe that our study has provided some essential evidence concerning the WTP for a COVID-19 vaccine.

## Conclusion

Having higher perceived risk, higher average monthly income, and having characteristics that lead to greater risk perception of developing COVID-19, such as a higher education level, the pre-existence of chronic diseases, etc., are positively associated with WTP. These variables could be considered in designing public health policies to fight against the COVID-19 pandemic. For example, subsidizing the COVID-19 vaccine for the low-income population and raising risk perception among the population should be considered in formulating vaccine-related interventions.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

This study was approved by the Ethics Committee of Kermanshah University of Medical Sciences (KUMS). (Ethics code: IR.KUMS.REC.1399.047). Informed consent was obtained from all respondents.

## Author contributions

Conceptualization and methodology: MS and BK. Data curation, formal analysis, funding acquisition, and writing original draft: MS. Project administration: BK. Visualization: BK and FN. Writing review and editing: MS, BK, GK, FN, SS, and AKK. All authors contributed to the article and approved the submitted version.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.



## References

- Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Bio Medica: Atenei Parmensis*. (2020) 91:157–160. doi: 10.23750/abm.v91i1.9397
- World Health Organization. WHO Coronavirus (COVID-19) Dashboard. Available from: <https://covid19.who.int/> (accessed on November 21, 2021).
- Yusuf F, Fahriani M, Mamada SS, Frediansyah A, Abubakar A, Maghfirah D, et al. Persistence of long COVID symptoms in COVID-19 survivors worldwide and its potential pathogenesis—a systematic review and meta-analysis. *Narra J*. (2021) 1:e36. doi: 10.52225/narra.v1i2.36
- Fajar JK, Ilmawan M, Mamada S, Mutiawati E, Husnah M, Yusuf H, et al. Global prevalence of persistent neuromuscular symptoms and the possible pathomechanisms in COVID-19 recovered individuals: A systematic review and meta-analysis. *Narra J*. (2021) 1:e36. doi: 10.52225/narra.v1i2.36
- Maserat E, Keikha L, Davoodi S, Mohammadzadeh Z. E-health roadmap for COVID-19 vaccine coverage in Iran. *BMC Public Health*. (2021) 21:1–11. doi: 10.1186/s12889-021-11419-y
- Lurie N, Saville M, Hatchett R, Halton J. Developing Covid-19 vaccines at pandemic speed. *New Engl J Med*. (2020) 382:1969–73. doi: 10.1056/NEJMp2005630
- Farhud DD, Zokaie S. A brief overview of COVID-19 vaccines. *Iran J Public Health*. (2021) 50:i. doi: 10.18502/ijph.v50i7.6656
- García LY, Cerda AA. Contingent assessment of the COVID-19 vaccine. *Vaccine*. (2020) 38:5424–9. doi: 10.1016/j.vaccine.2020.06.068
- Carpio CE, Sarasty O, Hudson D, Macharia A, Shibia M. The demand for a COVID-19 vaccine in Kenya. *Hum Vaccin Immunother*. (2021) 17:3463–71. doi: 10.1080/21645515.2021.1938494
- Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, et al. Willingness-to-pay for a COVID-19 vaccine and its associated determinants in Indonesia. *Hum Vaccin Immunother*. (2020) 16:3074–80. doi: 10.1080/21645515.2020.1819741
- Sarasty O, Carpio CE, Hudson D, Guerrero-Ochoa PA, Borja I. The demand for a COVID-19 vaccine in Ecuador. *Vaccine*. (2020) 38:8090–8. doi: 10.1016/j.vaccine.2020.11.013
- Wong LP, Alias H, Wong P-F, Lee HY, AbuBakar S. The use of the health belief model to assess predictors of intent to receive the COVID-19 vaccine and willingness to pay. *Hum Vaccin Immunother*. (2020) 16:2204–14. doi: 10.1080/21645515.2020.1790279
- Sallam, M, Anwar S, Yufika A, Fahriani M, et al. (2022). Willingness-to-pay for COVID-19 vaccine in ten low-middle-income countries in Asia, Africa and South America: A cross-sectional study. *Narra J* 2, e74. doi: 10.52225/narra.v2i1.74
- Dias-Godói IP, Sarmiento TTR, Reis EA, Gargano LP, Godman B, Acurcio Fd, et al. Acceptability and willingness to pay for a hypothetical vaccine against SARS CoV-2 by the Brazilian consumer: a cross-sectional study and the implications. *Exp Rev Pharmacoecon Outcomes Res*. (2022) 22:119–29. doi: 10.1080/14737167.2021.1931128
- Nguyen LH, Hoang MT, Nguyen LD, Ninh LT, Nguyen HTT, Nguyen AD, et al. Acceptance and willingness to pay for COVID-19 vaccines among pregnant women in Vietnam. *Trop Med Int Health*. (2021) 26:1303–13. doi: 10.1111/tmi.13666
- Coronavirus (COVID-19) Vaccinations: Our World in Data. (2021). Available from: <https://ourworldindata.org/covid-vaccinations> (accessed on November 27, 2021).
- Hanemann M, Loomis J, Kanninen B. Statistical efficiency of double-bounded dichotomous choice contingent valuation. *Am J Agric Econ*. (1991) 73:1255–63. doi: 10.2307/1242453
- Boyle KJ. Contingent valuation in practice. In: *A primer on nonmarket valuation*. Berlin, Germany: Springer (2017). p. 83–131.
- Cerda AA, García LY, Albornoz DV. Parents willingness to pay for a human papillomavirus vaccine to protect their adolescent daughters. *Maule Region, Chile Salud publica de Mexico*. (2014) 56:48–55. doi: 10.21149/spm.v56i1.7322
- Cerda A, Rojas J, García L. Disposición a pagar por un mejoramiento en la calidad ambiental en el Gran Santiago, Chile. *Lecturas de Economía*. (2007) 2007:143–60. doi: 10.17533/udea.le.n67a2025
- Lopez-Feldman A. *Introduction to Contingent Valuation Using Stata*. (2012). Jefferson City, MO: MPRA
- Detoc M, Bruel S, Frappe P, Tardy B, Botelho-Nevers E, Gagneux-Brunon A. Intention to participate in a COVID-19 vaccine clinical trial and to get vaccinated against COVID-19 in France during the pandemic. *Vaccine*. (2020) 38:7002–6. doi: 10.1016/j.vaccine.2020.09.041
- Lazarus JV, Ratzan SC, Palayew A, Gostin LO, Larson HJ, Rabin K, et al. A global survey of potential acceptance of a COVID-19 vaccine. *Nat Med*. (2021) 27:225–8. doi: 10.1038/s41591-020-1124-9
- Banik R, Islam MS, Pranta MUR, Rahman QM, Rahman M, Pardhan S, et al. Understanding the determinants of COVID-19 vaccination intention and willingness to pay: findings from a population-based survey in Bangladesh. *BMC Infect Dis*. (2021) 21:1–15. doi: 10.1186/s12879-021-06406-y
- Cerda AA, García LY. Willingness to pay for a COVID-19 vaccine. *Appl Health Econ Health Policy*. (2021) 19:343–51. doi: 10.1007/s40258-021-00644-6
- Qin W, Wang E, Ni Z. Chinese consumers' willingness to get a COVID-19 vaccine and willingness to pay for it. *PLoS ONE*. (2021) 16:e0250112. doi: 10.1371/journal.pone.0250112
- Catma S, Varol S. Willingness to pay for a hypothetical COVID-19 vaccine in the united states: a contingent valuation approach. *Vaccines*. (2021) 9:318. doi: 10.3390/vaccines9040318
- Harapan H, Wagner AL, Yufika A, Winardi W, Anwar S, Gan AK, et al. Acceptance of a COVID-19 vaccine in Southeast Asia: a cross-sectional study in Indonesia. *Front Public Health*. (2020) 8. doi: 10.3389/fpubh.2020.00381
- Vo NX, Nguyen TTH, Van Nguyen P, Tran QV, Vo TQ. Using contingent valuation method to estimate adults' willingness to pay for a future coronavirus 2019 vaccination. *Value Health Regional Issues*. (2021) 24:240–6. doi: 10.1016/j.vhri.2021.01.002
- Harapan H, Anwar S, Setiawan AM, Sasmono RT, Study AD. Dengue vaccine acceptance and associated factors in Indonesia: a community-based cross-sectional survey in Aceh. *Vaccine*. (2016) 34:3670–5. doi: 10.1016/j.vaccine.2016.05.026
- Paakkari L, Okan O. COVID-19: health literacy is an underestimated problem. *Lancet Public Health*. (2020) 5:e249. doi: 10.1016/S2468-2667(20)30086-4
- Harapan H, Anwar S, Bustamam A, Radiansyah A, Angraini P, Fasli R, et al. Willingness to pay for a dengue vaccine and its associated determinants in Indonesia: a community-based, cross-sectional survey in Aceh. *Acta Trop*. (2017) 166:249–56. doi: 10.1016/j.actatropica.2016.11.035
- Heidari M, Jafari H. Challenges of COVID-19 vaccination in Iran: In the fourth wave of pandemic spread. *Prehosp Disaster Med*. (2021) 36:659–60. doi: 10.1017/S1049023X21000777



## OPEN ACCESS

## EDITED BY

Rebecca Masters,  
Public Health Wales NHS Trust, United Kingdom

## REVIEWED BY

Rachel Bath,  
Public Health Wales NHS Trust, United Kingdom  
Diane L. Putnick,  
 Eunice Kennedy Shriver National Institute of  
Child Health and Human Development (NIH),  
United States

## \*CORRESPONDENCE

Sonia Collado-López  
✉ sonia.collado@insp.edu.mx

## SPECIALTY SECTION

This article was submitted to  
Health Economics,  
a section of the journal  
Frontiers in Public Health

RECEIVED 17 November 2022

ACCEPTED 10 February 2023

PUBLISHED 01 March 2023

## CITATION

Barragán-Vázquez S, Jaen J and  
Collado-López S (2023) Unconditional cash  
transfers for breastfeeding women in the  
Mexican informal workforce: Time for social  
justice. *Front. Public Health* 11:1101466.  
doi: 10.3389/fpubh.2023.1101466

## COPYRIGHT

© 2023 Barragán-Vázquez, Jaen and  
Collado-López. This is an open-access article  
distributed under the terms of the [Creative  
Commons Attribution License \(CC BY\)](#). The use,  
distribution or reproduction in other forums is  
permitted, provided the original author(s) and  
the copyright owner(s) are credited and that  
the original publication in this journal is cited, in  
accordance with accepted academic practice.  
No use, distribution or reproduction is  
permitted which does not comply with these  
terms.

# Unconditional cash transfers for breastfeeding women in the Mexican informal workforce: Time for social justice

Sofía Barragán-Vázquez<sup>1,2</sup>, Jocelyn Jaen<sup>2</sup> and  
Sonia Collado-López<sup>2\*</sup>

<sup>1</sup>Center for Nutrition and Health Research, National Institute of Public Health, Cuernavaca, Morelos, Mexico, <sup>2</sup>School of Public Health of Mexico, National Institute of Public Health, Cuernavaca, Morelos, Mexico

## KEYWORDS

breastfeeding, health economics, social justice, informal economy, low-and middle-income countries, unconditional cash transfers

## 1. Introduction

Proper nutrition during early life is essential to ensure a child's adequate growth, health, and development, preventing morbidity and mortality in the short and long term (1–4). Human milk is the optimal food source during the first 6 months of life, it naturally changes its composition in function with the child's growth to fit their needs. However, the prevalence of exclusive breastfeeding (EBF) during the first 6 months of life has been considerably low in Mexico and many low-and middle-income countries (LMICs) (5).

Women's employment has been reported as a key determinant for not breastfeeding in different countries, and working women have lower probabilities of ever breastfeeding (6–8). This is partly due to inadequate maternity leave legislations, which only covers those in formal employment, as well as inadequate support from family and health services. Current Mexican breastfeeding legislation provides support only to formally working mothers (9). Women in the informal economy (which includes diverse economic activities, jobs, and workers that are not regulated or protected by the Government), despite representing more than half of the female working force in Mexico (10) and in other LMICs (11), have long been overlooked by maternity legislation and policies.

### 1.1. Exclusive breastfeeding in Mexico

Mexico is still far from the global nutrition target of Exclusive Breastfeeding (EBF) by 2025, and health inequities are still present. From 2006 to 2012, the National Health and Nutrition Survey (ENSANUT) in Mexico showed that the prevalence of EBF decreased from 22.3 to 14.4%, particularly in rural areas, causing a health and economic burden of ~3,000 million dollars per year (7, 12). Calculations included direct health care costs of the diseases associated with inadequate breastfeeding practices, lost future earnings due to premature death, and infant formula expenses.

Actions were taken to successfully increase EBF prevalence via the 2014–2018 National Breastfeeding Strategy to 28% (13). However, despite this increase EBF prevalence in Mexico is still below the world's average (44 vs. 50%) (14) and evidence shows that health inequities in breastfeeding promotion and protection are not narrowing. According to Unar-Mungía et al. (7), the largest increase in EBF was in Mexico City, in non-indigenous women, and in those belonging to high socio-economic status, while the States in the South of Mexico, region that concentrates the largest share of the country's 100 most marginalized municipalities (15), had the lowest or even no improvement in different breastfeeding indicators.

The lack of strong actions and policies for EBF protection and promotion has important implications for public health in terms of costs, morbidity, and mortality. Particularly, the need for regulation of milk formula commercialization and advertisement, training of health personnel, regulation of breastfeeding rooms in workspaces, maternity leave duration policies, protection in the informal sector, and establishment of penalties for breaching the International Code of Marketing of Breastmilk Substitutes are all areas that need attention, so that actions directed to promote and support breastfeeding become more successful (16).

## 1.2. Barriers and policies for breastfeeding protection

Among all barriers to EBF, in Mexico, the need of returning to work is considered one of the key factors for not breastfeeding overall and for early weaning among mothers who seek to breastfeed (17). Women's right to breastfeed has been ensured since 1974 in the United Mexican States Political Constitution. Even though there are many areas in the legal framework that need short-term action, particularly breastfeeding promotion and protection in the informal sector has not been addressed. Currently, legislation is mainly focused on ensuring that women can provide breastfeeding without this representing the loss of formal employment or remuneration, for a limited (not optimal) time. Also, these laws provide the basis for suitable nursing spaces where women can extract milk (2 times during a period of 30 min). Nevertheless, women in the informal sector are left out of these initiatives and this lack of social protection is another structural and societal barrier that interferes with women's ability and right to optimally breastfeed (18).

## 2. Unconditional cash transfers

Due to the above, there is a need to implement public policies directed at this vulnerable group, in which unconditional cash transfers (UCTs) could arise as a way to "level the playfield." Cash transfers (CTs) programs are interventions aimed to address a key social determinant of health: income. Recent evidence shows that UCTs and Conditional Cash Transfers (CCTs) have positive impacts on a wide range of outcomes (19–21). However, unintended consequences have also been reported for CCTs such as exacerbation of social exclusion and creating opportunities for abuse of power (20). Operationally, conditionalities upon CCTs carries financial and administrative burdens, and certain behavioral requirements that may further complicate the success of the program in many LMICs, including Mexico (20).

On the other hand, UCTs programs are social and protection strategies that provide a small CTs to low-income families and communities where the only requirement to receive this financial support is to be subscribed to the benefit (22). And previous evidence suggests that UCTs for Mexican women working in the informal economy are economically feasible since in terms of costs they are similar to other programs already implemented in the country (23).

While CCTs programs have shown success over diverse nutrition-related outcomes, the short-lived window duration of time for EBF implies logistical difficulties and expenses that come with verification of these conditions, thus delaying transfers, and increasing the possibility that no timely transfers are made (24).

### 2.1. UCTs and health outcomes

There is a lack of evidence regarding UCTs and breastfeeding practices in LMICs. However, there is previous evidence about UCTs promoting positive health outcomes in maternal-child health. According to Durao et al. (24), UCTs in LMICs have shown high certainty evidence of improving food security, and low certainty of increasing dietary diversity and reducing stunting, as well as other nutrition-related outcomes. Also, Briaux et al. (25) reported that UCTs, in addition to community activities, improved children's linear growth in rural areas of Africa, while other studies (19) reported protective effects of UCTs by improving height for age, intake of animal food sources, household food insecurity, health-seeking behavior, delivery in health facilities and lowering the odds of low birthweight babies. For breastfeeding outcomes, Relton et al. (26) found that in areas with a low breastfeeding prevalence, providing financial incentives, conditional on the infant receiving any breast milk, improved breastfeeding rates.

Additionally, a relatively recent study reported a methodological framework to estimate the annual financial need of setting up maternity CTs for informally employed women in Mexico, reporting ranges between \$87 million and \$280 million dollars (18). This can be considered financially feasible since it is similar to social protection policies already implemented in the country directed to other population groups (23) and is considerably lower than the costs of not breastfeeding (18). Therefore, considering the logistical difficulties of CCTs, UCTs program for breastfeeding promotion and protection could be a promising policy in Mexico to improve children's health and development and to potentially enhance EBF prevalence. Also, it could get Mexico closer to achieving global nutrition targets and contribute to accomplishing children's good nutrition rights.

## 3. Discussion

Despite overall increases in EBF prevalence through many diverse policies, inequities in breastfeeding protection and promotion are still present in Mexico. One of the main barriers for EBF in Mexico and many LMICs is related to difficulties for women returning to work, and current legislation lacks policies to protect and promote better breastfeeding practices in the sector of the population that is the most unprotected, women working in the informal economy. These women are part of a considerably large population group who lack social protection measures and are subject to income instability, increasing their need to return to work, and thus challenging EBF practices. Policies should start supporting these groups in the population where EBF prevalence is not increasing, particularly vulnerable groups such as indigenous women and women in the southern states of the country.

Therefore, as a measure of social justice, we consider that CTs should be considered a plausible and adequate intervention to protect and promote breastfeeding in this population group without social protection. Even though there is favorable evidence of CCTs programs and breastfeeding and health-related outcomes, they entail administrative difficulties that, considering the very short window of support required for EBF and administrative costs, could jeopardize the success of the program. To our knowledge, there is no evidence of breastfeeding outcomes and UCTs in LMICs, however, there is evidence of positive outcomes in different health-related areas of UCTs programs, such as the experience in Togo (25) and Ecuador (27), as well as other LMICs (21). Also, considering that UCTs and CCTs have had similar health-related outcomes, it could also be the case for lactation.

However, considering that current evidence of UCTs on health outcomes comes from other LMICs, and that LMICs vary widely in EBF practices (28), as well as in structural, political, and community conditions that could impact the program, we consider the potential success resulting from a UCTs intervention in Mexico needs to be addressed in a pilot study. Mexico has a history of successfully implementing community-level programs to improve child nutrition-related outcomes such as PROGRESA/OPORTUNIDADES (29, 30), where similar communities with vulnerable populations would randomly receive the program at different times, thus allowing a comparison of the nutrition indicators between the early- vs late-implementation communities, generating evidence for a larger level implementation of the program. A pilot UCTs program that is aimed to improve breastfeeding practices for women in the informal economy could use a similar design, starting in most disadvantaged communities. Also, among starting points, we consider a monthly cash transfer would be suitable instead of a one-time transfer since they have shown to promote expenditure in basic household needs (31). Regarding inclusion criteria, all pregnant (3rd trimester) or lactating women without social protection provided by their work should be considered, which could probably be verified against social security databases. Moreover, we consider an indirect disbursement mechanism would be appropriate since a registry of informally working women could be a delicate subject. Fortunately, regarding the amount and duration of the program, results from

Vilar-Compte et al. (18) support using the poverty line for reference and a duration of 6 months as feasible (from birth up to 6 months post-partum). Finally, it could also be useful to leverage other potential interventions alongside UCTs, such as counseling in primary healthcare (32), compliance of the Code of Marketing of Breastmilk Substitutes in the Mexican legislation, raising national awareness on breastfeeding (33), and engaging key stakeholders involved in breastfeeding policy and programming (34).

Therefore, we consider that a well-designed UCTs pilot study for women working in the informal economy should start to be considered in Mexico as a potentially appropriate intervention to overcome this contextual barrier. Also, with an adequate design and implementation, it could contribute to the generation of further evidence and work as a reference regarding the effect of UCTs programs in breastfeeding practices in LMICs with similar social and health issues.

## Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

1. Horta BL, Victora CG. *Long-Term Effects of Breastfeeding: A Systematic Review*. WHO Library Cataloguing-in-Publication Data (2013). Available online at: <https://apps.who.int/iris/bitstream/handle/10665/79198/97892?sequence=1> (accessed January 19, 2023).
2. Martin RM, Smith GD, Mangtani P, Tilling K, Frankel S, Gunnell D. Breastfeeding and cardiovascular mortality: the Boyd Orr cohort and a systematic review with meta-analysis. *Eur Heart J*. (2004) 25:778–86. doi: 10.1016/j.ehj.2004.02.006
3. Victora CG, Bahl R, Barros AJD, França GVA, Horton S, Krasevec J, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet*. (2016) 387:475–90. doi: 10.1016/S0140-6736(15)01024-7
4. North K, Gao M, Allen G, Lee AC. Breastfeeding in a global context: epidemiology, impact, and future directions. *Clin Ther*. (2022) 44:228–44. doi: 10.1016/j.clinthera.2021.11.017
5. Olufunlayo TF, Roberts AA, MacArthur C, Thomas N, Odeyemi KA, Price M, et al. Improving exclusive breastfeeding in low and middle-income countries: a systematic review. *Matern Child Nutr*. (2019) 15:e12788. doi: 10.1111/mcn.12788
6. Johnston ML, Esposito N. Barriers and facilitators for breastfeeding among working women in the United States. *J Obstet Gynecol Neonat Nurs*. (2007) 36:9–20. doi: 10.1111/j.1552-6909.2006.00109.x
7. Unar-Munguía M, Lozada-Tequeanes AL, González-Castell D, Cervantes-Armenta MA, Bonvecchio A. Breastfeeding practices in Mexico: results from the National Demographic Dynamic Survey 2006–2018. *Matern Child Nutr*. (2020) 17:e13119. doi: 10.1111/mcn.13119
8. Castetbon K, Boudet-Berquier J, Salanave B. Combining breastfeeding and work: findings from the Epifane population-based birth cohort. *BMC Pregn Childb*. (2020) 20:110. doi: 10.1186/s12884-020-2801-x
9. Secretaría de Gobernación. *ACUERDO General del Pleno del Consejo de la Judicatura Federal, que reforma y adiciona el que establece las disposiciones en materia de actividad administrativa del propio Consejo, en relación con el periodo de lactancia*. Diario Oficial de la Federación (2022). Available online at: [https://www.dof.gob.mx/nota\\_detalle.php?codigo=5641254&fecha=25/01/2022#gsc.tab=0](https://www.dof.gob.mx/nota_detalle.php?codigo=5641254&fecha=25/01/2022#gsc.tab=0) (accessed November 14, 2022).



10. INEGI. *La COVID-19 y su impacto en las mujeres en México*. (2022). Available online at: <https://www.inegi.org.mx/tablerosestadisticos/mujeres/> (accessed July 24, 2022).
11. UN Women. *Women in Informal Economy*. Available online at: <https://www.unwomen.org/en/news/in-focus/csw61/women-in-informal-economy> (accessed November 09, 2022).
12. Colchero MA, Contreras-Loya D, Lopez-Gatell H, González de Cosío T. The costs of inadequate breastfeeding of infants in Mexico. *Am J Clin Nutr*. (2015) 101:579–86. doi: 10.3945/ajcn.114.092775
13. Shamah-Levy T, Vielma-Orozco E, Heredia-Hernández O, Romero-Martínez M, Mojica-Cuevas, J Cuevas-Nasu L, et al. *Encuesta Nacional de Salud y Nutrición 2018-19: Resultados Nacionales*. Instituto Nacional de Salud Pública (2020). Available online at: [https://ensanut.insp.mx/encuestas/ensanut2018/doctos/informes/ensanut\\_2018\\_informe\\_final.pdf](https://ensanut.insp.mx/encuestas/ensanut2018/doctos/informes/ensanut_2018_informe_final.pdf) (accessed July 31, 2021).
14. World Health Organization. *Infant and Young Child Feeding*. (2021). Available online at: <https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding> (accessed July 25, 2022).
15. Consejo Nacional de Población. *Consejo Nacional de Población*. Datos abiertos del índice de marginación (2021). Available online at: <https://www.gob.mx/conapo/documentos/indices-de-marginacion-2020-284372> (accessed January 4, 2023).
16. Ramírez-Silva I, Unar-Munguía M, Lozada AL, González-Castell D, Rivera M, Bonvecchio A. El costo de no amamantar en México: un llamado para la acción. In: Rivera Dommarco J, Barrientos Gutiérrez T, Oropeza Abúndez C, editors. *Síntesis sobre políticas de salud Propuestas basadas en evidencia*. México: Instituto Nacional de Salud Pública (2021). p. 164–9. Available online at: [https://www.insp.mx/resources/images/stories/2022/docs/220118\\_Sintesis\\_sobre\\_politicas\\_de\\_salud.pdf](https://www.insp.mx/resources/images/stories/2022/docs/220118_Sintesis_sobre_politicas_de_salud.pdf) (accessed November 17, 2022).
17. Bonvecchio Arenas A, Théodore Rowlerson F, González W, Lozada Tequeanes AL, Alvarado Casas R, Blanco García I. Barreras de la lactancia materna en México. In: González de Cosío Martínez T, Hernández Cordero S, editors. *Lactancia materna en México*. 1st ed. Ciudad de México: Academia Nacional de Medicina (2016). p. 77–82.
18. Vilar-Compte M, Teruel G, Flores D, Carroll GJ, Buccini GS, Pérez-Escamilla R. Costing a maternity leave cash transfer to support breastfeeding among informally employed Mexican women. *Food Nutr Bull*. (2019) 40:171–81. doi: 10.1177/0379572119836582
19. Novignon J, Prencepe L, Molotsky A, Valli E, de Groot R, Adamba C, et al. The impact of unconditional cash transfers on morbidity and health-seeking behaviour in Africa: evidence from Ghana, Malawi, Zambia and Zimbabwe. *Health Policy Plan*. (2022) 37:607–23. doi: 10.1093/heapol/czac014
20. UNICEF. *Conditionality in Cash Transfers: UNICEF's Approach*. (2016). Available online at: <https://www.unicef.org/easterncaribbean/media/731/file/Conditionality-in-Cash-Transfers-UNICEF's-Approach-2016.pdf> (accessed November 13, 2022).
21. Pega F, Pabayo R, Benny C, Lee EY, Lhachimi SK, Liu SY. Unconditional cash transfers for reducing poverty and vulnerabilities: effect on use of health services and health outcomes in low- and middle-income countries. *Cochrane Database Syst Rev*. (2022) 3:CD011135. doi: 10.1002/14651858.CD011135.pub3
22. Haman Ben O. Conditional and unconditional cash transfer programs : the recent experiences around the world. *Int Res Innov Soc Sci*. (2019) 3:210–9.
23. Martínez Vargas T. *Gasto público en becas escolares. Análisis de programas prioritarios*. Centro de Investigación Económica y Presupuestaria, A. C. Available online at: <https://ciep.mx/gasto-publico-en-becas-escolares-analisis-de-programas-prioritarios/> (accessed November 10, 2022).
24. Durao S, Visser M, Ramokolo V, Oliveira J, Schmidt BM, Balakrishna Y, et al. Community level interventions for improving access to food in low- and middle-income countries. *Cochrane Database Syst Rev*. (2020) 7:CD011504. doi: 10.1002/14651858.CD011504.pub2
25. Briaux J, Martin-Prevel Y, Carles S, Fortin S, Kameli Y, Adubra L, et al. Evaluation of an unconditional cash transfer program targeting children's first-1,000-days linear growth in rural Togo: a cluster-randomized controlled trial. Persson LA, editor. *PLoS Med*. (2020) 17:e1003388. doi: 10.1371/journal.pmed.1003388
26. Relton C, Strong M, Thomas KJ, Whelan B, Walters SJ, Burrows J, et al. effect of financial incentives on breastfeeding: a cluster randomized clinical trial. *JAMA Pediatr*. (2022) 172:e174523. doi: 10.1001/jamapediatrics.2017.4523
27. Fernald LCH, Hidrobo M. Effect of Ecuador's cash transfer program (Bono de Desarrollo Humano) on child development in infants and toddlers: a randomized effectiveness trial. *Soc Sci Med*. (2011) 72:1437–46. doi: 10.1016/j.socscimed.2011.03.005
28. Bhattacharjee NV, Schaeffer LE, Hay SI, Lu D, Schipp MF, Lazzar-Atwood A, et al. Mapping inequalities in exclusive breastfeeding in low- and middle-income countries, 2000–2018. *Nat Hum Behav*. (2021) 5:1027–45. doi: 10.1038/s41562-021-01108-6
29. Rivera JA, Sotres-Alvarez D, Habicht JP, Shamah T, Villalpando S. Impact of the Mexican program for education, health, and nutrition (progres) on rates of growth and anemia in infants and young children. *JAMA*. (2004) 291:2563. doi: 10.1001/jama.291.21.2563
30. Rivera JA, Rodríguez G, Shamah T, Rosado JL, Casanueva E, Maulén I, et al. Implementation, monitoring, and evaluation of the nutrition component of the Mexican Social programme (PROGRESA). *Food Nutr Bull*. (2000) 21:35–42. doi: 10.1177/156482650002100106
31. MERCY CORPS. *Cash Transfer Programming Toolkit*. Available online at: <https://www.calpnetwork.org/wp-content/uploads/2020/01/mercycorpscashtransferprogrammingtoolkitpart1.pdf> (accessed January 15, 2023).
32. Bueno-Gutiérrez D, Castillo EUR, Mondragón AEH. Breastfeeding counseling based on formative research at primary healthcare services in Mexico. *Int J Equity Health*. (2021) 20:173. doi: 10.1186/s12939-021-01491-6
33. González de Cosío T, Ferré I, Mazariegos M, Pérez-Escamilla R. Scaling up breastfeeding programs in Mexico: lessons learned from the becoming breastfeeding friendly initiative. *Curr Dev Nutr*. (2018) 2:nzy018. doi: 10.1093/cdn/nzy018
34. Buccini G, Harding KL, Ferré Eguiluz I, Safon CB, Hromi-Field A, González de Cosío T, et al. An analysis of stakeholder networks to support the breastfeeding scale-up environment in Mexico. *J Nutr Sci*. (2020) 9:e10. doi: 10.1017/jns.2020.4





## OPEN ACCESS

## EDITED BY

Timotej Jagric,  
University of Maribor, Slovenia

## REVIEWED BY

Weihua Liu,  
Tianjin University, China  
John Birge,  
The University of Chicago, United States

## \*CORRESPONDENCE

Lijian Qin  
✉ qinlj28@163.com  
Yanming Sun  
✉ ymsun@re.ecnu.edu.cn

## SPECIALTY SECTION

This article was submitted to  
Public Health Policy,  
a section of the journal  
Frontiers in Public Health

RECEIVED 20 November 2022

ACCEPTED 07 February 2023

PUBLISHED 08 March 2023

## CITATION

Chen H, Qin L, Jiang C, Qin M, Sun Y and Luo J  
(2023) Characteristics, risk management and  
GMP standards of pharmaceutical companies  
in China. *Front. Public Health* 11:1103555.  
doi: 10.3389/fpubh.2023.1103555

## COPYRIGHT

© 2023 Chen, Qin, Jiang, Qin, Sun and Luo.  
This is an open-access article distributed under  
the terms of the [Creative Commons Attribution  
License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or  
reproduction in other forums is permitted,  
provided the original author(s) and the  
copyright owner(s) are credited and that the  
original publication in this journal is cited, in  
accordance with accepted academic practice.  
No use, distribution or reproduction is  
permitted which does not comply with these  
terms.

# Characteristics, risk management and GMP standards of pharmaceutical companies in China

Hong Chen<sup>1</sup>, Lijian Qin<sup>1\*</sup>, Cong Jiang<sup>2</sup>, Mingshuai Qin<sup>3</sup>,  
Yanming Sun<sup>4\*</sup> and Jingjing Luo<sup>5</sup>

<sup>1</sup>Anhui University of Finance and Economics, Bengbu, Anhui, China, <sup>2</sup>University of Waterloo, Waterloo, ON, Canada, <sup>3</sup>Faculty of Economics, VSB-Technical University of Ostrava, Ostrava, Czechia, <sup>4</sup>Institute for Global Innovation and Development/School of Urban and Regional Science/Institute of Eco-Chongming, East China Normal University, Shanghai, China, <sup>5</sup>Anhui Center for Drug Evaluation and Inspection, Hefei, China

The Good Manufacturing Practice (GMP) is one of the gold standards by which governments worldwide judge modern pharmaceutical companies' production processes and product-safety standards. However, in all the nations, it is difficult to obtain real data about GMP inspection results, so conducting the related research is impossible. Taking advantage of a rare chance to obtain the on-site GMP inspection results in China, we have been able to initiate an empirical analysis of how company characteristics and risk management affect the GMP inspection results of certain pharmaceutical companies. The 2SLS method regression was employed in this study. Our four main findings are as follows. First, compared with Chinese state-owned companies, foreign commercial and private enterprises are held to higher standards. Second, the GMP inspection results tend to be better for those enterprises whose main sources of capital are not dependent on bank loans. Third, enterprises with higher fixed assets tend to receive the better GMP inspection results. Fourth, the longer the quality authorized staff has worked in a company, the better the GMP inspection results expected of that enterprise. These findings offer insights into inspections and production improvements in China and other GMP-compliant countries.

## KEYWORDS

pharmaceutical company characteristics, risk management, GMP, pharmaceutical company supervision, China

## 1. Introduction

Drug safety concerns have repeatedly emerged in China in recent years (1, 2). The drug production process is the source of drug quality and safety, and strengthening the supervision of pharmaceutical companies' production processes is the basis for ensuring drug safety (3). Good Manufacturing Practice (GMP) form the basis for a mandatory management system that most pharmaceutical companies around the world have agreed to follow to ensure their drugs' quality and consumer confidence. However, how can the GMP supervision of pharmaceutical companies be improved to ensure the pertinence of supervision? There is no empirical research on this issue globally because the confidentiality and non-publication of GMP inspection results make it difficult for the public. If a company could find out the characteristics that affect its GMP results, then supervising its manufacturing processes would become much more focused and relevant to meeting the GMP standards in future inspections. An unprecedented chance to obtain actual inspection results for some of China's GMP companies has given us a rare opportunity to carry out empirical testing of how these companies' external characteristics affect their compliance with GMP. This work is of great significance for improving the efficiency of GMP supervision, ensuring drug quality, and improving drug regulatory policies.

From a company's point of view, the whole process of government drug supervision, from the company's application for marketing to patient use, can be divided into three stages: product registration and approval, enterprise production, and circulation and sales (4–6). Based on data availability, most relevant research focuses on either the first stage (registration and approval) or the third stage (circulation and sales). The drug supervision research in the first stage focuses on the factors that influence the length of time after the initial application for a new drug to reach market, which is also a concern for pharmaceutical companies. As China's drug research and development capabilities are relatively weak, and there are fewer original drugs, the research at this stage mainly comes from developed countries such as the United States and Japan (7–10). Liu and Wang (11), Kelly et al. (12) and Wada et al. (13) researched how to strengthen the supply chain supervision of drug circulation in the third stage (marketing and sales).

Globally, the scant documentation available for researching the processes of pharmaceutical companies in the second stage (i.e., drug production) is based on work notes and papers from the Center for Drug Evaluation written by the China National Medical Products Administration inspectors. All GMP inspectors are government employees, but only in China their promotions are linked to publishing papers on their work. Luo et al. (14), Hu et al. (15) and Wang et al. (16), based on inspections of 46 and 197 pharmaceutical companies in Anhui Province and Liaoning Province of China, respectively, found that the maintenance of production equipment and laboratory management was insufficient, which led to the relatively standardized GMP of pharmaceutical manufacturers. The cost of manually cleaning production equipment is lower, and that of automatic cleaning is higher. Liu et al. (17), and Li and Fu (18) used the inspection results of 20 and 43 drug manufacturers in Shanghai, respectively, and found that most companies use manual cleaning methods, which have a high error rate. Although automatic cleaning works better, it is used only in big companies. Some enterprises even release some substandard materials for production. These production defects caused by human factors carry hidden dangers for drug quality and safety.

When Liu et al. (19), Lu et al. (20), and Cao and Wu (21) studied the on-site inspections of 26 enterprises in the Qinghai Province and 34 enterprises in the Guangxi Zhuang Autonomous Region, China, respectively, they found that some the companies had insufficient staff training, factories and production facilities were laid out in inefficient configurations, missing risk reviews and assessments, poor attention to the storage and maintenance of items, and incomplete or sloppy the self-inspection measures and records needed for GMP records. Yang et al. (22) found that China's pharmaceutical industry has low barriers to entry, and 98% of pharmaceutical companies are small and medium-sized enterprises. Entering and exiting the industry are relatively frequent, and thus the consistency and high standards needed for product quality cannot be guaranteed, which increases the difficulty of drug quality management. It is necessary for China to establish a unified and authoritative modern food and drug regulatory system to improve the government's drug regulatory capabilities (23–25). Li and Liang (26) further found that companies must comply with GMP guidelines for production and set higher production standards to ensure drug quality.

With regard to government regulation, in a narrow sense, it is the management and restriction of economic behaviors (27–29). It is the behavior of social public institutions to supervise and restrict the activities of enterprises according to certain rules. Government regulations can be divided into social regulations and economic regulations. The social regulation is to ensure the safety of the production process, while the economic regulation is to regulate prices and services in order to promote market equity. In a broad sense, government regulation is generally interpreted as the incentive and constraint of all public rights on private rights (30, 31). It is undeniable that when there are market failures which are hard to be effectively corrected, government regulation is usually a reasonable choice. This also serves as an important basis for explaining the necessity of government regulation. In addition, government regulation is considered to be established by politicians and regulators to pursue their own interests (32, 33). The cumbersome approval procedures, strict access barriers, and various regulation fees give regulators considerable discretion, allowing them to use these powers for “rent-seeking”. Further, regulators typically have limited resources for enforcement. Literature to date has shown that even with those limitations a wide variety of instruments—including inspections, warnings, penalties, and sanctions—can be effective in inducing compliance (33, 34).

The existing literature has laid a good foundation for this present study, but three problems need to be solved urgently: (1) the lack of empirical research based on the results of GMP inspection results; and (2) the lack of studies focused on the supervision of the drug production process, that is, the second stage; (3) the sample size is small in the only few Chinese papers. The main obstacle to solving these problems is that it is challenging to obtain GMP inspection results, for some reasons. First, the inspection results are not made public. For example, the US FDA stipulates a 10-year confidentiality period for inspection results, but even after it, GMP inspectors cannot expose any details that would let the outside world know which pharmaceutical company is involved. Second, inspectors' qualifications are high; thus, the requirements of inspectors are also relatively strict. After receiving an excellent education and passing the qualification examination, inspectors are then qualified for GMP inspection. Therefore, compared with the responsibilities of typical social-surveys investigators, the responsibilities of GMP inspectors are very high. Third, the potential cost of an investigation is vast. For instance, sometimes, even if the investigator wears sterile protective clothing, the inspected company may worry that the production environment could be contaminated. To eliminate potential risks due to an inspection, most companies need to pay a lot to maintain their production environment. Thus, the inspection process causes substantial extra costs, normally at least hundreds of thousands or even a million USD.

Based on the actual GMP inspection results of pharmaceutical companies in Anhui Province of China by the National Medical Products Administration, we the first conducted an empirical study on the second stage, that is, drug GMP supervision on a global scale, striving to solve the above problems to make exploratory contributions in the field. Our research goal is to empirically test whether a pharmaceutical company's characteristics and risk management impact its GMP inspections results. We will examine

the three hypotheses. Hypothesis 1, compared with state-owned enterprises, foreign-owned and private enterprises have a higher degree of GMP regulation. Hypothesis 2, enterprises with a higher gross fixed asset value have a higher degree of GMP regulation. Hypothesis 3, the degree of GMP regulation is higher for enterprises whose main source of funding does not rely on bank loans. This study discusses the differences in the actual implementation effects of GMP regulations in pharmaceutical companies and explores the reasons for these differences. The findings in this paper are consistent with those of Liu et al. (17), Li and Fu (18), Liu et al. (19), and Lu et al. (20). However, these articles did not examine the company's characteristics and did not compare the GMP examination results with those of foreign and private companies. In addition, they did not examine the differences among enterprises of different sizes. We examine these aspects, which is an important contribution of this paper. These findings may reflect the regulation's actual shortcomings, so this research provides policy support and reference for improving the regulation. In addition, the empirical research in this article makes a foundational contribution to academic research or policy maker. The theoretical contribution of this paper is that it applies external signals theory to the regulation of quality in the production process of pharmaceutical companies, using external characteristics of companies as an entry point for regulation and improving the feasibility and effectiveness of government regulation. The findings of this paper have important implications not only for China but also for countries around the world, especially for developing countries in general. The rest of the article is arranged as follows: the second part introduces the development process of GMP; the third part is the theoretical framework and econometrics model; the fourth part is the data source and descriptive statistical analysis; the fifth part is the empirical results, and the sixth part is the brief conclusion and recommendations.

## 2. The development history of GMP

In formulating and improving GMP, the United States is in a leading position globally. The American public's awareness of the need for government oversight of consumable products began in 1906, when the American journalist and famous social reformer Upton Sinclair exposed the dirty inside story of Chicago's meat-processing industry. The slaughtering and processing environment was extremely unhygienic, and a large number of pork products made of diseased pigs were sold, some partially deteriorated, and some even containing mice (35). The report's original intention was to arouse everyone's attention to the harsh working environment and workers' poor conditions, and it immediately had a significant impact on all sectors of American society. Simultaneously, syrups and adult health products used for the treatment of infant colic had also been found to contain addictive ingredients such as ethanol or morphine. The U.S. Congress enacted the Pure Food and Drug Act that year, making the sale of adulterated (contaminated) meat or food an illegal act for the first time. This was the first time that products were regulated. For one thing, a label now had to be accurate, and any dangerous ingredients had to be marked. If labeling was inaccurate or false, its producers were liable to charges of misleading advertising. This bill directly led to establishing a

new government agency in the United States—the Food and Drug Administration (FDA), which still has the power to seize illegal foods and drugs.

In 1935, sulfa drugs came out, and many manufacturers began to produce this new type of anti-infective treatment. Among patients who used the drug, 107 lost their lives within a year, most of them children. After inspection, the reason was found to be that a manufacturer had used the toxic solvent diethylene glycol in the drug's production (36). Congress reacted quickly and promulgated the Federal Food, Drug, and Cosmetic Act in 1938. For the first time, manufacturers had to certify products' safety before they were put on the market. In 1941, a U.S. pharmaceutical company produced sulfathiazole tablets that were contaminated with phenobarbital, a sedative and sleeping agent, which directly caused 300 deaths and injuries. This incident prompted the FDA to make a thorough revision of drug-production quality, which formed an embryonic form of GMP (37). During World War II, the amount of insulin and penicillin increased dramatically. To ensure the quality of such medicines, the United States required the FDA to test both before their release. Later, this rule was expanded to include all antibiotics requiring FDA certification. In the 1960s, the drug Thalidomide caused more than 10,000 cases of severe deformities in newborn babies, shocking the world (36). In response, in 1963, the US FDA promulgated the world's first "Good Manufacturing Practices for Drugs", that is GMP, to strengthen drug safety. This event was a milestone in the history of the pharmaceutical industry, marking the point where it began to realize total quality management and laying a solid foundation for ensuring medicines' quality.

The core of quality control lies in people, not only managers but also ordinary employees. This point is illustrated by a case from 1992, when a generic drug scandal broke out in the United States. The illegal activities cited included destroying samples, falsifying production records, and concealing changes in production processes, and not only were company executives charged; regular employees were also subject to the resulting legal sanctions. In line with FDA policy, all guilty personnel were removed from the company and barred from future work in the pharmaceutical industry; moreover, all offenders were named, and their illegal acts were published on the FDA website. Now, when the company submits a listing application to the FDA, it must ensure in writing that no removed personnel participate in the project (38). In the same period, another company in the United States illegally produced cardiac catheters, resulting in the death of at least one patient and causing at least 20 patients to undergo emergency cardiac surgery. The court-imposed sentences of between 18 months and 2 years on the company's three executives, with the judge emphasizing that companies do not commit crimes, only people do. The judge also encouraged the managers in other companies who might be involved in similar illegalities to think twice, and desist (39). In reinforcing consistent high standards of behavior, GMP regard people's subjective initiative as the basis of standardized production, thereby strengthening the standardized operations of all managers and ordinary employees to ensure the quality of medicines.

In the several years of practice after the US GMP guidelines were first promulgated, the practice proved GMP's effectiveness. Their

intense vitality quickly emerged, and countries all over the world followed suit. The World Health Organization included this system in the appendix of the International Pharmacopeia in 1967, and promulgated its own GMP regulations in 1969, recommending that member states use them as a regulatory system for drug production. Later, in 1979, GMP were once again introduced to the World Health Assembly member states; they were also confirmed as a World Health Organization body of regulations. Australia in 1968, the United Kingdom in 1971, the European Union in 1972, and Japan in 1974 issued their own GMP regulations. So far, more than 100 countries and regions around the world have implemented GMP. After many revisions, the US GMP standard is currently the world's most detailed version, with complete indicators and the highest standards of implementation. The United States requires that all pharmaceutical manufacturers in the United States and pharmaceutical companies exporting to the United States comply with United States GMP standards.

China put forward its own GMP standards 20 years later than the United States. Keeping in mind the GMP of more-advanced countries, China's National Pharmaceutical Industry Corporation formulated China's first domestic GMP in 1982, then began to carry out GMP pilot work in its sub pharmaceutical companies. In the early days of the founding of the People's Republic of China, due to the planned economy era, China's pharmaceutical industry was relatively backward, and basic supply needs could not be met, so the quality concept was weak. With the deepening of reforms and opening up and learning from foreign experience, the Chinese government officially formulated GMP in 1988 as a product specification for medicines. It was revised in 1992 and 1998. In the same period, the China National Medical Products Administration was established in 1998, as an agency directly under the State Council and specializing in drug supervision. Compared with advanced international standards, China's GMP standards still have many disparities. In October 2010, with the World Health Organization GMP as the bottom line, referred to as the EU GMP standards, and considering the backward situation of domestic pharmaceutical companies, China revised its GMP again. Although there is still a particular gap between them and the GMP standards of developed countries, compared with China's old GMP version, the new version reflects significant improvements in technology and management. China stipulates that all pharmaceutical manufacturers must obtain the latest version of GMP certification before it allows production. Despite the improved standards, China's existing pharmaceutical companies present a situation of multiple, small, scattered and low levels, and their independent innovation capabilities are weak. The implementation of the new version of GMP is conducive to ensuring the quality of pharmaceutical production, to promoting the upgrading of China's pharmaceutical industry, and to enhancing the international competitiveness of Chinese pharmaceutical manufacturers.

### 3. Methods

The theoretical basis of this article is the theory of external signals. According to the external-signals theory, many regulators

depend on information from external sources to make regulatory decisions. The information from external groups is important because it can reduce the uncertainties facing regulators and can lead to more defensible and perhaps more efficient decisions by them. Generally, regulators seek positive feedback from external groups. In contrast to positive feedback, negative feedback from external groups often causes trouble for regulators. Complaints about the decisions or behaviors of regulators may lead to government supervision, investigation or external attempts by interest groups to intervene in regulation activities, which are called troubles of regulators and often disrupts the regulators' operation. Increasing the efficiency of regulatory decisions may lead to more positive feedback from outside groups such as regulated firms, consumer groups, and politicians. The external-signals model provides a convenient framework for incorporating the role of such information into the process of regulator's decision making. This model suggests that regulatory decisions will be functions of the feedback from outside groups as well as of the information supplied by external sources to the regulator (32). In practice, regulatory measures taken by the government to protect consumers' health, life safety, living environment and public interests, include supervision and control of medicine's quality, efficacy, safety and so on. The special attributes of medicine determine that the main goal of government regulation is to ensure the quality and safety of medicine's production, prevent consumers from harming their health due to the use of drugs, and ensure their health and life safety. From the perspective of technical attributes of products and industries, government regulation of the pharmaceutical industry belongs to the category of social regulation, which is the regulation of the government on the quality of medicines and various activities accompanying them to establish specific standards, and to restrict and prohibit specific behaviors.

Due to market failures, countries around the world have generally strengthened government supervision in the medical and health fields. A crucial starting point is to ensure medicines' quality and safety. Noll (40) and Olson (41) proposed and developed the theory of external signals to explain which factors most concern regulatory agencies, and why regulators take the actions they do in response. For pharmaceutical manufacturers' supervision, the idea of external signals shows that a regulatory agency's actions are a function of a regulated company's characteristics, the features of risk management, the applicable regulatory policies, and the resources predetermined by the national macro-decision-making department. The goal is to maximize the regulatory agency's summation of the feedback signals received by the source. Following Luo (42), this paper adopts these four characteristics such as company's characteristics (size, ownership, financing, etc.); risk management characteristics (bank loan, annual quality review survey, multi-product collateral risk management, etc.); drug attribute characteristics (type of medicine, number of varieties produced throughout the year, etc.); the development characteristics demonstrated by the regulated company (proportion of R&D staff, expert help, etc.). The econometric model is (43):

$$GMP_i = \beta_0 + \beta_1 QY_i + \beta_2 FX_i + \beta_3 YP_i + \beta_4 FZ_i + \mu_i \quad (1)$$



The *GMP* on the left side of the above equation is the on-site inspection result of the drug enterprise, and  $i$  represents the inspected enterprise. The *QY* on the right side of the equation is the vector of corporate characteristic variables that affect the inspection results of pharmaceutical companies, such as the type of corporate ownership, the value of the company's fixed assets, the area of the purification zone, the operating time of the company, and the number of years the quality authorized person has entered the company. *FX* represents the variable vector of risk management characteristics, including whether the source of funds mainly relies on bank loans, whether to conduct annual quality review surveys, whether to establish multi-product collateral risk management, and whether to establish separate risk management procedures etc. *YP* represents the vector of drug characteristic variables, such as the type of drugs produced, the number of drug varieties produced throughout the year, the number of drug approval of the company, the efficiency of the company's capacity utilization, and laboratory maintenance costs, etc. *FZ* represents the development characteristic variable vector of the enterprise, including the proportion of enterprise R&D (research and development) personnel, personnel problems, whether to get expert help, the number of standard operating procedures, whether the enterprise expands and merges, and the enterprise quality system review cycle and other variables.  $\mu_i$  is the random error term.

In the formula (1), on the one hand, the variable of the value of fixed assets represents the production capacity of the interviewed company, it has an impact on the company's GMP inspection results. On the other hand, the inspection results will also impact the company's value of fixed assets. As a result, there could be endogenous problems between the GMP inspection results and the company's fixed assets variables. The endogenous issue will most often lead to biased estimation. Building on the ideas of Qin et al. (44), in the survey area, we choose the average value of pharmaceutical companies' fixed assets as an instrumental variable for the value of fixed assets of pharmaceutical companies at the regional level. The reason for choosing this variable is that the average value of fixed assets at the regional level is closely related to the value of fixed assets of the interviewed company; however, it does not directly impact the results of the GMP inspection of the interviewed company. It is a more appropriate instrumental variable according to the rule to choose an instrumental variable. In fact, we use the value of a company's fixed assets that is 1 year behind to strengthen the instrumental variables and weaken the impact of the inspection results on the company's value of fixed assets.

GMP inspection results are discrete variables, and some studies use discrete choice models for quantitative estimation. However, Qin et al. (44) and Ferrer and Frijters (45) believe that the results obtained with the discrete model and the linear regression model estimated by the OLS method do not differ significantly, so this paper uses the linear probability model for its quantitative estimation. The other reason for using the linear probability model is that we also want to solve the endogenous problem between variables and need to use instrumental variables (IV) to do so. In contrast, discrete choice models such as the Ordered Logit model are nonlinear models and cannot directly use instrumental variables. Therefore, to calculate IV estimates, this

article uses the two stage least square (2SLS) for quantitative testing. Simultaneously, the Multinomial Logit Model, the Ordered Logit and Ordered Probit model were used to test the robustness of the measurement results. In addition, we took the logarithm of the one-year lag of value of fixed assets to eliminate the non-normality of the data.

## 4. Results and discussion

### 4.1. Data sources and descriptive statistics

The data in this study comes from the actual inspection results of GMP in Anhui Province conducted by the State Drug Administration of China and face-to-face investigation of our research group. The investigation lasted for 3 years, covering the period from June 2017 to October 2019. The survey sample is selected by equidistant random sampling method. There are 380 pharmaceutical companies in Anhui Province, of which 294 are selected to be surveyed. The proportion of surveyed companies in all pharmaceutical companies in Anhui Province is 77%. The survey data consists of two parts. The first part is the actual result of the routine GMP normative inspection conducted by the inspectors of Anhui Provincial Drug Administration. As mentioned before, the inspectors of the Drug Administration are professionals in this field. They can only obtain the inspection qualification after passing the strict qualification examination. The second part is for the inspected companies. When inspectors of the Drug Administration carry out on-site inspection of the company, the investigators of the research group enter the company to conduct a questionnaire interview on the quality of the company's drug production and management, focusing on the company's characteristics and risk quality management. Investigators of the research group are allowed to participate in formal research only after formal training and passing examinations. After the investigation, the two parts of data are combined to build a complete data set which contains the GMP inspection results and condition of business for each company, forming the basic data for this study.

FDA inspectors conduct their on-site inspections following the Good Manufacture Practice of Medical Products (revised in 2010) promulgated by China's Ministry of Health. The GMP specification covers a total of 829 indicators. According to the seriousness of defects, each indicator's inspection results are divided into four categories: standard, minor defects, major defects, and severe defects, labeled 0, 1, 2 and 3, respectively. If an inspector uncovers a severe defect, the company is deemed to have failed the inspection. Consequently, when its GMP certificate expires, a company cannot continue to produce drugs, and offenders will be punished as drug counterfeiters. In severe cases, they can be held criminally responsible. Typically, after a GMP certificate expires, it will automatically be renewed for another 5 years if its other results are satisfactory, allowing the company to continue production.

Additionally, the result of a severe defect (failed) includes two situations: first, if any enterprise under inspection has one or more 3 ratings (i.e., severe defects) in all 829 indicators; second, if there are four and above 2 ratings (i.e., major defects). We have organized the results of the GMP inspection of 829 indicators into a total



TABLE 1 Comparison of GMP inspection results of enterprises with different ownership types.

GMP inspection results	Minor defects (1)	Major defects (2)	Severe defects (i.e., failed) (3)	Total defects (4)	Proportion of severe defects (3)/(4)
Type of enterprise					
State-owned enterprises					
Amount (unit)	4	7	3	14	21.43%
Proportion (%)	4.71	4.27	6.67	4.76	
Private enterprises					
Amount (unit)	73	150	42	265	15.85%
Proportion (%)	85.88	91.46	93.33	90.14	
Foreign-owned enterprises					
Amount (unit)	8	7	0	15	0%
Proportion (%)	9.41	4.27	0	5.1	
Total					
Amount (unit)	85	164	45	294	15.31%
Proportion (%)	100	100	100	100	

F-test is significant at the level of 10% ( $P = 0.0780$ ).

TABLE 2 Comparison of GMP inspection results of the main enterprise whether the source of funds depends on bank loans.

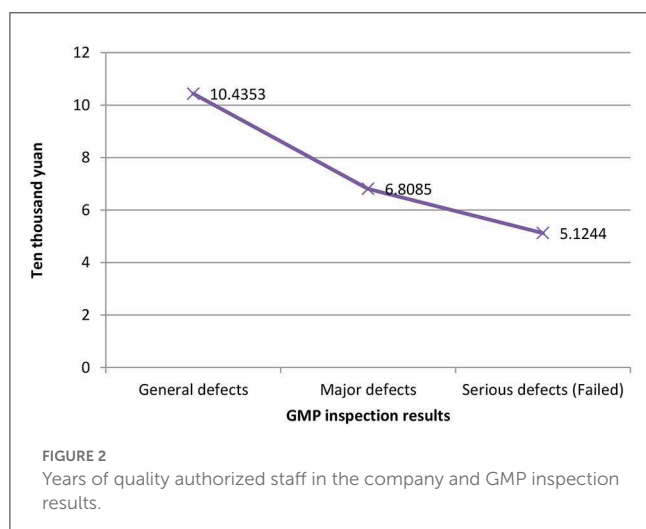
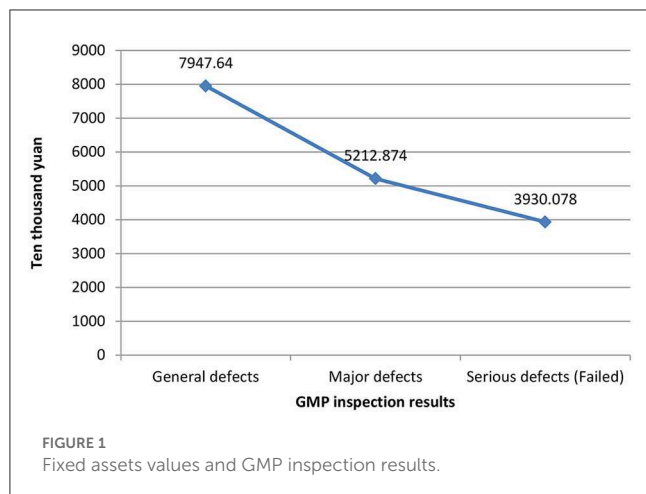
GMP inspection results	Minor defects (1)	Major defects (2)	Severe defects (i.e., failed) (3)	Total defects (4)
Funding source				
Not based on bank loans				
Amount (unit)	55	86	19	160
Proportion (%)	64.71	52.44	42.22	54.42
Mainly based on bank loans				
Amount (unit)	30	78	26	134
Proportion (%)	35.29	47.56	57.78	45.58
Total				
Amount (unit)	85	164	45	294
Proportion (%)	100	100	100	100

F-test is significant at the level of 5% ( $P = 0.0370$ ).

indicator that conveys the overall rating: if only 0 and no other values appear, it means normal and a value of 0 is assigned; if at least one 1 appears but no 2 or 3, then this indicates a minor defect and a value of 1 is assigned; if there are three or less 2s but no 3, it means a major defect and a value of 2; if there is at least one 3, or four or more 2s, it means a severe defect (not a pass) and the value 3 is assigned. The final inspection result is a combination of the National Medical Products Administration's results and the dependent variable used in this article. None of the companies surveyed for the paper received a final result of 0; the numbers of companies identified as having minor defects, major defects, and

severe defects (failed) are 85, 164, and 45, respectively. It can be seen that the proportion of severe defects (not passed) is 15.31%.

Table 1 provided a comparison of GMP inspection results of enterprises with different ownership types. Among the 294 enterprises in the sample, the numbers of state-owned enterprises, private enterprises, and foreign-owned enterprises were 14, 265 and 15, respectively. Among the variables of enterprise ownership types, the various enterprises' sample proportions are consistent with the country's overall proportion. In this study, none of the foreign companies had severe defects (failed) in their inspection results, indicating that the foreign companies maintain relatively



high GMP standards. The proportion of private enterprises with severe defects (failed) in the inspection results was 15.85%, but the proportion of state-owned enterprises with severe defects (failed) was as high as 21.43%. Compared with foreign-owned enterprises, both state-owned and private enterprises have big gaps in their production standardization. Table 2 compares GMP inspection results of the companies whether bank loan is their funding source. For companies that use bank loans as their primary source of funding, poor GMP inspection results can have severe consequences.

Figure 1 shows the relationship between different companies' fixed assets values and their GMP inspection results. The vertical axis represents the value of fixed assets, and the horizontal axis represents the GMP inspection results. It can be seen that the more the value of fixed assets, the better the results of the company's GMP inspection, vice versa. The relationship between the years of quality authorized staff and GMP inspection results is shown in Figure 2. The vertical axis is the number of years of quality authorized staff entering the company, and the horizontal axis is the GMP inspection results. The figure clearly shows that the longer the quality authorized staff has entered the company, the better the company's GMP standard result. However, the less the quality

authorized person has entered the company, the more severe the GMP inspection results of the company will be (failed). These results preliminarily show that the value of fixed assets and the variable of the number of years of quality authorized staff have a negative correlation with the results of GMP inspections.

The value of the company's fixed assets ranges between 1.344 billion RMB Yuan ( $\sim 1 \text{ USD} = 6.75 \text{ RMB Yuan}$ , year of 2020) and only 5 million RMB Yuan. This wide span shows that the scale of Chinese enterprises is quite different from western counterparts, and there will be big gaps in production capacity and production levels. The area of the purification area is 7,596 square meters for the largest enterprise, and there is no purification area for the smallest. The company's operation has been running for an average of 14 years, with the shortest term being 3 years. The operation time of an enterprise represents the production of its experience. The longer the operation history, the richer the production experience of the enterprise and the more helpful it is to standardize production. The longest quality authorized person has served for 36 years, and the shortest for only 1 year. For quality authorized personnel, 25.85% have a college degree or below, 66.33% have a bachelor degree, and only 7.82% have a Master degree or above. Quality authorized persons have special responsibilities in the GMP standard production process of drugs, and their education level needs to be improved. As much as 45.58% of enterprises, the source of funds in the process of GMP comprehensive transformation and implementation mainly relies on bank loans. It shows that the strength of the enterprise is weak, and the ability of self-financing is low. The definitions and descriptive statistics of other variables are shown in Table 3.

## 4.2. Main model results

Table 4 shows the regression results from the 2SLS model for examining the influencing factors of the corporate GMP inspection results. This is the main model result in this paper. At the same time, as shown under Model (1), this table also lists the measurement results of the OLS model. The coefficient values of Model (2) are all greater than those of the corresponding variables of Model (1), indicating that if the endogenous problem is not solved, the impact of variables such as enterprise characteristics and risk management characteristics on the results of GMP inspections will be underestimated. Among the enterprise characteristic variables of Model (2), the results of enterprise ownership type variables show that compared with state-owned enterprises, private and foreign enterprises have relatively better inspection results. In fact, the inspections of foreign pharmaceutical companies revealed no severe defects (fails). These companies are generally branches of relatively strong international pharmaceutical enterprises and have passed the stringent GMP certification processes in places such as Europe and the United States. Their adherence to production process guidelines and internal control indicators are relatively strict, and the degree of standardization company to company is high. Comparing national GMP standards, China's are inherently lower than those of major economies such as the United States, and its state-owned enterprises and private enterprises still lack GMP hardware and software investment.

TABLE 3 The definition of variables and descriptive statistics in this study.

Variables	Definition	Mean	Standard deviation	Minimum	Maximum
GMP inspection results	The GMP inspection results that are conducted by the FDA, the minor defect is 1, the major defect is 2, and the severe defect (failed) is 3.	1.8639	0.6520	1	3
<b>Type of enterprise ownership</b>					
State-owned enterprises	State-owned enterprise is 1, otherwise is 0	0.0476	0.2133	0	1
Private enterprises	Private enterprise is 1, otherwise is 0	0.9014	0.2987	0	1
Foreign enterprises	Foreign enterprise is 1, otherwise is 0	0.0510	0.2204	0	1
Fixed assets values	Value of the company's fixed assets (10,000 yuan)	5,857.6010	13,032.8700	500	134,449
Area of purification zone	No more than 100,000 bacteria/square meter area	155.7564	649.192	0	7,596
Enterprise operating time	Number of years since the establishment of the company (years)	14.0680	17.0409	3	214
Years of quality authorized staff in the company	Number of years the quality authorized staff has worked in the company (years)	7.6139	7.4411	1	36
<b>Education of quality authorized staff</b>					
College degree and below	If the enterprise quality authorized staff obtained a college degree or below, the degree is 1, otherwise is 0	0.2585	0.4386	0	1
Bachelor degree	If the enterprise quality authorized staff obtained a bachelor degree, the degree is 1, otherwise is 0	0.6633	0.4734	0	1
Master degree and above	If the enterprise quality authorized staff obtained a master degree or above, the degree is 1, otherwise is 0	0.0782	0.2690	0	1
Bank loan	The source of corporate funds mainly relies on bank loans as 1, otherwise is 0	0.4558	0.4989	0	1
Annual quality review survey	The annual quality review survey for drug batches that do not meet the quality standards is 1, otherwise is 0	0.7211	0.4492	0	1
Multi-product collateral risk management	Established a multi-product collateral risk management procedure for 1, otherwise is 0	0.5510	0.4982	0	1
Individual risk management procedures	Established a separate risk management procedure for 1, otherwise is 0	0.9626	0.1901	0	1
<b>Type of medicine</b>					
Medical oxygen	The production of medicines belongs to medical oxygen is 1, otherwise is 0	0.0442	0.2059	0	1
Chinese medicine decoction pieces	The production of medicines belong to Chinese medicine decoction pieces is 1, otherwise is 0	0.5272	0.5001	0	1
Preparation drugs	The production of medicines belong to Preparation drugs is 1, otherwise is 0	0.3605	0.4810	0	1
Sterile drugs	The production of medicines belong to Sterile drugs decoction pieces is 1, otherwise is 0	0.0680	0.2522	0	1
Number of varieties produced throughout the year	The number of types of drugs produced by the enterprise throughout the year (pieces)	149.2755	197.8091	1	871
Number of approved document numbers	Number of drug approval document numbers owned by the enterprise (pieces)	20.5102	45.5893	1	396
Capacity utilization	Annual capacity utilization rate (%)	61.3655	24.5813	10	100
Laboratory maintenance costs	Annual maintenance cost of the laboratory (10,000 yuan)	32.4241	95.6821	6	1,224
Proportion of RandD staff	The proportion of RandD staff to the total number of employees (%)	4.4796	6.8108	0	37
Staff issues	In the process of implementing GMP, the company considers the seriousness of the operating personnel's problems. 1, 2, 3, 4, and 5 respectively indicate: no, very little, general, more, and very much	3.0102	1.0368	1	5

(Continued)

TABLE 3 (Continued)

Variables	Definition	Mean	Standard deviation	Minimum	Maximum
Expert help	In the process of implementing GMP, the extent to which the company believes that it has received expert help, 1, 2, 3, 4, and 5 respectively indicate: no, very little, general, more, and very much	2.8299	1.1108	1	5
Number of standard operating procedures	Number of standard operating procedures established by the enterprise (unit)	578.6905	756.9782	6	7,798
Expand merger	The enterprise development strategy is to expand the merger to 1, or not to 0	0.1190	0.3244	0	1
Quality system review cycle	The quality system review cycle is 1 over half a year, and 0 within half a year	0.1565	0.3639	0	1

Overall, China companies' production concepts, quality awareness, and management techniques are in urgent need of improvement.

The results of the value of fixed assets show that when the value of a company's fixed assets is higher, the probability that the company's GMP inspection result will be seriously defective (i.e., fail) is significantly reduced. From another perspective, the lower the value of the company, the higher the probability that inspection will reveal severe defects (failures). The value of fixed assets represents the scale of the enterprise to a certain extent, with a high value of fixed assets invariably indicating a large-scale enterprise. Larger companies tend to have wide-ranging social influence, and severe product-quality problems will greatly damage the company's social reputation, reduce its image in the eyes of consumers, and interfere with market success. If a company has problems, the company will suffer greater losses, and the cost and price paid for regaining reputation and the market are also greater. It can be seen that companies with higher fixed assets have higher inherent requirements, pressures and motivations for standardized production. Therefore, strengthening the GMP supervision of enterprises with low fixed assets is one of the key work directions of the FDA in the future.

The estimation results of years of quality authorized staff in the company show that the longer time of the staff works in the company can significantly promote the level of GMP inspection result and reduce the risk of company's inspection results as severe defects (failed). Many years of practical experience in developed countries have shown that the quality authorized person system is an effective drug quality management system, which helps companies to ensure drug quality and fulfill social responsibilities. The main responsibilities of the quality authorized person include not only implementing the laws and regulations on drug quality management, organizing and regulating the company's drug production quality work; but also organizing, establishing and improving the production quality management system of the pharmaceutical company, and monitoring it to ensure effective operation. For the selection of key material suppliers, the production equipment, and key staff in production, quality, materials, equipment and engineering departments, the quality authorized staff has the right to decide and veto. The quality authorized staff is specially assigned and required to perform the function of product release. Once the product is released, it will directly face the patients, and the quality of the product will affect the life safety of the patient. In fact, the product release function

is the core function of GMP, which runs through the entire GMP system. In addition to the solid professional knowledge of the quality authorized staff, the understanding of the company's factory conditions, the grasp of the production skills and specialties of the company's employees, and the knowledge of the company's production facilities are all long-term requirements for these quality authorized staff.

Among the risk management characteristic variables, the regression results of the bank loan variables show that if a company mainly relies on bank loans for implementing GMP, the GMP inspection has a higher probability of identifying severe defects (failure). This trend can be explained by the nature of the modern pharmaceutical production industry, which is both technology-intensive and capital-intensive (46), meaning that producers face huge capital outlays when forced to modernize their production technologies. Before implementing GMP certification standards, there were big differences in the production methods between different pharmaceutical manufacturers in China, and there were also certain differences in product quality. Moreover, a big gap existed between Chinese production lines and the pharmaceutical production standards of developed countries. Chinese pharmaceutical manufacturers needed to renovate their original plants and equipment and other software and hardware following the GMP regulations; moreover, subsequent production facilities had to continue to comply with GMP's standards. Regardless of the original enterprise's comprehensive GMP transformation, or the maintenance of GMP production specifications after the transformation, huge investment is still required. If the enterprise can barely meet the needs of GMP transformation and development with self-raised funds, it will be burdened with greater repayment pressure from banks and other investors it borrowed from to make the transformation. This burden will increase the enterprise's operating costs and is not conducive to market competition. Generally speaking, after passing the GMP certification, the company's unit cost will have increased by nearly 20% on average due to equipment renewal, plant depreciation, and increased management costs. Companies that rely mainly on bank loans to implement GMP tend to lack self-owned funds, are small and relatively weak with regards to resources such as staff and financial backing, and usually have poor production capacity.

The results of other variables are also worthy of attention. Examining the time an enterprise has been in operation often

TABLE 4 2SLS method regression results of factors affecting the results of GMP inspection of pharmaceutical companies.

Variables	OLS model			2SLS model		
	Model (1)			Model (2)		
	Coefficients	SD	T-value	Coefficients	SD	T-value
<b>Characteristics of enterprises</b>						
<b>Type of enterprise ownership (reference group: State-owned enterprises)</b>						
Private enterprises	−0.3903**	0.1932	−2.0200	−0.6157***	0.2487	−2.4800
Foreign enterprises	−0.5458**	0.2341	−2.3300	−0.6422***	0.2553	−2.5200
Total fixed assets values	−0.0555	0.0345	−1.6100	−0.2533**	0.1292	−1.9600
Area of purification values	−0.0001	0.0001	−1.2600	−0.0001	0.0001	−0.9800
Enterprise operating time	−0.0030	0.0026	−1.1600	−0.0019	0.0028	−0.6600
Years of quality authorized staff work in the company	−0.0143**	0.0063	−2.2900	−0.0129**	0.0067	−1.9300
<b>Quality authorized staff's degree (reference group: College degree and blow)</b>						
Bachelor	0.2005**	0.0863	2.3200	0.2593***	0.0986	2.6300
Master and above	−0.0465	0.1524	−0.3100	0.0598	0.1747	0.3400
<b>Characteristics of risk management</b>						
Bank loan	0.1843**	0.0749	2.4600	0.2335***	0.0852	2.7400
Annual quality review survey	−0.2759***	0.0855	−3.2300	−0.2627***	0.0909	−2.8900
Multi-product collateral risk management	−0.1459*	0.0828	−1.7600	−0.0875	0.0951	−0.9200
Individual risk management procedures	0.4419**	0.1967	2.2500	0.4852**	0.2102	2.3100
<b>Characteristics of drugs</b>						
<b>Type of medicine (reference group: Medical oxygen)</b>						
Chinese medicine decoction pieces	−0.0524	0.2038	−0.2600	−0.1435	0.2234	−0.6400
Preparation drugs	−0.0002	0.2015	0.0000	0.0107	0.2137	0.0500
Sterile drugs	0.1759	0.2553	0.6900	0.1824	0.2706	0.6700
Number of varieties produced throughout the year	0.0003	0.0002	1.1500	0.0004	0.0003	1.4800
Number of approved document numbers	0.0005	0.0010	0.4600	0.0016	0.0013	1.2400
Capacity utilization	0.0019	0.0015	1.2900	0.0015	0.0016	0.9600
Laboratory maintenance costs	0.0206	0.0419	0.4900	0.0204	0.0444	0.4600
<b>Characteristics of development</b>						
Proportion of RandD staff	0.0025	0.0058	0.4400	0.0001	0.0064	0.0100
Staff issues	0.0292	0.0368	0.7900	0.0388	0.0394	0.9800
Expert help	−0.0199	0.0343	−0.5800	−0.0200	0.0363	−0.5500
Number of standard operating procedures	0.0000	0.0001	0.5200	0.0000	0.0001	0.6600
Expand merger	−0.0395	0.1151	−0.3400	−0.0849	0.1253	−0.6800
Quality system review cycle	0.1447	0.0994	1.4600	0.1516	0.1054	1.4400
Constant term	2.1989***	0.4454	4.9400	3.7765***	1.0953	3.4500
Adj R-squared	0.1559			0.0521		
N	294			294		

\*\*\*, \*\*, and \* indicate significant at the statistical level of 1, 5, and 10%, respectively. SD refers to standard deviation.



TABLE 5 Multinomial Logit model regression results of factors affecting GMP inspection results of pharmaceutical companies.

Variables	GMP inspection result is the major defect			GMP inspection result is the severe defect		
	Model (1)			Model (2)		
	Coefficients	SD	Z-value	Coefficients	SD	Z-value
Type of enterprise ownership (reference group: State-owned enterprises)						
Private enterprises	−1.5776**	0.8224	−1.9200	−2.0432*	1.0950	−1.8700
Foreign enterprises	−1.3523	0.9280	−1.4600	−17.0599	1521.4800	−0.0100
Fixed assets values	−0.2889**	0.1494	−1.9300	−0.3727*	0.2232	−1.6700
Years of quality authorized staff work in the company	−0.0110	0.0271	−0.4100	−0.1066**	0.0469	−2.2700
Bank loan	0.7894**	0.3413	2.3100	1.1656***	0.4666	2.5000
Pseudo R <sup>2</sup>	0.1915					
N	294			294		

(1) The result of the GMP inspection in the above table is that the minor defect is used as the reference group; (2) \*\*\*, \*\* and \* indicate significant at the statistical level of 1, 5, and 10%, respectively; (3) The other controlled variables same as those in Table 4.

shows that the longer a company has been established, the lower the probability of severe defects being found during inspection. However, this result is not statistically significant. Measuring the variables of a company's annual quality internal review survey usually indicates that if the company finds drug batches that do not meet quality standards, it will increase its production diligence. Consequently, the probability of it failing a later GMP inspection is significantly reduced. The purpose of the annual quality review is to ensure the stability and reliability of the production process, and to ensure that the transition of raw materials into finished pharmaceutical products meets the requirements of the current GMP, and that the quality of drugs meets the predetermined standards. The establishment of a multi-product co-line risk management system has improved the level of GMP production standards. Companies have noted that previous lack of quality awareness in employees led to the occurrence of GMP production irregularities in the past. The guidance and help of industry experts have since improved the standardization of GMP production.

### 4.3. Further analysis

Table 5 shows the regression results of the Multinomial Logit model of the factors such as the enterprise characteristics and risk management, affecting the GMP inspection results both the major defects and the severe defects, i.e., failed. First, the smaller the value of fixed assets, the higher the probability that the inspection result will be a severe defect. Second, the longer the quality authorized staff has been in the company, the more likely it is that the company's inspection result is a severe defect. Third, companies that mainly rely on bank loans will have worse inspection results. Lastly, if the annual quality review survey is not conducted, the probability that the company's inspection results fail will be significantly increased. From the perspective of drug types, compared with the medical oxygen category, the production of Chinese medicine decoction pieces, preparation drugs, and sterile

drugs, the inspection results of these three types of drugs are severe defects, that is, the probability of failing is higher.

### 4.4. Robustness test

Table 6 reports the econometric regression results of the ordered dependent model. Its purpose is to test the stability of the regression results of each variable. On the one hand, the results of the Ordered Logit model and the Ordered Probit model are basically similar; on the other hand, compared to the estimation results of the 2SLS model (Table 4), the econometric regression results of the ordinal dependent variable model (Table 6), not only, for each variable, the signs of the coefficient are basically the same, but also the significance of the estimated values of the corresponding variable coefficients are the same. This indicates that the econometric regression results in this paper are relatively robust. These results also show that if these corporate characteristics and quality risk management characteristics that have a greater influence on the results of GMP inspections are used as the focus, strengthening the supervision of pharmaceutical manufacturers will help improve the degree of GMP regulations of pharmaceutical manufacturers. It also helps to ensure the production quality of medicines.

## 5. Conclusion and discussion

Based on the on-site inspection and survey data of GMP of pharmaceutical companies in Anhui Province of China, by the National Medical Products Administration, this paper empirically tests the impact of corporate characteristics and risk management on the GMP regulations. The empirical research in this article provides an essential practical basis for academic research and policy maker. It also provides a scientific basis for any country to improve the targeted and effective supervision of pharmaceutical

**TABLE 6** The regression results of the ordinal dependent variable model of the influencing factors of the GMP inspection results of pharmaceutical companies.

Variables	Ordered Logit model			Ordered Probit model		
	Model (1)			Model (2)		
	Coefficients	SD	Z-value	Coefficients	SD	Z-value
<b>Type of enterprise ownership (reference group: State-owned enterprises)</b>						
Private enterprises	−1.5325**	0.6975	−2.2000	−0.8580**	0.3827	−2.2400
Foreign enterprises	−2.0196**	0.8295	−2.4300	−1.1964***	0.4741	−2.5200
Fixed assets values	−0.1963*	0.1178	−1.6700	−0.1151*	0.0679	−1.6900
Years of quality authorized staff work in the company	−0.0531**	0.0222	−2.3900	−0.0319***	0.0129	−2.4800
Bank loan	0.6402***	0.2594	2.4700	0.3787***	0.1484	2.5500
Pseudo $R^2$	0.1346			0.1351		
N	294			294		

(1) \*\*\*, \*\*, and \* indicate significant at the statistical level of 1, 5, and 10%, respectively; (2) The other controlled variables same as those in Table 5.

companies. Four research results are found. First, both foreign-owned and private enterprises have a higher GMP result than state-owned enterprises. Second, a company's GMP inspection results are worse when its source of funds is more dependent on bank loans. Third, for companies with less fixed assets, their GMP inspection results are worse. Fourth, the shorter the quality authorized employee has been with a company, the worse that company's GMP inspection results. To improve the pertinence of pharmaceutical manufacturers' supervision, strengthen the GMP standardization of pharmaceutical production, and ensure the production quality of pharmaceuticals, the above aspects should be taken as the entry point for supervision.

Contrasting with foreign-owned and private enterprises, state-owned enterprises are both market entities and administrative entities privileged, and they can obtain additional resources. State-owned enterprises began overlooking and disregarding quality responsibility, caused by many enterprises having ambiguous budget constraints and setting excessive non-business objectives, plus the non-marketization of incentive mechanisms caused by the government. The root cause is these state-owned enterprises are protected by government policy and are given resource monopoly, which is causing some serious consequences. State-owned enterprises have become the priority development targets at all levels of government with absolute financial support, exclusive policy resources, strong economic strength, and funds that are ultimately "exhausted" by the finances. Some have even become "shadow banks", where they could obtain loans at extremely low rates due to their special privileges, and then lend out those loans at higher rates to private enterprises.

One of the important driving forces of China's economic growth miracle since the period of Reform and Opening-up is that private enterprises have obtained a wider space for development. The people's enthusiasm for innovation and entrepreneurship has been released explosively; private enterprises have served the entire society at a much higher efficiency than state-owned enterprises. It also creates wealth for capital holders. In the market

economy environment, the competition of various enterprises is a comprehensive competition of product quality and efficiency. Ensuring quality, adhering to integrity, fair trading, and respect for market rules is the long-term survival of all enterprises, including state-owned enterprises. All enterprises registered in China must establish equal status in law and treat them equally in terms of policies to provide a market basis for fair competition among all enterprises. Simultaneously, we must adhere to supply-side structural reforms' mainline and accelerate market-oriented reforms in the financial sector. China's financial institutions are not yet market entities in the true sense. At present, a considerable number of financial institutions in China have inadequate restraint and incentive mechanisms. Illegal lending and non-market-based lending operations occur from time to time, which increases potential financial risks and is not conducive to the development of the real economy, including pharmaceutical companies. And product quality control. For corporate loans, it should be resolved through market means such as market financing and personal lending. Further, it is necessary to strengthen the legislative work in the financial field, improve the financial market's level of supervision, promote the commercialization of banks, and establish a new market-oriented bank-enterprise relationship.

Although this paper is a research on how to strengthen the supervision of pharmaceutical production companies from the perspective of drug supervisors, we still need to consider how to protect the quality of drug production from government departments and enterprises. From a government department, local protectionism is subject to local protectionism to strengthen the concentration of drug production enterprises. China's drug production enterprises have more than 7,000, and only more than 100 pharmaceutical companies such as USA and Japan and other pharmaceutical powers. The top three drug production enterprises, China's concentration is 6.16%, while the United States reached 32%; for the top 10 drug production enterprises, China's concentration is 14.26%, and the United States is as high as 63%, Japan also reached 52% (47). With lower

concentration, China's pharmaceutical production enterprises have poor economic benefits, and the homogenization of products is serious. For example, the number of NOFCS drug production enterprises is as high as more than 800. More than 80% of pharmaceutical companies in China are small and medium-sized enterprises, the production equipment is relatively small, and the production equipment is older, and the problem with the management level is very prominent (1). Affected by the economic concept of local development, local protection, government supervision is not in place, leading to the quality awareness of the company, thus affecting the production standards and the quality of the drug, and will ultimately endanger the lives of the people. For companies with weak funds, we must dare to face their own market position, we must work with large enterprises, or become a subsidiary of large enterprises, to improve their production level. However, these companies cannot blindly rely on compliant or non-compliant means to obtain external funds to maintain their own survival. State-owned enterprises and private enterprises should also do everything possible to learn GMP standard production experience to improve their production levels and meet the requirements of GMP.

Although this paper has created an exclusive empirical study in GMP drug production supervision, there are still some shortcomings. First, the number of sample companies has to be increased. In the existing literature study in this field, the sample amount used herein is relatively, but the representation of the sample can be further enhanced if the number of observed values of the existing samples can be largely expanded. Second, the sample uses cross-sectional data and cannot eliminate the influencing factors that do not change over time. As mentioned above, the non-openness of the GMP examination results, the professional data collection, and the huge cost of the on-site inspection, are the biggest obstacles to data acquisition and are also fundamental reasons that are difficult to have a breakthrough in this research area. In the future, we should strengthen cooperation with relevant departments, carry out continuous long-term planning, and collect data on a larger scale and for a longer period to further study this challenging area.

## References

1. Zhu HP. Why China's pharmaceutical industry has not become bigger and stronger. *China Med Insur.* (2018) 36:15–8.
2. Wang JY, Zhang WX. Research on public opinion governance of drug safety. *Chin J Public Health Manag.* (2021) 37:288–90. doi: 10.19568/j.cnki.23-1318.2021.03.0002
3. Tauqeer F, Myhr K, Gopinathan U. Institutional barriers and enablers to implementing and complying with internationally accepted quality standards in the local pharmaceutical industry of Pakistan: a qualitative study. *Health Policy Plan.* (2019) 34:440–9. doi: 10.1093/heapol/czz054
4. Joseph A, Henry B, Ronald W. Innovation in the pharmaceutical industry: New estimates of R&D costs. *J Health Econ.* (2016) 47:20–33. doi: 10.1016/j.jhealeco.2016.01.012
5. Xue F, Xi Q. Discussion on the main risk points of supplier management in pharmaceutical GMP. *Chin J Pharm.* (2021) 52:131–36. doi: 10.16522/j.cnki.cjph.2021.01.015
6. Giuseppe A, Giuseppe E, Deigo G, Rocco M, A. spatial analysis of health and pharmaceutical firm survival. *J Appl Stat.* (2015) 44:1560–75. doi: 10.1080/02664763.2016.1214249
7. Gregory W, Alexis C, Morgan H. Improving pharmaceutical innovation by building a more comprehensive database on drug development and use. *Health Aff.* (2015) 34:319–27. doi: 10.1377/hlthaff.2014.1019
8. Fernando G, Jesus L, Borja P, David F. Measuring the efficiency of large pharmaceutical companies: an industry analysis. *Eur J Health Econ.* (2017) 18:87–608. doi: 10.1007/s10198-016-0812-3
9. Meredith YS, Andrea R, Priya B, Peter GM, Mol SE, Emily F, et al. The RIMES statement: A checklist to assess the quality of studies evaluating risk minimization programs for medicinal products. *Drug Safety.* (2018) 41:389–401. doi: 10.1007/s40264-017-0619-x
10. Lim J, Cho H. An analysis of the factors related to EU GMP non-compliance-focusing on active substance. *Hum Med Prod.* (2021) 65:46–55. doi: 10.17480/psk.2021.65.1.46
11. Liu W, Wang Y. Quality control game model in logistics service supply chain based on different combinations of risk attitude. *Int J Prod Econ.* (2015) 161:181–91. doi: 10.1016/j.ijpe.2014.12.026
12. Kelly D, Martin BW, Josephson GG, Vadakkepatt JL. Political management, research and development, and advertising capital in the pharmaceutical

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

## Author contributions

Conceptualization: HC and LQ. Methodology: LQ and YS. Software: MQ and LQ. Writing: CJ and MQ. Formal analysis: HC, CJ, YS, and JL. All authors contributed to the article and approved the submitted version.

## Funding

We gratefully acknowledge the supports by the Social Science Foundation of Anhui Province of China (AHSKY2020D44), the Key Project of Humanity and Social Science Supported by the Bureau of Education of Anhui Province (2022AH050561), and the major project of the Social Science Foundation of Anhui Province of China (AHSKZD2019D04).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- industry: a good prognosis. *J Mark.* (2018) 82:87–107. doi: 10.1509/jm.15.0297
13. Wada M, Ozaki A, Miyachi T, Tanimoto T, Crump A. Pharmaceutical good manufacturing practice: Leuplin production in Japan identifies major international shortcomings. *Invest New Drugs.* (2021) 39:1167–69. doi: 10.1007/s10637-021-01080-y
14. Luo JJ, Hu SG, Chen H. Analysis of defect items in GMP follow-up inspection and unannounced inspection of pharmaceutical manufacturing enterprises in Anhui Province in 2012. *Anhui Med.* (2014) 42: 585–8. doi: 10.3969/j.issn.1009-6469.2014.03.068
15. Hu SG, Luo JJ, Dou YH, Yang SY. Analysis and countermeasure research of new edition GMP certification inspection of assed production enterprises in Anhui Province. *China Pharm Equip.* (2014) 56:6–9. doi: 10.19514/j.cnki.cn32-1628/tm.2014.20.002
16. Wang SJ, Yu M, Wang GG, Ma SH. Environment monitoring and environmental microbial library establishment in clean area of pharmaceutical industries. *Chin J Pharm.* (2020) 51:1334–40. doi: 10.16522/j.cnki.cjph.2020.10.018
17. Liu YS, Hu CL, Ding YC. The status quo and regulatory countermeasures of cleaning verification in pharmaceutical manufacturers. *Shanghai Food Drug Regul Informat Res.* (2014) 38: 9–19.
18. Li JP, Fu QY. Analysis and supervision of data reliability of pharmaceutical production enterprises in Shanghai. *Shanghai Med.* (2018) 39:10–3.
19. Liu XL, Han DB, Pan P. Defect analysis and improvement suggestions for the new version of GMP certification inspection of Chinese herbal medicine production enterprises in Qinghai Province. *Chin Pharm Affairs.* (2016) 56:869–73. doi: 10.16153/j.1002-7777.2016.09.004
20. Lu SH, Wei YY, Li S, Wei GH. Comparison of defects in drug GMP follow-up inspection and certification inspection. *Chin J Pharm Industry.* (2019) 50:118–25. doi: 10.16522/j.cnki.cjph.2019.01.016
21. Cao LL, Wu ZA. Defects existing in the pharmaceutical manufacturing enterprises that withdrew the pharmaceutical GMP certificate during the GMP tracking inspection and unannounced inspection in China. *Chin J Pharm.* (2021) 52:574–80. doi: 10.16522/j.cnki.cjph.2021.04.019
22. Yang DS, Niu JZ, Xu MD. The application of USA and EU GMP database in the selection for reference preparations of generic drugs in China. *China Pharm.* (2021) 35: 407–14. doi: 10.16153/j.1002-7777.2021.04.007
23. Xu JH. Thoughts on perfecting the unified and authoritative food and drug regulatory system. *China Food Drug Superv.* (2016) 42:16–22.
24. Zhou LJ, Shang RX, Zhan CC. Study on the optimization of drug safety supervision system in the perspective of social co-governance. *Health Econ Res.* (2019) 35:54–7. doi: 10.14055/j.cnki.33-1056/f.2019.06.015
25. Jin YY, Zhao LB, Wang J. Revelation of EU GMP regulatory system to pharmaceutical manufacturers in China. *China Pharm.* (2021) 30:1–4.
26. Li D, Liang Y. Research on pharmaceutical enterprise six sigma management application under GMP background: Taking BT company as an example. *Chin J Pharm Industry.* (2019) 67:464–69. doi: 10.16522/j.cnki.cjph.2019.04.017
27. Viscusi WK, Joseph H, John V. *Economics of Regulation and Antitrust*. 4th ed. Cambridge, MA: MIT Press (2005).
28. Earnhart D, Rassier GD. Effective regulatory stringency and firms' profitability: the effects of effluent limits and government monitoring. *J Regul Econ.* (2016) 50:111–45. doi: 10.1007/S11149-016-9304-8
29. Ma C. Self-regulation versus government regulation: an externality view. *J Regul Econ.* (2020) 58: 166–83. doi: 10.1007/s11149-020-09415-y
30. Mitnick BM. *The Political Economy of Regulation: Creating, Designing, and Removing Regulatory Forms*. New York, NY: Columbia University Press (1980). doi: 10.2307/2067755
31. Rosenbloom HD, Kravchuk SR. *Public Administration: Understanding Management, Politics, and Law in the Public Sector*. New York, NY: Mc Graw-Hill, Inc. (2004). doi: 10.4324/9781003198116
32. Olson M. Firm characteristics and the speed of FDA approval. *J Econ Manag Strategy.* (1997) 6: 377–401. doi: 10.1111/J.1430-9134.1997.00377.X
33. Andarge T, Lichtenberg E. Regulatory compliance under enforcement gaps. *J Regul Econ.* (2020) 57:181–202. doi: 10.2139/ssrn.3388688
34. Shimshack JP. The economics of environmental monitoring and enforcement. *Annu Rev Resour Economics.* (2014) 6:339–60. doi: 10.1146/ANNUREV-RESOURCE-091912-151821
35. Sinclair, U. *The Jungle*. New York, NY: Doubleday, Jabber, and Co. (1906).
36. Office of Women's Health of USA. *FDA Milestones in Women's Health: Looking Back as we Move into the New Millennium*. Rockville, MD: FDA (2000). Available online at: <http://www.fda.gov/womens/milebro.html>
37. Center for Drug Evaluation and Research. *Time Line: Chronology of Drug Regulation in the United States*. Rockville, MD: FDA (2014). Available online at: <http://www.fda.gov/cder/about/history/timeline1.htm>
38. Office of Regulatory Affairs of USA. *Compliance Reference: Debarment List*. Rockville, MD: FDA (1992). Available online at: [www.fda.gov/ora/compliance\\_ref/debar/default.htm](http://www.fda.gov/ora/compliance_ref/debar/default.htm)
39. Center for Biologics Evaluation and Research. *Draft Guidance for Industry: Manufacturing, Processing, or Holding of Active Pharmaceutical Ingredients*. Rockville, MD: FDA (1998). Available online at: [www.fda.gov/cber/gdlns/active.pdf](http://www.fda.gov/cber/gdlns/active.pdf)
40. Noll RG. Government regulatory behavior: A multidisciplinary survey and synthesis. *Reg Pol Soc Sci.* (1985) 1:126–38. doi: 10.1525/9780520313651-004
41. Olson M. Regulatory agency discretion among competing industries: inside the FDA. *J Law Econ Org.* (1995) 11:379–405. doi: 10.1093/oxfordjournals.jleo.a036877
42. Luo JJ. Study on the relation of the quality management of drug production company and company metris in Anhui Province. *China Pharmaceutical University (Dissertation)* (2020).
43. McFadden D. Economic choices. *Am Econ Rev.* (2001) 91:351–78. doi: 10.1257/aer.91.3.351
44. Qin L, Chen C, Wang W, Chen H. How migrants get integrated in urban China-The impact of health insurance. *Soc Sci Med.* (2021) 272:113–28. doi: 10.1016/j.socscimed.2021.113700
45. Ferrer A, Frijters P. How important is methodology for the estimates of the determinants of happiness. *Econ J.* (2004) 114:641–59. doi: 10.1111/j.1468-0297.2004.00235.x
46. Wu SE, Zhong WZ, Wei JB, Huang ZL. Financing sources, cash holdings and R & D smoothing: evidence from the biomedical manufacturing. *China Econom Q.* (2016) 15:745–66. doi: 10.13821/j.cnki.ceq.2016.01.14
47. Guo CL. The current situation and main problems of China's pharmaceutical production and circulation system. *Econ Res Ref.* (2014) 31:4–27.



## OPEN ACCESS

## EDITED BY

Timotej Jagric,  
University of Maribor, Slovenia

## REVIEWED BY

Zhenjie Liang,  
Minjiang University, China  
Chong Feng,  
Xiamen University of Technology, China

## \*CORRESPONDENCE

Miao Zhu  
✉ 20008@hqu.edu.cn

## SPECIALTY SECTION

This article was submitted to  
Public Health Policy,  
a section of the journal  
Frontiers in Public Health

RECEIVED 24 October 2022

ACCEPTED 13 February 2023

PUBLISHED 09 March 2023

## CITATION

Wang W, Weng F, Chen Y and Zhu M (2023)  
Two-stage dual-game model approach to view  
the difficulty of healthcare accessibility.  
*Front. Public Health* 11:1078675.  
doi: 10.3389/fpubh.2023.1078675

## COPYRIGHT

© 2023 Wang, Weng, Chen and Zhu. This is an  
open-access article distributed under the terms  
of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/)  
(CC BY). The use, distribution or reproduction  
in other forums is permitted, provided the  
original author(s) and the copyright owner(s)  
are credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted which  
does not comply with these terms.

# Two-stage dual-game model approach to view the difficulty of healthcare accessibility

Weiwei Wang<sup>1,2,3</sup>, Futian Weng<sup>1,2,3</sup>, Yusheng Chen<sup>4</sup> and Miao Zhu<sup>5\*</sup>

<sup>1</sup>School of Medicine, Xiamen University, Xiamen, China, <sup>2</sup>National Institute for Data Science in Health and Medicine, Xiamen University, Xiamen, China, <sup>3</sup>Data Mining Research Center of Xiamen University, Xiamen University, Xiamen, China, <sup>4</sup>Finance and Economics College, Jimei University, Xiamen, China, <sup>5</sup>School of Statistics, Huaqiao University, Xiamen, China

This study proposed a two-stage dual-game model methodology to evaluate the existing difficulty of healthcare accessibility in China. First, we analyzed a multi-player El Farol bar game with incomplete information by mixed strategy to explore the Nash equilibrium, and then a weighted El Farol bar game was discussed to identify the existence of a contradiction between supply and demand sides in a tertiary hospital. Second, the overall payoff based on healthcare quality was calculated. In terms of the probability of medical experience reaching that expected level, residents are not optimistic about going to the hospital, and the longer the observation period is, the more pronounced this trend becomes. By adjusting the threshold value to observe the change in the probability of being able to obtain the expected medical experience, it is found that the median number of hospital visits is a key parameter. Going to the hospital did bring benefits to people with consideration of the payoffs, while the benefits varied significantly with the observation period among different months. This study is recommended as a new method and approach to quantitatively assess the tense relationship in access to medical care between the demand and supply sides and a foundation for policy and practice improvements to ensure the efficient delivery of healthcare.

## KEYWORDS

El Farol Bar problem, game theory, learning theory, Nash equilibrium, healthcare accessibility

## 1. Introduction

Healthcare resources are always limited compared to the demand of residents. With increasing healthcare burdens, such as aging populations and growing prevalence of communicable or non-communicable diseases (1), how to efficiently allocate limited healthcare resources is gaining increasing attention globally, and the idealized way of allocating resources is to match available supply with demand (2). However, this is a multi-sector game involving patients, medical institutions, doctors, and relevant departments (3), which can be summarized as the demand side, supply side, and regulating side of healthcare services. In China, the healthcare service system was different from other countries, which has formed a system of universal medical insurance and covers more than 95% of Chinese citizens, including three major insurance programs, namely, Urban Employee Basic Medical Insurance, Urban Resident Basic Medical Insurance, and New Rural Cooperative Medical Insurance. From the perspective of delivery, China's healthcare delivery system is fragmented and hospital-centered, constituted of four major categories of providers, namely, hospitals, primary healthcare institutions, professional public health organizations, and others (e.g., physician clinics) (4). Hospitals are designated as primary, secondary, or tertiary institutions based on a three-tiered grade system, and further subdivided into three



subsidiary levels according to the size, staff and equipment, and medical quality. Due to a large population together with disease burden transitions over the past few decades (5), China experienced an increasing demand for healthcare, which placed significant pressure on its healthcare system to become more accessible, affordable, and efficient (6).

From the supply side, China has made significant investments in its healthcare services, and the total health expenditure increased from CNY 1,998.39 billion in 2010 to CNY 6,519.59 billion in 2019, with a proportional increase from 11.03 to 17.93% (7). Moreover, the healthcare workforce increased from 8,207,502 to 12,928,335 over the same period, while the number of healthcare institutions increased from 936,927 in 2010 to 1,007,579 in 2019 (8). From the demand side, the demand for healthcare services increased due to disease burden transitions and an aging population; moreover, the majority of the population tends to seek primary care at large tertiary hospitals, which has resulted in the highly concentrated allocation of supply-side resources at tertiary public hospitals. Gaps in health-related investment and investment-output efficiency are of the first importance in the research of fundamental mismatch between supply and demand sides as well as other drivers related to this issue. On the one hand, the number of tertiary hospitals was 2,996 in 2020, accounting for 8.46% of hospitals. On the other hand, tertiary hospitals engage in 54.21% of outpatient services and 51.07% of inpatient services (9). Health service delivery is organized as highly centralized in the Chinese healthcare system and relies on rigid institutional arrangements (10). Since there are few, if any, gatekeepers to services in hospitals, it is common for tertiary hospitals to provide basic outpatient services in addition to broader research and advanced medical services. This expansive service provision, combined with greater public trust in larger public hospitals over local health clinics, has overburdened public hospitals, resulting in significant systemic inefficiencies (11, 12).

Healthcare resources are always limited compared to demand, and how to most efficiently allocate limited healthcare resources is gaining increasing attention. The ultimate goal of the healthcare supply chain is to meet the demands of healthcare requirements, and it is usually practically synonymous between hospitals and the concept of a healthcare delivery system (13). A growing body of literature has studied the use of healthcare services and the factors associated with utilization. Spurred by the desire to help ensure that all members of society would make optimal use of healthcare, medical and public health researchers and behavioral and social scientists have been increasingly drawn to the study of human behavior and health (14). In non-emergency situations, the last experience attending medical care has an influence on the next medical decision to a certain extent. Given the fact that the mismatch between the supply and demand sides of medical resources is particularly prominent in tertiary hospitals, whether those in healthcare will change their decision-making to avoid resource contention is a research area of practical significance.

The purpose of this article is to show, using a two-stage dual-game model, how an individual chooses the oncoming medical-seeking behavior given previous attendance experience and medical service capacity. In previous studies, researchers usually set the payoffs of going to a hospital as a fixed value and discuss the relationship between the probability of patients going to the

hospital and the payoffs, without consideration of influences from others. To deal with this gap effectively, we propose a new, dynamic dual-game model. Specifically, we construct an El Farol Game model to evaluate the payoff of healthcare seeking a tertiary hospital, thus forming a dual-game effect that allows the original model to estimate the payoff for going to the hospital, with full consideration of interactions between these two non-independently game models. Moreover, the reinforcement learning was also adopted as a supplement to the methodology, which has been broadly applied in optimizing decision-making issues (15, 16) and has a special potential in sequential decision-making in the context of healthcare domains (17). The El Farol Bar problem can be seen as a prototypical model of distributed resource allocation in which a given agent's utility depends on the number of other agents who choose to utilize the same resource (18). Most of the literature on the El Farol Bar problem and its derivatives is devoted to the search for decision rules in the use of the resource. Taking a tertiary hospital in China as an example, we focus on the antagonism between demand and supply sides, capturing the influence of medical resources contradiction on people's tendency to seek healthcare in tertiary hospitals combined with the consideration of healthcare quality measured through a composite healthcare payoff index.

## 2. Materials and methods

### 2.1. Data sources

The data used for analysis in this study were collected from two sources. The number of daily outpatient visits to a tertiary hospital for January–December 2020, as well as information on the healthcare quality index, including bed occupancy rate, average stay length of discharged patients, total number of treatments, number of admissions, average daily hospital physician visits, and average daily number of inpatient bed days for hospitalized patients, were collected from Hospital-X, one of the major tertiary hospitals in Zhangzhou, Fujian Province, which integrates medical treatment, teaching, and research. The population migration in this city is relatively low and the choice over healthcare facility for residents is relatively stable, which facilitates the following analysis by excluding spatial factors and is more suitable for analytic structure consequently. The other data source is the Health and Healthcare Development Statistics Bulletin, from which we obtained the national healthcare service data as a complement.

### 2.2. Analysis

#### 2.2.1. El Farol Bar game

We consider a generalized El Farol Bar game which was proposed by Arthur (19) to demonstrate his point that perfect rationality and a logical apparatus have limits in dealing with complicated problems. In this generalized El Farol Bar game, there are  $N$  players. Each player can choose one of the  $k$  actions in the action set  $\{0, 1, \dots, k-1\}$ . Those players who choose action zero always receive a payoff of zero. Player  $i$  who chooses action  $j$  receives a payoff of  $w_{ij}H$ , if the sum of all actions played by the  $N$

players is less than or equal to  $c$ . Otherwise, player  $i$  who chooses action  $j$  receives a payoff of  $-w_{ij}L$ . We assume that  $H > 0$  and  $L > 0$ . The payoffs are summarized in Table 1.

At first, we analyze a multi-player El Farol bar game according to Tirole (20), in which there are  $N$  players and each player assumes that the other player adopts a mixed strategy. Each player maintains a belief probability distribution for the other players with equal weights in order to calculate his/her expected payoff for each action. Specifically, let  $x_i(t)$  be the fraction of time that player  $i$  takes action 1 in time interval  $(0, t)$ , and this information is known to everyone in this game. Each player, except the player  $i$ , believes that player  $i$  adopts a mixed strategy, in which player  $i$  takes action 1 with probability  $x_i(t)$  and action 0 with probability  $1 - x_i(t)$ .

Now, we consider the fictitious play of a specific player  $i$ . Let  $u_{ij}(t)$  denote  $i$ 's expected payoff by taking action  $j$  and  $\{X_1, X_2, \dots, X_N\}$  be a sequence of independent Bernoulli random variables. Specifically,

$$P(X_k = j) = \begin{cases} x_k & j = 1 \\ 1 - x_k & j = 0 \end{cases}$$

The event  $\{X_k = j\}$  denotes player  $i$ 's belief that player  $k$  will take action  $j$  in  $k$ 's mixed strategy. Based on this belief, we can analyze  $i$ 's expected payoff. First, we define  $u_{i,0} = 0$ . In addition,

$$\begin{aligned} u_{i,1} &= HP \left( \sum_{k=1, k \neq i}^N X_k + 1 \leq c \right) - LP \left( \sum_{k=1, k \neq i}^N X_k + 1 > c \right) \\ &= H - (H + L) P \left( \sum_{k=1, k \neq i}^N X_k \geq c \right) \end{aligned}$$

$u_{i,0} \leq u_{i,1}$  if and only if

$$P \left( \sum_{k=1, k \neq i}^N X_k \geq c \right) \leq u \quad (1)$$

where

$$u = \frac{H}{H + L}$$

Clearly,  $u$  is strictly between zero and one. Now, rewrite the condition in Eq. (1). Let  $p = \{1, 2, \dots, N\}$  be the set of all players and  $p_{-i} = \{1, 2, \dots, i-1, i+1, \dots, N\}$  with an exclusion of player  $i$ . Now, consider subset  $S'$  of set  $p_{-i}$ . The number of elements in  $S'$  equals to  $j$ . That is,  $|S'| = j$ . We have

$$\begin{aligned} P \left( \sum_{k=1, k \neq i}^N X_k \geq c \right) &= \sum_{j=c}^N P \left( \sum_{k=1, k \neq i}^N X_k = j \right) \\ &= \sum_{j=c}^{N-1} \sum_{\forall S' \subseteq p_{-i}} \prod_{k \in S'} x_k(t) \prod_{l \in p_{-i}-S'} (1 - x_k(t)) \end{aligned} \quad (2)$$

where the second summation on the right side of Eq. (2) can be evaluated by enumerating all possibilities

$$\sum_{j=c}^{N-1} \sum_{\forall S' \subseteq p_{-i}} \prod_{k \in S'} x_k(t) \prod_{l \in p_{-i}-S'} (1 - x_k(t)) < u \quad (3)$$

Player  $i$  will take action 1 in the fictitious play if inequality (3) holds. We can derive a balance equation for the number of times that action 1 is taken in time interval  $(0, t)$ . Specifically,

$$(t+1)x_i(t+1) = tx_i(t) + I \{u_{i,0}(t) \leq u_{i,1}(t)\}$$

where  $I\{E\}$  is an indicator function of event  $E$ . If event  $E$  occurs,  $I\{E\} = 1$ . Otherwise,  $I\{E\} = 0$ . We can approximate this balance by a differential equation

$$\begin{aligned} \dot{x}_i(t) &= \frac{x_i(t)}{t+1} + \frac{1}{t+1} I \{u_{i,0}(t) \leq u_{i,1}(t)\} \\ &= \frac{x_i(t)}{t+1} + \frac{1}{t+1} I \left\{ \sum_{j=c}^{N-1} \sum_{\forall S' \subseteq p_{-i}} \prod_{k \in S'} x_k(t) \prod_{l \in p_{-i}-S'} (1 - x_k(t)) \leq u \right\} \end{aligned}$$

$i = 1, 2, \dots, N$  is an on-autonomous dynamical system.

Recall that the value of an indicator function is either 1 or 0. Thus, the entries of  $x^*$  are either 1 or 0. Let  $k$  be the number of unity entries in vector  $x^*$ . We can conclude that  $k$  cannot be 0, nor can be  $N$ . Suppose  $k = 0$ , then the  $i$ -th entry of  $x^*$ , denoted by  $x_i^*$ , is  $x_i^* = 0$ . In this case, the product of entries which correspond to any subset of  $p_{-i}$  is zero. Thus, inequality Eq. (3) holds, since  $u$  is strictly between 0 and 1, which implies that  $x_i^* = 1$ , and brings contradictions with the assumption that  $x_i^* = 0$ . In contrast, if  $k = N$ ,  $x_i^* = 1$  for some players, since  $x_i^*$  is an  $N-1$  dimensional vector, it is easy to check that all products on the left side of Eq. (3) are 0, except the product corresponding to the case in which  $j = N - 1$  and  $S' = p_{-i}$  with the product 1. It follows that  $x_i^* = 0$ , which contradicts with the assumption. Thus, we conclude that  $1 \leq k \leq N - 1$ .

Since  $k < N$ , there is at least one unity entry in  $x^*$ . Assume that  $x_i^* = 1$  for some players, it follows that for each player, Eq. (3) must hold and the corresponding indicator function gives the value 1. Thus,

$$\sum_{\forall S \subseteq p_{-i}} \prod_{k \in S'} x_k^*(t) \prod_{l \in p_{-i}-S'} (1 - x_k^*(t)) = 0 \quad (4)$$

or any  $j = \{c, c+1, \dots, N-1\}$ . For Eq. (4) to hold, there must be at least  $(N-1) - c + 1$  zero entries in the vector  $x_i^*$ . Hence,

$$k \leq 1 + (N-1) - (N-1-c+1) = c$$

In contrast, since  $k < N-1$ , there is at least one zero entry in  $x^*$ , thus,

$$\sum_{\forall S \subseteq p_{-i}} \prod_{k \in S'} x_k^*(t) \prod_{l \in p_{-i}-S'} (1 - x_k^*(t)) = 1 \quad (5)$$

there are at least  $c$  unity entries in vector  $x_i^*$ . Suppose that there are  $n < c$  unity entries in  $x_i^*$ , the only nonzero term in the summation on the left side corresponds to the product in which  $j = n$  and set  $S'$  contains exactly the indexes of all the unity entries in  $x_i^*$ . All other values of  $j$  and selections of  $S'$  contribute zero to the sum on the left side of Eq. (5). Since  $x_i^* = 0$ , it follows that

$$k = n \geq c$$

We note that  $x^*$  corresponds to a Nash equilibrium of pure strategies.

Let  $x_{ij} = A_{ij}(t)/t$  for player  $i$  and action  $j$ , while  $X_i$  be a random variable whose probability mass function is

$$P(X_i = j) = A_{ij}(t)/t$$

for  $i = 1, 2, \dots, N$ , and  $j = 0, 1, \dots, k-1$ . To analyze the fictitious play process of this generalized El Farol Bar game, we assume that each player aggregates the belief probability distribution of individual opponents and maintains an aggregated belief probability distribution. For example, player  $i$  maintains the probability mass function of

$$Y_i = X_1 + X_2 + \dots + X_{i-1} + X_{i+1} + \dots + X_N$$

Player  $i$  determines the best action by calculating expected payoffs using the probability mass function of  $Y_i$ . Specifically,  $u_{i,0}(t) = 0$ . Furthermore,

$$\begin{aligned} u_{ij}(t) &= w_{ij}HP(Y_i + j < c) - w_{ij}LP(Y_i + j > c) \\ &= w_{ij}(H + L)\left(\frac{H}{H+L} - P(Y_i \geq c - j + 1)\right) \end{aligned} \quad (6)$$

Denote the probability mass function of  $Y_i$  by

$$y_{ij} = P(Y_i = j)$$

For  $i = 1, 2, \dots, N$  and  $j = 0, 1, \dots, (N-1)(k-1)$ , we rewrite Eq. (6) as

$$u_{ij}(t) = w_{ij}(H + L)\left(\frac{H}{H+L} - \sum_{k=c-j+1}^{(N-1)(k-1)} y_{ik}\right) \quad (7)$$

One can derive a set of balance equations for the number of times that actions are taken by each player. That is,

$$(t+1)x_{ij}(t+1) = tx_{ij}(t) + I\{j = \operatorname{argmax}\{u_{ik}(t)\}\} \quad (8)$$

One can approximate the above set of difference equations by the following system of differential equations:

$$x'_{ij}(t+1) = \frac{-x_{ij}(t)}{t+1} + \frac{1}{t+1}I\{j = \operatorname{argmax}\{u_{ik}(t)\}\} \quad (9)$$

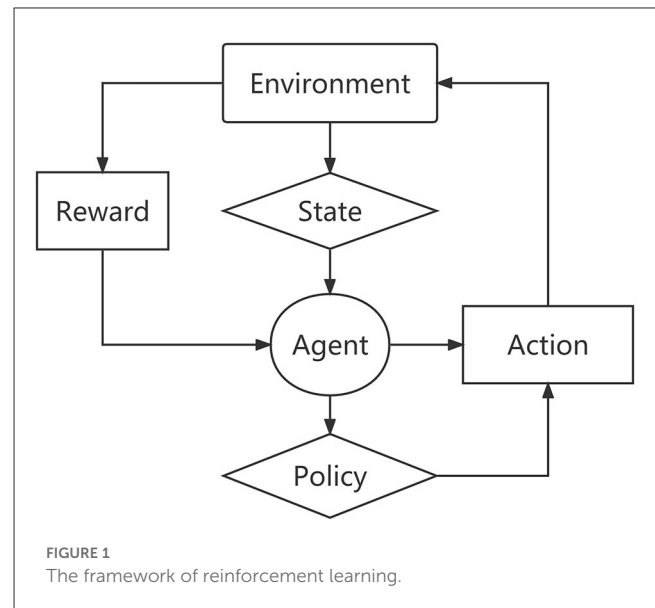
for  $i = 1, 2, \dots, N$ , and  $j = 0, 1, \dots, k-1$ .

Now, we consider the equilibrium point of the system in Eq. 9. For fixed  $i$  and  $j$ , let  $x_{ij}^*$  be the equilibrium point and denote vector  $x_{ij}^*$  as  $\{x_{i,0}^*, x_{i,1}^*, \dots, x_{i,k-1}^*\}$ . Since  $\{x_{ij}(t) : 0 \leq j \leq k-1\}$  is a probability distribution, exactly one indicator function in the set of equations for each specific  $i$  and  $0 \leq j \leq k-1$  is one. Other indicator functions are zero. That is, for each  $i$ , there is an action  $j(i)$  correspondingly. The value of the indicator function corresponding to  $j(i)$  is one and others are all zero. We can construct it as follows:

$$x_{ij}^* = \begin{cases} 1 & j = j(i) \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

Define

$$y_{ij}^* = \begin{cases} 1 & j = j^* \\ 0 & \text{otherwise} \end{cases} \quad (11)$$



where  $j^* = \sum_{k=1, k \neq j} j(k)$ .

Substituting (6) into (1), we can obtain

$$u_{ij}(t) = \begin{cases} -w_{ij}L & c - j + 1 \leq j \\ w_{ij}H & \text{otherwise} \end{cases}$$

It can be seen that  $u_{ij}(t)$  achieves the maximum value when  $j = c - j^*$ . Thus, we have

$$j(1) + j(2) + \dots + j(N) = c \quad (12)$$

Eq. (12) corresponds to a Nash equilibrium of fixed strategies.

Here, we can see that the bar problem is very similar to the scenario of a patient going to a hospital for treatment. Each hospital has a certain capacity limit. When the number of patients exceeds a certain level, each patient will receive medical benefits less than the normal, which brings the mindset that it is difficult to access healthcare for the public. To clarify this problem, we apply a dual-game model consisting of hospital-pharmacy and hospital-patient to reflect the existence of healthcare access problem for the local population.

## 2.2.2. Reinforcement learning

Reinforcement learning is a branch within machine learning that is adept at controlling an individual that can act autonomously in a given environment and continuously improve its behavior by interacting with the environment. Reinforcement learning problems include learning what to do and how to map the environment into actions to maximize reward (21). In this article, we introduce reinforcement learning to solve the game problem.

Reinforcement learning consists of an agent, an environment, a state, an action, a reward, and a policy (22, 23). As shown in Figure 1, the strategy determines the agent's behavior at a given time, thereby mapping the current state of the environment into actions that correspond to a set of the so-called stimulus-response rules in psychology.

Specifically, the reinforcement learning elements can be expressed as:

$$D = \{S, A, Q, D, \gamma\}$$

where  $S$  is the state set space;  $A$  is the set space for actions;  $R$  denotes the reward obtained by the agent after taking action according to the state;  $P$  is the transition probability matrix of state action;  $\gamma$  denotes the return discount rate, and the value is between 0 and 1.

Suppose the sequence generated by the interaction between the agent and the environment is:

$$\tau = \{s_0, a_0, r_0, s_1, a_1, r_1, \dots\}$$

The return of the agent at time  $t$  is  $r_t$ , and then the total return after time  $t$  is

$$G_{t=0:T} = R_t = r_{t+1} + r_{t+2} + \dots + r_T$$

Definitely, the strategy is the mapping of the action probability distribution  $\pi(a|s)$  of each state  $s \in S$  and action  $a \in A$ , that is, the probability of the agent taking action  $a$  in state  $s$  is

$$\pi(a|s) = p(A_t = a | S_t = s), \exists t$$

Therefore, given the initial state distribution  $\rho_0$  and the strategy  $\pi$ , the probability of occurrence of a  $T$ -step trajectory  $\tau$  in the Markov process is

$$p(\tau|\pi) = \rho_0(S_0) \prod_{t=0}^{T-1} p(S_{t+1}|S_t, A_t) \pi(A_t|S_t)$$

Finally, expected return  $J(\pi)$  can be defined as

$$J(\pi) = \int_{\tau} p(\tau|\pi) R(\tau) = \mathbb{E}_{\tau \sim \pi} [R(\tau)]$$

Here,  $R$  denotes the reward function;  $p(\tau|\pi)$  indicates the probability of occurrence of the trajectory. Reinforcement learning can maximize returns by optimizing strategies and then solve the above game problems.

## 2.2.3. Dual-game model approach to healthcare-seeking behavior analysis

As the basic component of this dual-game model, we have a need to depict the hospital-pharmacy game at first. We set the probability of going to a hospital as  $p_0$  and the payoff  $E$  in the situation, while the probability of going to a pharmacy as  $1 - p_0$  and the payoff  $e$ . Then, we set the payoff as 0 for the case of neither going to a hospital nor a pharmacy and the payoff as  $E + e$  for the case of both going to the pharmacy and hospital. The expected payoff  $E$  is determined by the El Farol game model, where the initial probability in the model is  $p_0$ . Thus, the expected payoff equation in the El Farol game model will become an important parameter of the hospital-pharmacy model. At the same time, these two game models are not independent but interrelated. As demonstrated earlier, the hospital-pharmacy model is based on the underlying game theory model, and we will focus our research on hospital-patient game.

In reality, data on the “difficulty of healthcare accessibility” has a time-dimension feature. Thus, for each day, each individual who has a latent need for medical treatment is involved in a “hospital-patient” game. Notably, we need to make some reasonable assumptions about our model. First, we define the optimal number of hospital visits as  $c$ . Second, we define the probability  $p$ , which represents the probability that a patient believes the current number of hospital visits is less than the optimal number  $c$ . Third, the probability  $p$  is updated for each patient based on previous hospital visits for a day or some days. For the update method here, we apply Markov decision processes (MDPs), which can be simply expressed as  $M = \{S, A, R, w\}$ , where

1. The set  $S$  is the set of probabilities  $p$ .
2. The set  $A$  is the set of finite actions; here, we set it as the patient's self-predicted behavior after viewing previous experience. The behavior here is mainly for the patient to self-renew “the probability of receiving good treatment at the hospital.”
3. The set  $R$  represents the immediate reward of a patient taking an action (i.e., reward).  $R$  is set to 0 and 1; 1 represents the number of hospital visits less than the expected number of patients, and 0 is the opposite.
4.  $w$  is denoted as the learning rate.

We introduce the concept of discount rate into this function so that the reward returned from future states is multiplied by this discount coefficient. This implies that the present reward is more important than the reward returned in the future, which is also more intuitive. Finally, we can write the whole system of MDPs as the following two equations:

A balance equation is

$$p_t = (1 - \omega)p_{t-1} + \omega \times R \times I\{Action_t\} \quad (13)$$

where  $p_{t-1}$  denotes the probability of choosing to go to the hospital at time  $t - 1$ ;  $Action_t$  and  $p_t$  express the action and the probability of choosing to go to the hospital at time  $t$  separately.

For the balance equation, we need to obtain an expression for its convergence to a steady state. Since the event  $S$  is probabilistic events, it satisfies the basic requirements of probability. We assume that the initial probability  $p_1 = p$ , then

$$\begin{aligned} p_2 &= (1 - \omega)p + \omega \times R \times I\{Action_2\} \\ p_3 &= (1 - \omega)p_2 + \omega \times R \times I\{Action_3\} \\ &= (1 - \omega)^2 p + (1 - \omega) \times \omega \times R \times I\{Action_2\} \\ &\quad + \omega \times R \times I\{Action_3\} \\ &\vdots \\ p_t &= (1 - \omega)^{t-1} p + (1 - \omega)^{t-2} \times \omega \times R \times I\{Action_2\} + \dots \\ &\quad + \omega \times R \times I\{Action_t\} \end{aligned}$$

Therefore, we can determine the range of  $p_t$  as follows:

$$\begin{aligned} p_t &= (1 - \omega)^{t-1} p + (1 - \omega)^{t-2} \times \omega \times R \times I\{Action_2\} + \dots \\ &\quad + \omega \times R \times I\{Action_t\} \\ p_t &\geq (1 - \omega)^{t-1} p \\ p_t &\leq (1 - \omega)^{t-1} p + (1 - \omega)^{t-2} \omega + \dots + \omega \\ &= (1 - \omega)^{N-1} p + \omega \frac{(1 - (1 - \omega)^{t-1})}{1 - (1 - \omega)} \\ &= 1 - (1 - \omega)^{t-1} (1 - p) \\ &\leq 1 \end{aligned}$$

TABLE 1 Payoffs of a generalized El Farol Bar game ( $H > 0$  and  $L > 0$ ).

Actions	Payoffs if the sum of actions is less than or equal to $c$	Payoffs if the sum of actions is greater than $c$
0	0	0
1	$w_{ij}H$	$-w_{ij}L$

TABLE 2 Change in  $p$ -value in emergency situations for 12 months.

Month	Update $p$ -value (average)	Month	Update $p$ -value (average)
Jan	0.968	Jul	0.813
Feb	1	Aug	0.806
Mar	0.994	Sep	0.9
Apr	0.993	Oct	0.845
May	0.9613	Nov	0.827
Jun	0.82	Dec	0.845

The other equation is the expected payoff equation:

$$E = Hp - L(1 - p) \quad (14)$$

Recall that a “hospital–patient” game with  $N$  players. Each player can choose one of the two actions: 0 or 1. A patient who chooses the action “not see a doctor” always receives a payoff of 0. If a patient chooses the action “see a doctor”, then the payoff he or she receives depends on the sum of the actions of all patients. If the sum is less than or equal to  $c$ , the player receives a payoff of  $H$ . Otherwise, the player receives a payoff of  $L$ . We assume that  $H > 0$  and  $L > 0$ . The notation used throughout the main text is summarized in [Supplementary Table S1](#).

## 3. Results

### 3.1. Emergency situation

The outpatients are usually separated into emergency and general outpatients according to the emergency degree. Emergency care, which is intended for patients who are in critical illness, deserves prioritization in life-saving treatments (24) and in medical resource allocation, it is significantly different from the general situations, which requires us to analyze these two different situations separately. Here, we carry on the analysis of emergency outpatients at first. Due to the specificity of emergency patients, we chose  $p = 1$  and one observation day for model analysis, and we also chose the average daily number of emergency outpatients in Hospital-X as the threshold value. The experimental results are shown in [Table 2](#).

We can find that the variation of  $p$  for emergency situations ranges between 0.8 and 1, with an average value of 0.897, demonstrating the insufficiency of healthcare resources impeded healthcare accessibility for emergency outpatients for many months, while the willingness for individuals seeking urgent healthcare services to a tertiary hospital remained close to 1. Here again, as the emergency model is a special case of the outpatient

TABLE 3 The overall situation with probability under changed observation days.

Day(s) of observation	The mean probability	Number of days with $p$ greater than 0.5 ( $n = 366$ )	Percentage of days with $p$ greater than 0.5 ( $n = 366$ )
1 day	0.481	149	0.408
2 days	0.467	149	0.408
3 days	0.455	139	0.381
4 days	0.446	116	0.318
5 days	0.439	116	0.318
6 days	0.433	97	0.266
7 days	0.428	94	0.258

model, and the volume of outpatient care is much higher than that of emergency for the main body of hospital operations, we will focus on the outpatient model in the following sections.

### 3.2. Balance equation

#### 3.2.1. Overall analysis

We used the daily number of visits to Hospital-X in 2020 for analysis. First, we set the threshold  $c = 1,250$  based on the average number of daily visits in 2020 (mean: 1,238.88). Second, we chose the learning efficiency as 0.2. Third, we set the initial value of probability  $p$  as 0.5 according to our selection of different observation strategies for the updated  $p$ -value. Finally, we obtained the  $p$ -value change in 2020 (refer to [Table 3](#)).

In [Figure 2](#), we can see that when the observation strategy is  $>3$  days, the change in the probability  $p$  of patients perceiving the number of hospital admissions to be less than the limit  $c$  shows the same trend. Therefore, in our subsequent simulations and studies, we will select the three strategies for the observation of 1, 2, and 3 days as the main object of analysis. Here, we choose to analyze the overall situation with the specific values presented in [Table 3](#). We can also see that in 2020, with the increase in the number of days in the observation strategy, the average value and the trend of  $p$  obviously show a decreasing trend (refer to [Figure 3](#)).

Simultaneously, the number of days with a probability  $p$  greater than 0.5 also shows an obviously decreasing trend. Moreover, we find that regardless of the number of observation days, the number of days with a probability  $p > 0.5$  does not exceed 180 days. As such, we found that under the current conditions, the public does not show optimism about good access to healthcare, which reflects the public's perception of difficulty in healthcare access. In addition, we found that people are not optimistic about good access to healthcare under the current conditions, which reflects the “difficulty of healthcare accessibility”. Simultaneously, we found that when people receive more information about medical care, it will aggravate their perception of the difficulty in healthcare accessibility.

Consider the fact that physician-specific aspects are usually outstanding in the field of most valuable considerations for patients





FIGURE 2

The probability that a patient believes the current number of hospital visits is less than the threshold under changed strategies.

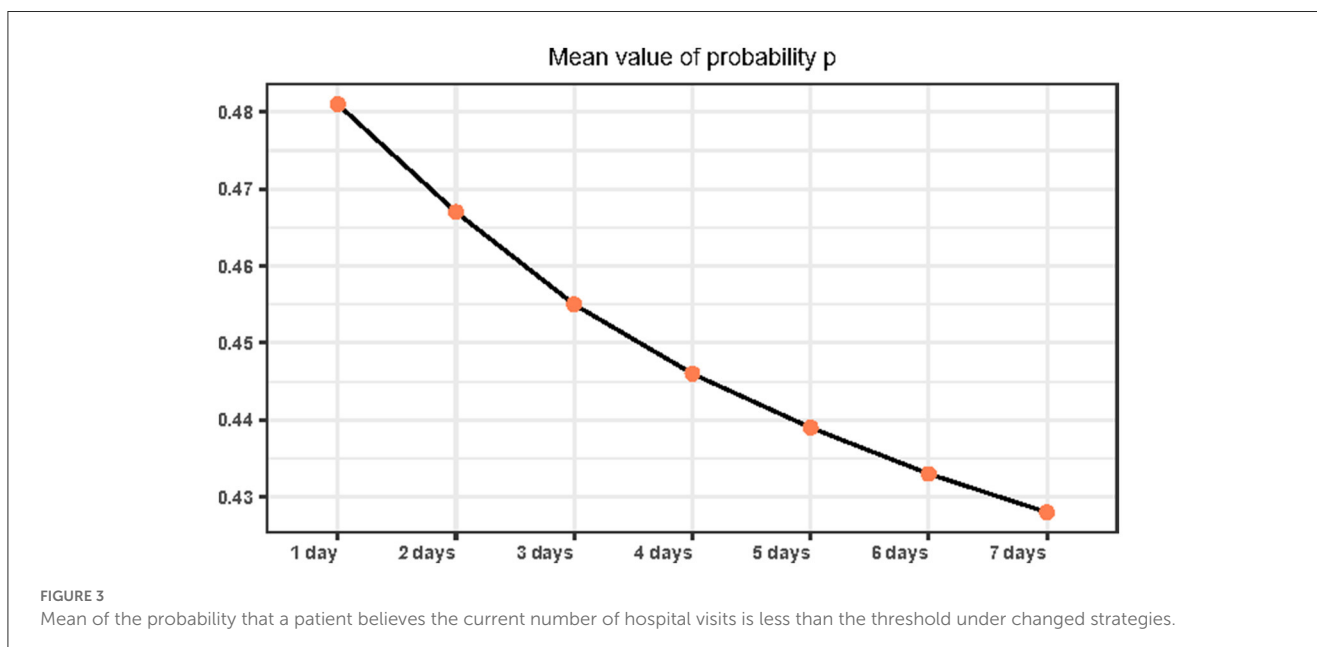


FIGURE 3

Mean of the probability that a patient believes the current number of hospital visits is less than the threshold under changed strategies.

(25). As the physician scheduling is usually fixed by the day of the week for outpatient services in China, especially for specialists, here outpatient numbers on different days of the week are extremely heterogeneous with respect to physician scheduling. As shown

in [Supplementary Table S2](#), compared to weekends, the weekdays are more likely to be overwhelmed with heavy outpatient loads and bring down the belief probability of receiving a preferred health service. Moreover, we can find heterogeneity even within the

TABLE 4 The variation pattern of final  $p$ -value for 3 days.

Original	Update $p$ -value (average)	Rate of change
0.3	0.353	18%
0.4	0.404	1%
0.5	0.455	−9%
0.6	0.506	−16%
0.7	0.557	−20%

TABLE 5 The variation pattern of final  $p$ -value for 7 days.

Original	Update $p$ -value (average)	Rate of change
0.3	0.386	29%
0.4	0.407	2%
0.5	0.428	−14%
0.6	0.449	−25%
0.7	0.470	−33%

workdays, and the lowest belief probability comes on Monday as most specialists are scheduled and there is a surge in demand due to the weekend accumulation.

### 3.2.2. Setting of initial $p$ -value

According to the above analysis, we can find that the  $p$ -value decreases with observation days and needs detailed discussion. Here, we set a range of values from 0.3 to 0.7 as initial  $p$ , and observe the changes in our model at different  $p$ -value sets. First, we set  $p = [0.3, 0.7]$  and three observation days with a learning coefficient of 0.2 to observe the variation pattern of the final  $p$ -value. Second, we set  $p = [0.3, 0.7]$  and seven observation days with a learning coefficient of 0.2 to observe the variation pattern of the final  $p$ -value. The specific data are shown in Tables 4, 5.

We can see an interesting phenomenon from the above two sets of data. The value after updating will become higher than the initial value by our updating algorithm when  $p < 0.5$ , while the contrary happens when  $p \geq 0.5$ . Moreover, the adjustment amplitude is smallest at the set of  $p = 0.4$ , and the further away from 0.4, the greater the adjustment amplitude is. Furthermore, we approached the Nash equilibrium point infinitely by Newton's method to be 0.41. Meanwhile, the more observation days and the more information obtained in our set, the greater the  $p$ -value changes after the update.

### 3.2.3. Discount rate

Our goal is to measure the difficulty of healthcare accessibility and provide evidence for improving the status. As such, we need to consider the impact of past experiences on the probability  $p$  at first and we changed the discount rate to observe the trend of the mean probability  $p$ . According to the previous data analysis, three observation strategies of 1, 3, and 5 days and a threshold  $c$  of 1,250 were selected for further analysis.

According to Eq. (6), we can find that the influence of action will become more important as the discount rate increases, which makes the objective factors play a dominant role. First, we start with the threshold  $c = 1,250$  when the population observes that hospital visits are more stressful than relaxing. In this condition, the mean value of  $p$  shows a decreasing trend with an increase in the discount rate. The strategy of observing 1 day was most significantly affected by the discount. Simultaneously, we find that when the discount rate  $\gamma$  increases, the discount rate of the strategy of observation days becomes less pronounced and the final  $p$ -means will tend to be the same, as shown in Figure 4A.

Statistics for the number of days with a probability  $p > 0.5$  show some interesting scenarios (refer to Figure 4B). With  $\gamma = 0.5$  as the dividing line, the number of days with probability  $p > 0.5$  shows an inverse effect as the number of days in the observation strategy increases when  $\gamma < 0.5$ . Under the situation of  $\lambda > 0.5$  and objective factors appearing in a dominant position, we find that the observation strategy will not affect the statistic of the number of days with a probability  $p > 0.5$ .

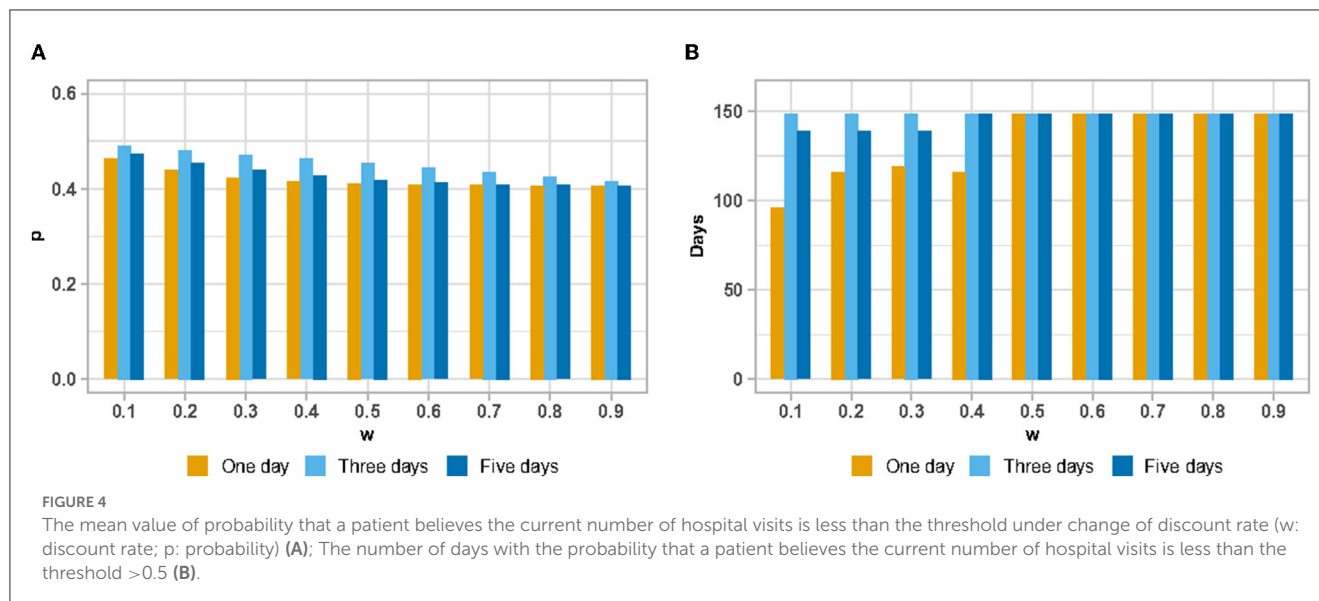
### 3.2.4. Threshold value

The second idea was to increase the capacity of the hospital, which we hoped would relieve the difficulty of healthcare accessibility for the whole population. Therefore, we changed the value of the threshold  $c$  to observe the trend of the mean probability  $p$ . Based on the previous data analysis, three conditions were selected to observe 1, 2, and 3 days, with a discount rate of 0.2. Based on the results of the processing presented in Figure 5, we can find that the trend of the entire probability  $p$  divided into two main phases, which are the two parts of the threshold  $c < 1,350$  and  $> 1,350$ .

The point where the threshold  $c = 1,350$  is of great importance obviously. By analyzing the number of hospital visits in 2020, we found that 1,350 was the median number of hospital visits. In addition, we found that when choosing threshold  $c$  as 1,350, the mean value of  $p$  obtained was 0.5 regardless of the strategy chosen by the patient. This suggests that the median number of hospital visits is an important influencing parameter under this update function. However, it is difficult for patients to obtain this data.

When the threshold  $c < 1,350$ , the number of days that the population observes hospital visits exceeding the threshold  $c > 180$  days, indicating that the population believes the overall medical resources are showing saturation. At this point, as the amount of information available to the public increases, it makes the public present a less optimistic mindset about access to care. Despite this state of affairs, the direct difference between these strategies is not significant, indicating that people maintain their confidence in going to the hospital despite the notion of the difficulty in healthcare accessibility, which is also reflected in the expected payoff equation later.

When the threshold  $c > 1,350$ , the public observes that the number of hospital outpatient clinics is tight for  $< 180$  days, indicating that the overall medical resources are not saturated. At this time, with an increase in the amount of information available to the public, the public is optimistic about the medical treatment situation and tends to increase optimism rapidly. The main reason



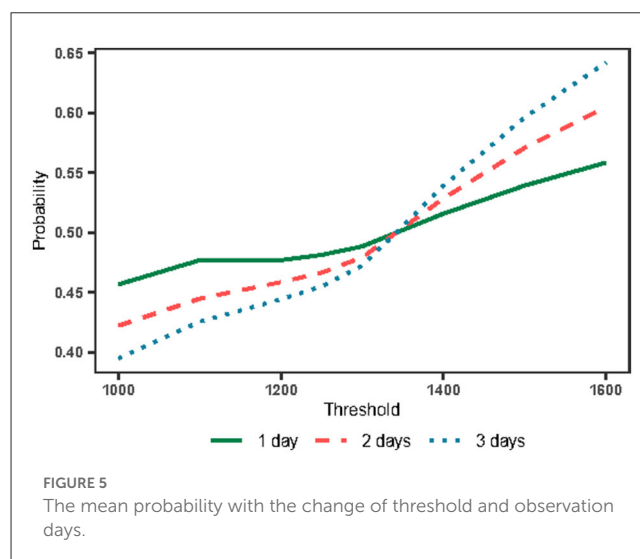
for this phenomenon is that an increase in the threshold  $c$  increases the number of consecutive days when medical resources are abundant. Thus, it is easier to accumulate the confidence value as the number of days under observation increases.

Notably, increasing the threshold value  $c$  (i.e., the capacity of hospitals) can reduce the difficulty of healthcare accessibility. However, we cannot increase hospital access indefinitely for two main reasons. First, the hospital–patient game was built on the basis of analysis of the minority (patients). When the probability increases, it will lead to a larger number of patients' inrush, which will probably make the number of visits exceed the threshold, thereby destroying the system's equilibrium successively. The second reason is the cost constraints of the hospital itself.

### 3.3. Expected payoff equation

We explored the balance equation in previous sections and now we need to analyze the other core equation, i.e., the expected payoff equation Eq. (14). The most central part of the expected payoff equation is the setting of the payoff  $H$  and  $L$ . Here, we use two major classes of eight items to construct an evaluation index system to comprehensively quantify the expected payoff. The measure of payoff  $H$  includes four indicators, including the number of beds, bed utilization rate, average number of consultations per day, and inpatient beds, while the measure of payoff  $L$  includes total number of consultations, number of hospital admissions, average disposable income, and average hospitalization days of discharged patients.

According to the impact and importance brought by each indicator, we calculated the composite index of healthcare payoff for each indicator *via* the aggregative indicator method. The final data are presented in Table 6. By calculating the resulting payoff  $H$  and  $L$  through the aggregative indicator and combining the results of our previous calculations about the probability  $p$ , we can obtain the trend of the core expected payoff. Here, we select three cases of observation strategy (1 day, 2 days, and 3 days, respectively) for



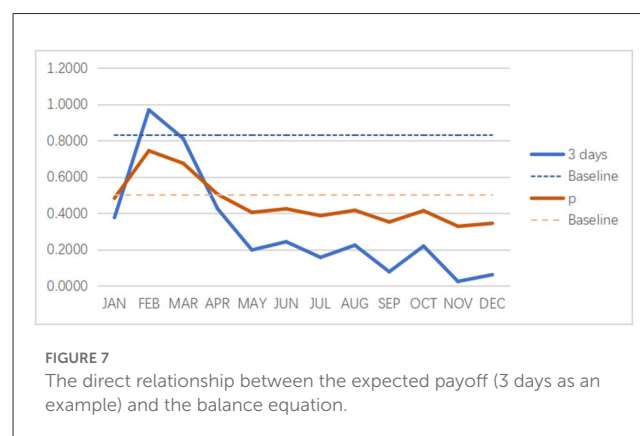
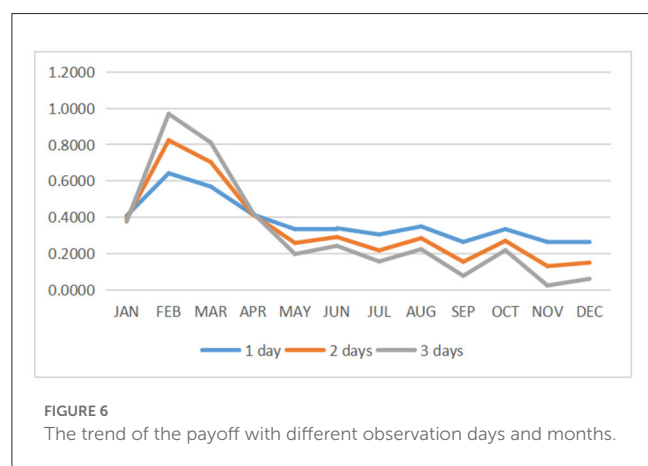
analysis (refer to Figure 6). From the overall trend, we can see that the expected payoff for all three cases (i.e., from 1 to 3 days) is  $>0$ , which indicates that the hospital has brought good payoffs to the people and increased the confidence of visiting the hospital.

By looking at the data throughout 1 year, it is observed that people have higher payoffs between January and March, which is due to the fact that the hospital is not saturated during these months (i.e., the “difficulty of healthcare accessibility” phenomenon is not serious). However, people's expectations of hospital revenue tend to be close to 0 from October to December. In addition, the expectations remain positive, which indicates that people are clearly feeling the pressure to get medical treatment with satisfaction.

We use  $p = 0.5$  as the baseline and observe the direct relationship between the expected payoff equation and the balance equation (refer to Figure 7). We take three observation days as the analysis time period. First, we can find a positive correlation

TABLE 6 The composite measure index for healthcare.

Payoff category	Indicators	National data	Instance data	Evaluation standard value	Comprehensive index	Payoff
H	Number of Beds	1,002	1,200	1.2	1.98	1.55
	Bed utilization rate	81.50%	64.63%	0.79	2.07	
	Average number of consultations per day	6.3	5.47	0.87	1.32	
	Inpatient number per day	2.1	2.9	1.38	−3.81	
L	Total number of consultations	600,801	499,438	0.83	1.69	−0.72
	Number of hospital admissions	31,285	38,775	1.24	−2.39	
	Average disposable income	32,189	30,949	0.96	−0.39	
	Average hospitalization days of discharged patients	8.6	8.28	0.96	0.37	



between the two equation values. Second, we find that a slight change in the  $p$ -value causes a significant change in the final result of the expected payoff equation, especially from August to December.

## 4. Discussion

The main purpose of this study was to investigate how the inclination of individuals seeking healthcare services is influenced by previous attendance to tertiary hospitals where the mismatch between supply and demand sides is especially prominent due to absolute or relative inadequacy of medical resources. The research on the problem of healthcare service has drawn extensive attention, models of patients, patients and doctors, and hospitals and related sectors have been widely discussed. The most grim reality in China is “difficult and expensive to seek medical services”, and patients are directly faced with medical institutions and the supplied medical services. Therefore, this study takes patient and tertiary hospital as the main object of analysis, taking into consideration of crowding and medical service level, and aims to find out the mismatch which causes patients’ intuitive feeling of difficulty in seeking medical treatment.

Populations’ access to healthcare is extensively addressed by the public and policymakers, with a focus on equity and efficiency. As a complex and multi-factorial construct, access to healthcare has been validated in numerous studies considering healthcare systems, socioeconomic status, and resource allocation, which have generated distinct perspectives of accessibility to healthcare. Globally, healthcare accessibility is a major concern for the public and policymakers. Healthcare accessibility mainly depends on the availability and affordability of healthcare services (26), and in turn, it influences people’s psychology and behavior choice in healthcare seeking. Populations do not act through straight rational algorithms, but their decision might reflect aspects that are in contradiction with cost and benefit. As a particular action is a function of the two interacting variables, i.e., perceived benefits and perceived losses, a bad experience will increase the cost under given benefits brought by healthcare attendance in non-emergent situations.

Although health outcomes have improved in the past several decades, China, as one of the middle-income countries with a large amount of population, is faced with a contradiction between resource-constrained settings in medicine and changing health needs as well as growing public expectations, posing challenges for the public getting approach to healthcare services (4). Since the establishment of the People’s Republic of China in 1949, China’s

healthcare system has undergone several transformations with the aim of ensuring that all sectors of society have equal and adequate access to primary healthcare, regardless of socioeconomic and geographical factors. However, existing studies suggest that most people in China believe that the system is unequal and that wealthy people and those living in cities enjoy much greater access to care than poor and rural residents in the country (12). One of the greatest challenges faced by the Chinese medical system is the highly concentrated allocation of supply-side resources at tertiary public hospitals. Compared to primary healthcare institutions, tertiary hospitals are usually well-equipped with advanced facilities and well-trained specialists (27), resulting in overwhelming workloads and long-waiting lines, which bring challenges to equality and efficiency of health resource allocation and health service utilization (28).

Different from situations in an emergency, the results show that by calculating the probability, outpatients in general situation are not overly optimistic about having good access to healthcare, which reflects the sentiment of “difficulty for healthcare accessibility”. Simultaneously, we found that when people receive more information about medical care, the perception of difficulty for healthcare accessibility will be aggravated. Second, the probability analysis reveals the basic beliefs of the public. Although they believe that the current medical efficiency is controversial and that it is difficult to access medical care, the overall efficiency of visiting the hospital is considered good. However, the overall positive benefit leads to people being more willing to visit a hospital, thereby increasing the burden on hospitals and further causing the probability to tend toward 0. The two aforementioned points jointly explain the phenomena of difficulty for healthcare accessibility from the patient’s perspective.

Technological advances make it possible to get online hospital appointments for residents. Now, most of the tertiary hospitals in China use a hierarchical diagnosis and treatment system and most people arrange their attendance time at the hospital based on the arrangement through the online system. Considering the emergency degree with healthcare, there is a prioritization in life-saving treatments and medical resources allocation for emergency care, and the emergency outpatient departments are usually independent of the general outpatient departments to improve the efficiency of medical treatment. However, the overburdened workforce and equipment, as well as limited admission time caused by absolute or relative medical resources insufficiency, remain access barriers to healthcare services, further affecting patients’ choice for healthcare resources utilization to a great extent. Compared to other countries, residents in China usually seek medical treatment by going to a pharmacy or hospital, not their family doctor when he or she is ill, and there appears another choice in healthcare-seeking behavior. The ranking of global medical quality shows that China has been one of the countries with the largest improvement in the quality of medical care from 1990 to 2015. The gap index in the quality of inter-regional medical services in China also narrowed (29).

Gaps in health-related investment and investment-output efficiency are also reflected in human resources for medical care, which are clearly a prerequisite for health care, with most medical interventions needing the services of doctors, nurses, or other types of health workers. The global shortfall in healthcare workers

will reach 12.9 million by 2035 (30), resulting in shortages of medical personnel for hospitals, and the shortage of healthcare professionals is even more acute in China (31). The scarcity of available physicians, especially specialists, forces managers to focus on their daily scheduling and work time. Meanwhile, physician-specific aspects are usually outstanding in the field of most valuable considerations for patients (25), so another contradiction arises. As the physician scheduling is usually fixed by the day of the week for outpatient services in China, the outpatient numbers on different days of the week are extremely heterogeneous, consequently, resulting in another presentation of inequality and insufficiency.

Minimizing difficulty in healthcare accessibility helps to close the gaps for the public in healthcare seeking, and many new methods have been developed to improve such measures. Accessibility and satisfaction related to healthcare services are conceived as multidimensional concepts (4). Moreover, the selection of an appropriate model must be based on an analysis of real-world healthcare utilization behavior. When dealing with healthcare, it is important to consider the differences in each hospital or criterion. Based on the indicators adopted by other scholars and the concerns of this study, the indicators were selected from the following three aspects: outpatient services, inpatient services, and bed utilization (7, 32–34). Detailed information is included in the healthcare payoff indicator (e.g., information regarding healthcare staff qualities, quality of interaction, or helpfulness). All of these different characteristics could generate a more integral perspective of accessibility to healthcare. It is also important to mention that we generalized the concept of healthcare service supply in our study to consider the patients receiving services.

Ultimately, we used game theory to explore and solve the dilemma of difficulty for healthcare accessibility. However, we found that solving this phenomenon is not simple. Access to medical care involves a combination of a series of factors, and any change in the healthcare system has an effect on two sides. Good healthcare access and high quality of care will bring a good attendance experience and improve the actual payoff, followed by a demand increase and supply burden on hospitals, which will lower down attendance experience and tend to a new equilibrium state only if the medical resources with high quality are saturated compared to demand. The role of the regulating side appears fundamental for solving this problem, which requires stakeholders to work together, coordinate arrangements, and allocate medical resources to meet basic medical demands for residents. Based on the current situation, strengthening health education and improving the health status of residents (35), strengthening the primary care system and promoting the utilization of primary care, implementing hierarchical diagnosis and treatment, reasonably diverting the demand for medical services (3), and rationalizing the leveraged adjustment mechanism of medical insurance (36) are the main directions to solve this problem.

We chose a combined method of El Farol Bar problem and reinforcement learning to get an overview of this problem. The methodology described in this study enables us to interpret the mismatch between supply and demand sides in the face of complex interaction models and help resource allocation from the perspective of regulating side as well. Moreover, the expected payoff equation is sufficient to combine the quality of medical service



into the model. In fact, the results provided particular evidence on such a question overall and this method proved to be applicable in the analysis of such situations, which can be used to conduct further research on resource management. Our illustration of this methodology in the context of difficulty for healthcare access led to several key findings. First, the population is not optimistic about going to a tertiary hospital for medical treatment overall despite the efforts devoted to promoting healthcare accessibility. Second, there is an obvious mismatch between supply and demand sides from the analysis of the data, which needs further efforts from the regulating side. Third, the expected payoff based on healthcare quality released an optimistic signal about healthcare services. Finally, the main strength of the present study lies not only in its contribution to the fundamental evidence on the contradiction between supply and demand sides of healthcare but also provides the development of mixed-method approaches with a dual-game model that incorporate concepts and techniques from different perceptions. Limitations exist in our current model, which provides directions for our future study. First, as the region where the research object is located has implemented a hierarchical diagnosis and treatment system, there is no significant difference in waiting time, so we did not take this factor into account in the model. Second, financial status and transportation problems are also prominent considerations for healthcare choice. However, the coverage of universal medical insurance reduces the financial barriers to a large extent, the migration in this city is relatively low, and the choice of healthcare facility for residents is relatively stable, which facilitate the analysis with the given model. Third, the model gives consideration to both demand and supply sides, and both players might have incomplete and/or imperfect information. In future study, we will measure the waiting time for medical treatment through questionnaires and on-site traffic statistics considering the other hospitals of different levels and apply our model in different medical specialties further.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

Conception or design of the study, validation, and critical revision of the article: MZ. Methodology: WW. Software: YC. Data

analysis and interpretation: WW and FW. Drafting the article: FW. All authors contributed to the article and approved the submitted version.

## Funding

The study was funded by the Major project of the National Social Science Foundation (20&ZD137).

## Acknowledgments

The study gratefully acknowledges the financial support provided by the Major project of the National Social Science Foundation (20&ZD137).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## Author disclaimer

The views expressed in this article are those of the authors and do not reflect the position of any institution or government.

## Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2023.1078675/full#supplementary-material>

## References

- Li X, Lu J, Hu S, Cheng KK, De Maeseneer J, Meng Q, et al. The primary health-care system in China. *Lancet*. (2017) 390:2584–94. doi: 10.1016/S0140-6736(17)33109-4
- Pan J, Wei D, Seyler BC, Song C, Wang X. An External Patient Healthcare Index (EPHI) for Simulating Spatial Tendencies in Healthcare Seeking Behavior. *Front Public Health*. (2022) 31:786467. doi: 10.3389/fpubh.2022.786467
- Li G, Li Z, Wan H. Analysis and suggestions on unreasonable admission from the perspective of game theory. *China Health Quality Management*. (2022) 29:25–8.
- Chen X, Qian X. *Overview of Healthcare System in China*. Quality Spine Care. Cham: Springer (2019).
- Yang GH, Wang Y, Zeng YX, Gao GF, Liang XF. Rapid health transition in China, 1990–2010: findings from the global burden of disease study 2010. *Lancet*. (2013) 381:1987–2015. doi: 10.1016/S0140-6736(13)61097-1
- Liu GG, Vortherms SA, Hong X. China's health reform update. *Annu Rev Public Health*. (2017) 38:431–48. doi: 10.1146/annurev-publhealth-031816-044247

7. Yu BH, Wang T, He CA. Study on measuring the efficiency of China's health care service system based on three-stage DEA. *Manage Rev.* (2021) 33:120–9. doi: 10.14120/j.cnki.cn11-5057/f.20210616.007
8. *China Health Statistical Yearbook.* (2021). Available online at: <https://data.cnki.net/Yearbook/Single/N2021020144> (accessed June 9, 2022).
9. *Statistical Bulletin on the Development of Health Care in China in 2020.* (2021). <https://data.cnki.net/Yearbook/Single/N2021020144http://www.nhc.gov.cn/guihuaxxs/s10743/202107/af8a9c98453c4d9593e07895ae0493c8.shtml> (accessed June 10, 2022).
10. Pan J, Liu GG, Gao C. How does separating government regulatory and operational control of public hospitals matter to healthcare supply? *China Econ. Rev.* (2013) 27:1–14. doi: 10.1016/j.chieco.2013.07.002
11. Eggleston K, Li L, Meng Q, Lindelow M, Wagstaff A. Health service delivery in China: a literature review. *Health Econ.* (2008) 17:149–65. doi: 10.1002/hec.1306
12. Shi L, Lee DC, Liang H. Community health centers and primary care access and quality for chronically-ill patients – a case-comparison study of urban Guangdong Province, China. *Int J Equity Health.* (2015) 14:90. doi: 10.1186/s12939-015-0222-7
13. Heydari M, Lai KK, Fan Y, Li XA. Review of emergency and disaster management in the process of healthcare operation management for improving hospital surgical intake capacity. *Mathematics.* (2022) 10:2784. doi: 10.3390/math10152784
14. Ell K, Castañeda I. Health Care Seeking Behaviour In: S Loue, editor. *Handbook of Immigrant Health.* Boston, MA: Springer (1998).
15. Madeo D, Mocenni C, Palma G, Rinaldi SA. Game theory proof of optimal colorings resilience to strong deviations. *Mathematics.* (2022) 10:2781. doi: 10.3390/math10152781
16. Cao B, Zhang Q, Cao M. Optimizing hybrid-channel supply chains with promotional effort and differential product quality: a game-theoretic analysis. *Mathematics.* (2022) 10:1798. doi: 10.3390/math10111798
17. Tang SP, Wiens J. Model selection for offline reinforcement learning: Practical considerations for healthcare settings. *Machine Learning Healthcare Conference PMLR.* (2021) 149:1–34.
18. Schosser J. Fairness in the use of limited resources during a pandemic. *PLoS ONE.* (2022) 17:e0270022. doi: 10.1371/journal.pone.0270022
19. Arthur WB. Inductive reasoning and bounded rationality. *Am Econ Rev.* (1994) 84:406–11.
20. Tirole J. *The Theory of Industrial Organization.* New York, NY: MIT Press Books (1988).
21. Fudenberg D, Levine DK. *The Theory of Learning in Games.* New York, NY: MIT Press Books (1988).
22. Hopkins E. Two competing models of how people learn in games. *Econometrica.* (2006) 70:2141–66. doi: 10.1111/j.1468-0262.2002.00436.x
23. Erev I. How people play games: reinforcement learning in experimental games with unique, mixed strategy equilibria. *Am Econ Rev.* (1998) 88:848–81.
24. Schell CO, Gerdin Wärnberg M, Hvarfner A, Höög A, Baker U, Castegren M. The global need for essential emergency and critical care. *Crit Care.* (2018) 22:284. doi: 10.1186/s13054-018-2219-2
25. Erhard M, Schoenfelder J, Fügner A, Brunner JO. State of the art in physician scheduling. *Eur J Oper Res.* (2018) 265:1–18. doi: 10.1016/j.ejor.2017.06.037
26. Cabrera-Barona P, Blaschke T, Kienberger S. Explaining accessibility and satisfaction related to healthcare: a mixed-methods approach. *Soc Indic Res.* (2017) 133:719–39. doi: 10.1007/s11205-016-1371-9
27. Yip W, Hsiao W. Harnessing the privatization of China's fragmented health-care delivery. *Lancet.* (2014) 384:805–18. doi: 10.1016/S0140-6736(14)61120-X
28. Sun J, Luo H. Evaluation on equality and efficiency of health resources allocation and health services utilization in China. *Int J Equity Health.* (2017) 16:127. doi: 10.1186/s12939-017-0614-y
29. GBD. Healthcare Access and Quality Collaborators, and others. Healthcare Access and Quality Index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990–2015: a novel analysis from the Global Burden of Disease Study 2015. *Lancet.* (2015) 390:231–66.
30. Gulland A. Shortage of health workers is set to double, says WHO. *BMJ.* (2013) 347:f6804. doi: 10.1136/bmj.f6804
31. Wu Q, Zhao L, Ye X. Shortage of healthcare professionals in China. *BMJ.* (2016) 354:i4860. doi: 10.1136/bmj.i4860
32. Ying CN. The productive efficiency of Chinese hospitals. *J China Economic Review.* (2011) 22:428–39. doi: 10.1016/j.chieco.2011.06.001
33. Flokou A, Aletras V, Niakas D. Decomposition of potential efficiency gains from hospital mergers in Greece. *Health Care Manag Sci.* (2016) 20:1–18. doi: 10.1007/s10729-016-9365-3
34. Khushalani J, Ozcan YA. Are hospitals producing quality care efficiently? An analysis using dynamic network data envelopment analysis (DEA). *Socioecon Plann Sci.* (2017) 60:15–23. doi: 10.1016/j.seps.2017.01.009
35. Hu YL, Xu YY. Analysis of multivariate game of Chinese medical insurance payment policy. *Jiangxi Soc Sci.* (2022) 42:39–48.
36. Sun J, Hu CJ, Stuntz M, Hogerzeil H, Liu Y. A review of promoting access to medicines in China - problems and recommendations. *BMC Health Serv Res.* (2018) 18:125. doi: 10.1186/s12913-018-2875-6



## OPEN ACCESS

## EDITED BY

Stefania Salmaso,  
Independent Researcher, Rome, Italy

## REVIEWED BY

Xindong Li,  
Qilu University of Technology, China  
Zhe Dong,  
Shandong Women's University, China

## \*CORRESPONDENCE

Xigang Zhang  
✉ zxigang163.com

## SPECIALTY SECTION

This article was submitted to  
Public Health Policy,  
a section of the journal  
Frontiers in Public Health

RECEIVED 21 October 2022

ACCEPTED 21 February 2023

PUBLISHED 14 March 2023

## CITATION

Chen B and Zhang X (2023) Path analysis and  
empirical test of medical service enhancement  
for common prosperity under government  
participation. *Front. Public Health* 11:1076355.  
doi: 10.3389/fpubh.2023.1076355

## COPYRIGHT

© 2023 Chen and Zhang. This is an  
open-access article distributed under the terms  
of the [Creative Commons Attribution License  
\(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction  
in other forums is permitted, provided the  
original author(s) and the copyright owner(s)  
are credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted which  
does not comply with these terms.

# Path analysis and empirical test of medical service enhancement for common prosperity under government participation

Baoqi Chen and Xigang Zhang\*

School of Economics, Shandong University of Finance and Economics, Jinan, China

The level of medical services is the link between the two strategic goals of “healthy China” and “common prosperity,” and government participation plays an important adjustment role in it, so it is of great theoretical and practical significance to study its inner logic. In this paper, we firstly analyze the mechanism of medical service level to promote the development of common prosperity and the role of government in it; secondly, we construct a panel dynamic regression model and a threshold regression model to verify the relationship between the three. It is found that the contribution of both equity and efficiency of health care services to the achievement of common wealth is non-linear, and the degree of government participation plays an important adjustment role, with single and double threshold effects between them and the level of common prosperity, respectively. In the process of participating in the medical service market, the government should clearly position itself, actively play the demand-led role of the market, encourage private capital to provide quality medical services, and purposefully optimize the financial expenditure structure according to the local actual situation. There are many ways in which the government can be involved in health care, and there will be differences between China and other countries around the world. These are all worthy of further discussion.

## KEYWORDS

medical services, medical fairness, medical efficiency, common prosperity, government participation, threshold effect

## 1. Introduction and literature review

### 1.1. Introduction

The improvement of medical services is a key factor in improving the quality of the workforce, and since the 1980s the Chinese government has been committed to improving the medical conditions of its people through various policy instruments. The rapid economic development of China after the reform and opening up to become the second largest economy in the world has provided the material basis for the Chinese government to increase public healthcare services. The contradiction between the limited medical resources and the unlimited expansion of medical demand is becoming more and more prominent; the imbalance of medical resources allocation between urban and rural areas, regions and populations; local governments are keen on economic construction investment, but less enthusiastic about public services such as medical services, which are “large investment and slow to yield results,” and local governments are often “absent” in the medical service industry. Studies have shown that the improvement of medical services can promote the quality of regional economic development, and

thus enhance the level of common prosperity, but the emergence of these problems has increased the uncertainty of this promotion effect. The dual attributes of the medical service industry and the characteristics of information asymmetry determine that the solution to these problems must rely on the government's macro-control ability.

At present, we still have a number of questions to answer: Does the improvement of medical service quality contribute significantly to the achievement of common prosperity, and what are its underlying mechanisms? Are the different aspects of medical service quality consistent in their contribution to common prosperity? How can the government play its role in the process of medical service development contributing to the realization of common prosperity?

## 1.2. Literature review

So far, many scholars have done a lot of research on three themes: medical services, government participation, and common prosperity. The improvement of the level of economic development is the proper meaning of common prosperity, and a large number of studies have shown that promoting the improvement of the level of health care services can promote economic development by improving the quality of human capital and driving the upgrading of industrial structure (1). Health expenditure has a significant effect on improving the quality of economic growth, with each 1% increase in health expenditure improving the quality of economic growth by about 0.06% (1, 2). There are at least three main interaction mechanisms between health and economic growth and economic development: first, health affects the production function through various direct or indirect channels; second, since health also affects people's utility levels, it affects physical capital investment and educational human capital investment in the form of health consumption and health investment; finally, economic growth and economic development can have an impact on health through the level and structure of food as well as nutrition consumption (2, 3) by using panel data from more than 100 countries, the development of the health investment sector was studied on the economic structure, and the results of the study showed that the development of health industry has a positive significance in promoting the transformation of industrial structure (3); in addition, the level of medical and health services has an impact on the well-being of residents' lives. Li and Chang (4) and Miao and Li (5) found that the adequacy, publicness and convenience of health care services have a significant impact on the happiness of rural residents' life by studying the relationship between health care services and the happiness of rural residents.

Although China's health care reform has been effective, a series of problems still exist in medical services (6). Based on the coefficient of variation, Thiel index, Gini coefficient and spatial autocorrelation model, found that the overall regional differences in the supply level of basic medical and health resources in China are large, but in recent years, they show a trend of fluctuation and narrowing (6, 7), the growth rate of total factor productivity in China's medical industry exists in significant differences between regions, showing the status quo of high in the west and low in the

east (7, 8); by constructing a stochastic frontier production model, the study found that the overall efficiency level of China's health care system is low and there are significant regional differences (8, 9); there are different degrees of quantitative and qualitative imbalances in various types of health care resources in hospitals and primary health care institutions in China, and the greater the imbalance in the allocation of health care resources, the lower the efficiency of their utilization (9). Since the healthcare service industry has both commodity and public good attributes, the government has been playing an important role in its growth, but the results generated by this role are still controversial (10). After the government broke the pricing mechanism of drug prices affecting doctors' income, the supply side of medical services would obtain corresponding income through "excessive examination and equipment to support doctors," and the price control of medical services would have little effect (10, 11); government spending and government competition can promote the improvement of medical and health services, but excessive government competition is inhibitory, and there are significant regional differences (11); government health spending "crowds out" residents' health care consumption, and the crowding-out effect decreases as residents' income increases (12).

Existing studies are important references for understanding the internal logic among the three, but they either study an issue relatively independently or are limited to discussing the mutual influence relationship between the two topics, and few scholars have conducted theoretical analysis and empirical tests on the internal logic among the three. Based on the results of the existing literature, this paper has the following marginal contributions: first, there are few studies in the existing literature on the path of medical service level improvement to promote the realization of common prosperity, and this paper adds in this aspect. Second, the paper argues whether the fairness and efficiency of medical service level are consistent in promoting common prosperity. Third, to address the uncertainty of government participation in medical services, the threshold effect between the level of medical services and the realization of common prosperity is verified using the degree of government participation as the threshold variable, and it is found that government participation within the threshold value can effectively promote the realization of common prosperity.

## 2. Analysis of the mechanisms of action

### 2.1. The path of medical service level improvement for common prosperity

The theoretical connotation of common prosperity is constantly enriched in practice, and the realization of common prosperity at different historical stages shows different characteristics. An accurate understanding of the contemporary characteristics of common prosperity is the prerequisite for a correct understanding of the influence of the level of medical services on the level of realization of common prosperity. The two basic elements of the common prosperity are "common" and "affluence": "affluence" is expressed in the increase of the overall economic level of the country and the increase of individual

disposable income. “Common” means the sharing of material wealth, which is expressed in the gradual reduction of regional differences, urban-rural differences and differences among people (13). Medical service is both an important component of national economic development and an important part of the equalization of basic public services, and has the dual attributes of economy and people’s livelihood (14). Medical services can accelerate the realization of common prosperity in China by promoting the overall economic level and personal income level of the country and the people’s sense of well-being.

### 2.1.1. Macro level: Medical service development for economic scale increase

From the perspective of macroeconomic composition, consumption as one of the important driving force of macroeconomic growth, the drive for economic growth is increasingly apparent. China’s large population, with the increase in per capita income and health awareness, people pay more attention to disease prevention, the number of medical institutions in China continues to grow, which in turn makes the rigid demand for medical industry grows, the medical economy consumption potential is constantly stimulated and accelerated release. The number of visits to hospitals and health institutions in China has increased from 5.83 billion in 2008 to 7.741 billion in 2020, and the total cost of medical treatment has increased from 200 billion yuan in 2010 to 722 billion yuan in 2020 (15).

From the perspective of the growth momentum of the macro-economy, with the rise of the new economic growth theory in the 1980s, new economists regarded technological progress and human capital as the main driving forces of economic growth (8, 16). Among many studies on human capital, education and health are the main factors determining the difference of human capital. The impact of the improvement of medical services on human capital includes both direct and indirect effects. First, the improvement of medical service level can directly improve workers’ working years and work efficiency; second, the improvement of medical service level improves the return level of education investment in human capital investment by extending workers’ working hours and life span, which further promotes the improvement of education investment and indirectly promotes the improvement of human capital. In the context of accelerating population aging and the gradual disappearance of demographic dividend, improving the quality of labor force will become a key driving force to promote economic development (17, 18).

### 2.1.2. Industrial structure: The industrial restructuring effect of medical services

Medical service improvement boosts the development of health industry. In recent years, with the deepening of aging in China and the increasing attention of people to their own health problems, the health industry as a new service industry is gaining more and more attention and has gained rapid development (19). From the development status of health industry in developed countries, health industry has the characteristics of large investment scale, high rate of return and strong pulling effect, etc. With the transformation of China’s economy from high speed to high quality

development, the rapid development of the industry will become an important part of China’s high quality economic development (20). Medical services as an important part of the health industry, the improvement of the level of medical services can indirectly promote the quality of economic development by promoting the development of the health industry (21).

Medical service development promotes the transformation of industrial structure. The improvement of the level of medical service industry attracts more capital to enter and also increases people’s demand for health services and related products. The increase of capital investment and product demand will certainly attract more labor from primary and secondary industries to transfer to this industry, thus promoting the transformation and upgrading of industrial structure (22). In addition, with the improvement of technology, especially the development of digital technology, the boundaries of the health industry are gradually expanded, and the synergistic development effect between the health industry and other industries is enhanced, which further promotes the upgrading of the industrial structure. The optimization and upgrading of industrial structure will inevitably lead to the mutual transfer of industries in different regions, which can, to a certain extent, accelerate the industrial upgrading of backward regions.

### 2.1.3. Micro aspect: Medical services increase the income of the population

While the level of consumption is an important factor affecting GNP from a macro perspective, the micro level of consumption depends on the income level of individual laborers. The impact of factors such as urbanization level, industrial structure optimization, and digital economy development on residents’ income is exogenous, and the ability of residents to obtain income ultimately depends on individual working hours and skill level. The improvement of medical services can directly extend the working time and efficiency of individual workers, and indirectly promote the improvement of workers’ skills. A general increase in the population’s income can effectively reduce the income gap between populations (23, 24).

## 2.2. Ways of government participation in medical service level improvement

Medical services have different characteristics from general services and commodities, mainly in three aspects: firstly, medical services have the dual attributes of “public goods” and “commodities”; secondly, because of the strong professionalism of medical technology and the lack of medical knowledge of patients, there is a wide information asymmetry in the medical service market; finally, due to the government’s entry regulation and the professionalism of medical technology, there is monopoly in the medical market. Finally, there is a monopoly in the medical service market due to the government’s entry regulation and the professionalism of medical technology. The attributes and characteristics of medical services determine that there is a wide range of market failures in this field, which provides the necessary



conditions for the government to intervene in the medical service market. Government participation in medical services in our economic practice mainly includes government subsidies and government regulation.

### 2.2.1. Government subsidies

Government subsidies include both supply-side subsidies and demand-side subsidies. First, the supply-side subsidies can not only improve medical service technology and the supply of medical services, but also provide financial support to medical service providers, accelerate the renewal of medical equipment, promote medical technology, and promote the improvement of medical services (25). Second, demand-side subsidies can not only directly increase the demand-side medical consumption capacity, but also reduce consumers' preventive savings by changing their consumption expectations, thus increasing their current medical consumption level and promoting the development of the medical service industry. To a certain extent, government subsidies can promote the development of the health care industry, but excessive subsidies for health care services will inevitably crowd out funds invested in its public service projects or economic construction, and there is uncertainty about the impact on the overall economic development.

### 2.2.2. Government regulation

The government regulation of medical service industry is mainly based on entry regulation and price regulation. In the process of implementing entry regulation in China, the entry threshold of medical institutions is controlled by setting the threshold of investment scale, qualification license and other measures. In the development of medical institutions, in the public medical field, each region is encouraged to focus on developing a certain number of public hospitals to improve the level of public welfare of medical services, and in the private medical field, social capital is encouraged to enter the medical service field to promote the development of medical institutions by introducing a competitive mechanism to force the improvement of the efficiency of medical institutions. In the implementation of price regulation, it is hoped that controlling pharmaceutical pricing will alleviate the long-standing problem of expensive medical care due to the imbalance between supply and demand of medical services in China. However, government regulation has its own shortcomings; the focused cultivation of public hospitals in the region will result in the monopoly phenomenon of medical institutions, and price regulation will weaken the enthusiasm of new drug research and development as well as the effective supply of drugs.

The theories related to government regulation mainly include public interest regulation theory and interest group regulation theory. According to the public interest regulation theory, the medical service market itself cannot form effective price constraints and mechanisms to limit the consumption of medical services due to its own defects, resulting in the inefficient allocation of resources in the field. The government is the protector of public interests, and through government regulation of the market, it can solve the market failure and thus optimize the allocation of resources and improve social welfare. However, the interest group regulation

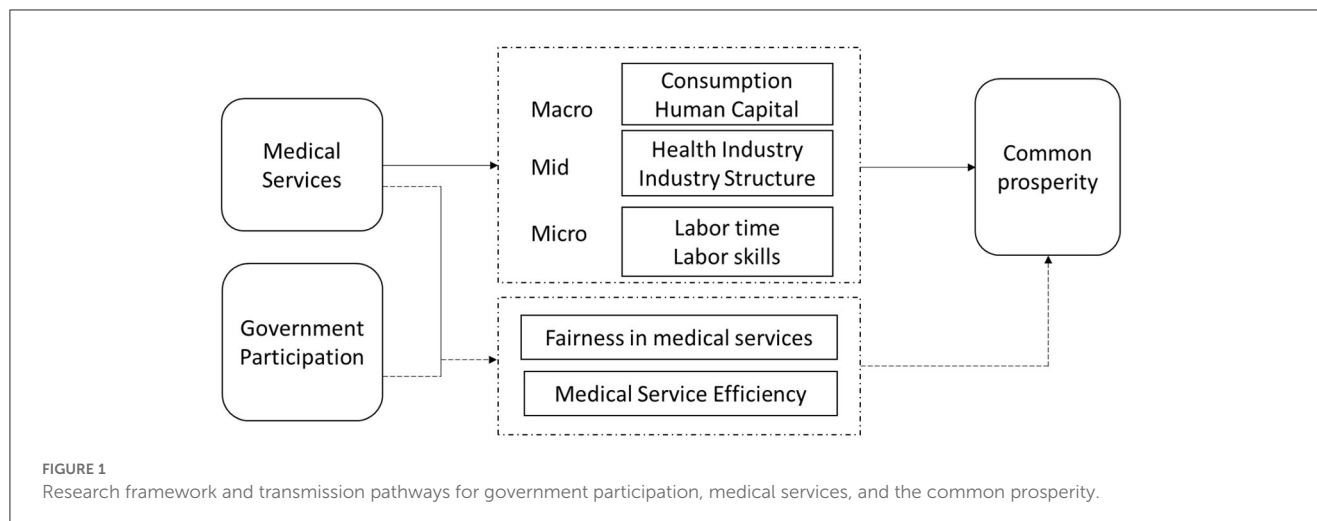
theory has a different attitude toward the role of government in the healthcare market. It believes that government regulation restricts the effective competition in the market and increases the interests of special interest groups, and advocates relaxing government regulation and relying on the efficiency of the free market to achieve efficiency optimization in the healthcare field. Based on the results of available empirical tests, the impact of government regulation on the market for health care services should be inconclusive. Different levels of government involvement and methods of involvement can have different effects on the improvement of medical services, and relevant evidence suggests that the effect of medical service quality on common wealth may be non-linear at different levels of government involvement.

## 2.3. The regulating role of government participation

There is no doubt that the improvement of medical services can contribute to the realization of common prosperity in China, but at the present stage, there are still many problems in the field of medical services in China. The basic characteristics of common prosperity are "common" and "prosperity," and these two characteristics correspond to the field of medical services, which are expressed in the fairness and efficiency of medical services.

The fairness of medical services is reflected in two aspects of development: the accessibility and the availability. In terms of accessibility, it refers to the reasonable distribution of medical service institutions between urban and rural areas and between regions, and everyone can get the corresponding medical services within a reasonable space. Availability is mainly reflected in the price of medical services, which means that the consumption level of medical services is within the affordable range of the residents, and the high-income people and low-income people can get the most basic medical protection. The high efficiency of medical services can better promote the equity of medical services. The current contradiction between the rising demand of people for medical services and the insufficient supply and unbalanced allocation of medical resources is becoming more and more prominent. Limited to the current system and economic level, it is impossible to increase the supply of medical resources through a large-scale increase in investment in the short term, which makes it necessary for China to focus on the improvement of the efficiency of medical services. Due to the profit-driven mechanism of the market, it is impossible to achieve the fairness of medical services by purely relying on market forces, and the public goods attribute of medical services also determines that the market cannot solve its efficiency problems, so to achieve the fairness and efficiency of medical services, we must rely on the power of government macro-control (26, 27).

The facts of China's medical services market also prove the need for government involvement. At present, China's medical service market is characterized by "induced consumption" and "excessive medical care" due to information asymmetry, and "difficulty in accessing medical care" due to uneven distribution of medical resources. This series of problems not only hinders the improvement of people's economic living standards and happiness,



but also seriously hinders the realization of the goal of common prosperity in China. The solution of these problems requires government intervention, and the different degrees of government involvement and methods of participation will certainly have different results on the fairness and efficiency of medical services. The mechanism of action is analyzed as shown in Figure 1.

### 3. Variable descriptions and statistical characteristics

#### 3.1. Variable description

##### 3.1.1. Explanatory variable: Level of achievement of common prosperity (Comp)

The measurement of the level of common prosperity involves both material and spiritual dimensions as well as “common” and “prosperous” aspects, so it cannot be measured by a single indicator. In this paper, based on relevant literature, we have constructed 2 primary indicators, 6 secondary indicators, 14 tertiary indicators and 27 bottom indicators according to the different characteristics of material and spiritual common prosperity (see Table 1), taking into account the availability of inter-provincial data. The evaluation results of the level of common prosperity achievement were calculated using the entropy weight method.

The calculation method of some indicators is explained as follows: total labor productivity using the ratio of GDP to total employment in the three industries in each province; the contribution of residential consumption using the ratio of total retail sales of consumer goods to GDP in each province; foreign trade dependence using the share of imports and exports in GDP of each province; the urban-rural disposable income gap using the Thayer index of urban-rural income for each province; the urban-rural consumption gap using the ratio of urban per capita consumption expenditure to rural per capita consumption expenditure in each province; the urban-rural disparity in livelihood and health care uses the ratio of the number of health care beds per 1,000 people in urban areas to the number of health care beds per 1,000 people in rural areas in each province.

R&D investment intensity using R&D expenditure as a proportion of GDP; human capital innovativeness accumulation using the number of students per 10,000 students in school. fixed asset investment ratio using the share of fixed asset investment in GDP; the ratio of the number of employees in the cultural and entertainment industry per 10,000 people is adopted as the ratio of the number of employees in the cultural and entertainment industry to the number of resident population in each province.

##### 3.1.2. Core explanatory variables

The government mainly influences the fairness and efficiency of medical services to make them better contribute to the realization of common wealth, so this paper sets two variables of fairness and efficiency of medical services as the core explanatory variables.

The fairness of medical services (Msf) is divided into two aspects: accessibility and availability. Accessibility is replaced by the number of medical beds available per capita. The number of medical beds per capita reflects, to a certain extent, the level of medical security and the distribution of resources for medical services, and a larger value indicates better accessibility of medical services. The ratio of per capita disposable income to per capita medical expenditure is used as an indicator of the availability of medical services, which can reflect the ability of residents' disposable income to pay for medical expenditure. The fairness of medical service is a comprehensive consideration of the availability and accessibility and both are positively related to the fairness of medical service, so we set the value of medical service fairness index as the product of availability and accessibility.

The efficiency of medical services (Mse) is mainly reflected in output efficiency, and this paper adopts the Malmquist index method proposed by Fare et al. in Data Envelopment Analysis (DEA) to measure the efficiency value of medical services, and learns from the research results of Yu (7), and the input indicators are selected as the number of health personnel, total assets of medical and health institutions, total medical and health costs, and the output indicators are selected as the number of consultations in health care institutions, and the number of discharges from health care institutions (7).

TABLE 1 Evaluation system of the level of common prosperity realization in China.

Primary indicators	Secondary indicators	Tertiary indicators	Bottom indicators	Attribute	Weight
Material common prosperity	Developmental	Economic benefits	Total labor productivity	+	0.0421
			GDP per capita	+	0.0371
			Disposable income per inhabitant	+	0.0392
		Economic structure	Resident consumption contribution rate	+	0.0097
			Engel coefficient	–	0.0119
			Foreign trade dependence	+	0.0841
	Shareability	Crowd gap	Gini coefficient	–	0.0318
		Urban-rural gap	Disposable income gap	–	0.0027
			Consumption gap	–	0.0066
			People's health care gap	–	0.0072
	Sustainability	Technology Innovation	R&D investment intensity	+	0.0699
			R&D personnel full time equivalent	+	0.1208
			Number of patents granted per 10,000 people	+	0.1037
		Capital accumulation	Labor accumulation	+	0.0091
			Human capital innovation power accumulation	+	0.0255
			Percentage of fixed asset investment	+	0.0219
		Ecological optimization	Emissions of major pollutants from exhaust gases	–	0.0089
			Emissions of major pollutants in wastewater	–	0.0113
			Growth rate of energy consumption per unit of GDP	–	0.0051
			Total afforestation area per 10,000 people	+	0.0834
Spiritual common prosperity	Personal enhancement	Culture and entertainment	Per capita expenditure on culture and entertainment	+	0.0359
		Library reading	Public library book and periodical literature lending attendance	+	0.0661
		Physical and mental health	Green space per capita	+	0.0153
	Cultural services	Industry support	Percentage of employees in the cultural and entertainment industry per 10,000 people	+	0.0996
		Government support	Culture and tourism business expenses accounted for the proportion of government financial expenditure	+	0.0265
	Social harmony	Family harmony	Divorce rate	–	0.0179
		Public safety	Number of traffic accidents	–	0.0065

### 3.1.3. Threshold variables

Government participation (Govpart) is influenced by the will of national and local governments in the direction of implementation, but the intensity of participation and the choice of participation in the implementation process are limited by the level of local fiscal revenue and economic development. For the research object of this paper, the ratio of local health care fiscal expenditure to local

gross domestic product is used as a proxy variable for the degree of government participation.

### 3.1.4. Control variables

In order to reduce the problem of endogeneity due to the omission of variables, this paper selects five factors as control

TABLE 2 Statistical description of data for each variable.

Variables	Max	Min	Mean	Std
Comp	0.523	0.104	0.229	0.084
lnMsf	7.215	3.238	5.693	0.876
Mse	1.171	0.559	0.959	0.077
Govpart	0.073	0.006	0.019	0.010
Fd	2.783	0.669	1.436	0.452
Age	0.237	0.067	0.139	0.029
Edu	0.219	0.099	0.160	0.025
Is	0.836	0.286	0.465	0.095
Ind	0.748	0.067	0.374	0.131
lnMsfGovpart	0.312	0.04	0.113	0.046
MseGovpart	3.47	0.038	0.525	0.62
lnMsf2	52.056	10.483	33.167	8.411
Mse2	1.371	0.312	0.924	0.140

variables, namely, the level of regional financial development (Fd), the degree of aging (Age), the level of education development (Edu), the degree of industrial structure optimization (Is), and the degree of industrialization (Ind). Among them, the level of regional financial development adopts the ratio of domestic and foreign currency loan balance to GDP of regional GDP as a proxy variable; the level of regional aging adopts the ratio of regional elderly dependency as a proxy variable; the level of industrial structure optimization adopts the ratio of output value of tertiary industry to GDP of regional GDP as a proxy variable; the level of industrialization adopts the ratio of industrial value added to regional GDP.

## 3.2. Data sources and statistical characteristics

### 3.2.1. Data sources

Due to the lack of relevant data for Hong Kong, Macao and Taiwan in China, and the lack of data for 2009 and 2010 for some provinces. For 2020, the outbreak of COVID-19 virus caused an abnormal increase in the level of medical consumption, therefore, this paper selects panel data from 2010 to 2019 for 31 provinces (autonomous regions and municipalities directly under the central government) in China. The data are obtained from the China Statistical Yearbook, China Statistical Yearbook of Culture and Related Industries, local government work reports and statistical yearbooks of each province, and the missing data for some years in individual provinces are extrapolated from the rate of change of nearby years.

### 3.2.2. Statistical characteristics of data

lnMsfGovpart indicates the interaction item of medical service fairness and government involvement; MseGovpart indicates that

the efficiency of medical services and government involvement in the interaction items; lnMsf2 denotes the quadratic term of lnMsf; Mse2 denotes the quadratic term of Mse. The statistical description of the various data is shown in Table 2.

## 4. Model construction and analysis of results

### 4.1. Dynamic panel model construction and result analysis

#### 4.1.1. Description of estimation method and model form

Because common prosperity is a dynamic development process, the achievement of each milestone is bound to be influenced by the development results of the previous phase, so it is necessary to include the lagged term of the common prosperity achievement level index as an explanatory variable in the process of constructing the model; in addition, considering the possible endogeneity problem among the variables, combined with the characteristics of balanced panel data, this paper learns from Arellano and Bond (15) and Blundell and Bond's Generalized Method of Moments (GMM) for the econometric analysis (28). Compared with the differential GMM, the systematic GMM can solve the problem of weak instrumental variables that may exist in the differential equation, and can use the information of variable level changes and differential changes to effectively overcome the bias caused by the inclusion of lagged terms of the explained variables in the explanatory variables, and solve the endogeneity problem caused by a part of omitted variables that change over time but not with individuals (29–31).

Based on the previous mechanism analysis, the following dynamic panel model is constructed to systematically analyze the following three questions: are the fairness and efficiency of medical services important factors affecting the achievement of common prosperity? Is the impact of medical service level on common affluence non-linear? Does the level of government involvement play a moderating role in the relationship between the level of health care services and common prosperity?

A dynamic panel regression model of the form of equation (1) is constructed to analyze whether the improvement of medical services can contribute to the achievement of common prosperity.

$$Comp_{it} = \alpha_0 + \alpha_1 Comp_{it-1} + \alpha_2 \ln Msf_{it} + \alpha_3 Mse_{it} + \varepsilon_{it} \quad (1)$$

$$Comp_{it} = \beta_0 + \beta_1 Comp_{it-1} + \beta_2 \ln Msf_{it} + \beta_3 Mse_{it} + \beta_4 Govpart_{it} + \varepsilon_{it} \quad (2)$$

$$Comp_{it} = \lambda_0 + \lambda_1 Comp_{it-1} + \lambda_2 \ln Msf_{it} + \lambda_3 Mse_{it} + \lambda_4 Govpart_{it} + \lambda_5 X_{it} + \varepsilon_{it} \quad (3)$$

Equation (2) is to add the variable of the degree of government participation to Equation (1) to investigate the role of the degree

of government participation in the process of increasing the level of common prosperity achievement. Equation (3) is based on Equation (2) by adding control variables that may have an impact on the common prosperity index in order to test the reliability of the results of Equation (2).

The above model can only verify whether the level of medical service and government participation have any effect on the level of achieving common prosperity, and whether there is a non-linear relationship between them needs further model construction and analysis. Equations (4) and (5) is based on Equation (3) and introduces the quadratic term of medical service level as the independent variable to verify whether the relationship between the two is non-linear. If the non-linear relationship exists, whether the degree of government participation is the cause of this relationship needs to be further demonstrated. Equations (6) and (7) are based on Equation (3) by adding the cross term of the level of medical service and the degree of government participation to investigate the moderating role of the degree of government participation in the process of medical service level contributing to the achievement of common prosperity.

$$\begin{aligned} Comp_{it} = & c + X_1 Comp_{it-1} + X_2 \ln Msf_{it} + X_3 Mse_{it} \\ & + X_4 Govpart_{it} + X_5 \ln Msf_{2it} + X_6 X_{it} + \varepsilon_{it} \end{aligned} \quad (4)$$

$$\begin{aligned} Comp_{it} = & c + \iota_1 Comp_{it-1} + \iota_2 \ln Msf_{it} + \iota_3 Mse_{it} + \iota_4 Govpart_{it} \\ & + \iota_5 \ln Msf_{2it} + \iota_6 \iota_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

$$\begin{aligned} Comp_{it} = & c + \kappa_1 Comp_{it-1} + \kappa_2 \ln Msf_{it} + \kappa_3 Mse_{it} \\ & + \kappa_4 Govpart_{it} + \kappa_5 \ln Msf_{2it} + \kappa_6 \kappa_{it} + \varepsilon_{it} \end{aligned} \quad (6)$$

$$\begin{aligned} Comp_{it} = & c + \nu_1 Comp_{it-1} + \nu_2 \ln Msf_{it} + \nu_3 Mse_{it} \\ & + \nu_4 Govpart_{it} + \nu_5 \ln Msf_{2it} + \nu_6 \nu_{it} + \varepsilon_{it} \end{aligned} \quad (7)$$

Where: are the coefficients of the explanatory variables,  $\varepsilon$  are the error terms of the corresponding models,  $c$  is a constant term, and  $X$  is some series of control variables.

#### 4.1.2. Analysis of model estimation results

Systematic GMM estimation was performed for the above models, and the AR (2) statistics for all models regression results were greater than 0.05, indicating that there was no second-order autocorrelation, and the Hansen test values for each model ranged from 0.1 to 0.25, indicating that the instrumental variables selected in the models were valid and there was no over-identification problem. The specific regression results for each model are shown in Table 3.

In general, the regression results of all seven equations show that the first-order lagged term of the common prosperity index is significant at the 1% statistical level and the regression coefficients are all positive, indicating that there is a significant time continuity

in the improvement of the level of common prosperity realization in China, and the realization of common prosperity in the early period can provide positive promotion for the later period. From the comparison among the equations, we can see that both the fairness and efficiency of medical services are important factors affecting the realization of common wealth through the estimation results of Equation (1), and from the coefficient size, the current efficiency of medical services has a more obvious role in promoting common wealth; Equation (2) increases the variable of the degree of government participation, although the coefficient of fairness of medical services decreases from 0.027 to 0.019 and the coefficient of efficiency of medical service increases from 0.065 to 0.083, the significance level of both does not change fundamentally, and the regression result of Equation (2) shows that the size of government participation is also one of the factors that affect the realization of common prosperity in China; from the regression result of Equation (3), the addition of control variables does not substantially change the results of Equations (1) and (2), which further indicates that the conclusion obtained from Equations (1, 2) is stable and reliable.

Equations (4)–(7) are constructed mainly to analyze whether there is a non-linear relationship between the level of medical services and common prosperity. According to the regression results of Equation (4), the coefficient of the quadratic term of the efficiency of medical services is negative and significant at the 5% statistical level. Thus, it can be judged that there is an inverted U-shaped non-linear relationship between the level of common prosperity and the efficiency of medical services in China. This means that before the inflection point, the efficiency of medical services can promote the level of common prosperity, but after the inflection point, the efficiency of medical services can hinder the achievement of common prosperity. This is mainly because, under the condition of limited resources, the rapid increase of medical service efficiency will cause the loss of equity to a certain extent, and the efficiency increase will hinder the process of achieving common prosperity when the promotion effect of efficiency increase is smaller than the hindrance effect of equity loss, on the contrary, the efficiency increase can promote the achievement of common prosperity. The regression results of Equation (5) do not indicate that there is a significant relationship between the quadratic term of the level of common prosperity and the fairness of medical services, so we can judge that there is no U type relationship between the two, but whether there is other types of non-linear relationship needs further investigation. The regression results of Equations (6) and (7) show that the coefficients of the interaction term between government participation and fairness and efficiency of health care services are positive and significant at least at the 5% level, indicating that government participation plays a moderating role in the improvement of medical services and the achievement of common prosperity. The coefficient of the interaction term between government participation and medical fairness is larger than the coefficient of the interaction term between government participation and medical efficiency, which indicates that government participation plays a more significant role in regulating the fairness of medical



TABLE 3 Systematic GMM regression results for Equations 1–7.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
L. comp	0.917*** (0.06)	0.879*** (0.024)	0.674*** (0.132)	0.852*** (0.068)	0.725*** (0.052)	0.756*** (0.035)	0.531*** (0.145)
lnmsf	0.027*** (0.005)	0.019*** (0.006)	0.026*** (0.023)	0.065** (0.032)	0.039** (0.025)	0.031*** (0.017)	0.058** (0.04)
Mse	0.065*** (0.013)	0.083** (0.035)	0.048** (0.031)	0.091* (0.621)	0.059*** (0.024)	0.049** (0.03)	0.112*** (0.042)
Govpart		0.687** (0.275)	0.564*** (0.779)	0.647** (0.583)	0.652** (0.257)	0.549** (0.841)	0.648*** (0.751)
Mse2				−0.586** (0.248)			
lnMsf2					0.014 (0.075)		
lnMsfGovpart						0.498*** (0.71)	
MseGovpart							0.315** (0.042)
Fd			−0.012 (0.036)	0.031** (0.045)	0.042*** (0.024)	0.026** (0.017)	0.024* (0.021)
Age			−0.223 (0.167)	−0.325** (0.033)	−0.301*** (0.094)	−0.036 (0.049)	−0.613** (0.227)
Edu			0.150* (0.212)	0.313 (0.324)	0.045 (0.145)	0.046* (0.126)	0.418 (0.269)
Is			0.525*** (0.203)	−0.004 (0.086)	0.142*** (0.037)	0.076** (0.028)	0.464** (0.214)
Ind			0.423** (0.195)	0.324 (0.047)	0.165* (0.034)	0.016 (0.015)	0.29** (0.118)
cons	−0.202*** (0.048)	−0.198*** (0.12)	−0.739*** (0.167)	0.124*** (0.291)	−0.012*** (0.058)	−0.157*** (0.053)	−0.642*** (0.157)
AR(2)	0.387	0.424	0.353	0.189	0.276	0.254	0.463
Hansen test	0.124	0.225	0.152	0.227	0.191	0.268	0.126

(1) \*\*\*, \*\*, \* denote significant at the 1%, 5%, and 10% statistical levels. (2) L. comp is the first-order lagged term of the common prosperity index. (3) The values in parentheses are robust standard errors.

services to promote the achievement of common prosperity. In conclusion, the contribution of the level of medical service to the realization of common prosperity in China will be influenced by the degree of government participation, and the size and timing of government participation need to be further analyzed through the threshold effect.

#### 4.1.3. Curves based on LOWESS method

In order to further verify the existence of non-linear relationships between variables from the perspective of data, the LOWESS method is applied to curve-fit the equity and efficiency of medical services and the level of achievement of common wealth, respectively. The LOWESS method is a non-parametric fitting

method that is not constrained by the overall distribution and parameters, and can be used to do preliminary if the relationship or functional form between variables is uncertain analysis. The result is shown in [Figure 2](#).

First, the fairness of medical service can promote the improvement of the level of common prosperity, and there are obvious stages between them. Secondly, the effect of efficiency of medical services on common prosperity can be divided into three intervals, and the overall relationship shows “an inverted U-shaped” non-linear relationship. The regression results of the dynamic panel model show that both fairness and efficiency of medical services are important factors affecting the level of common wealth. Different levels of government participation will

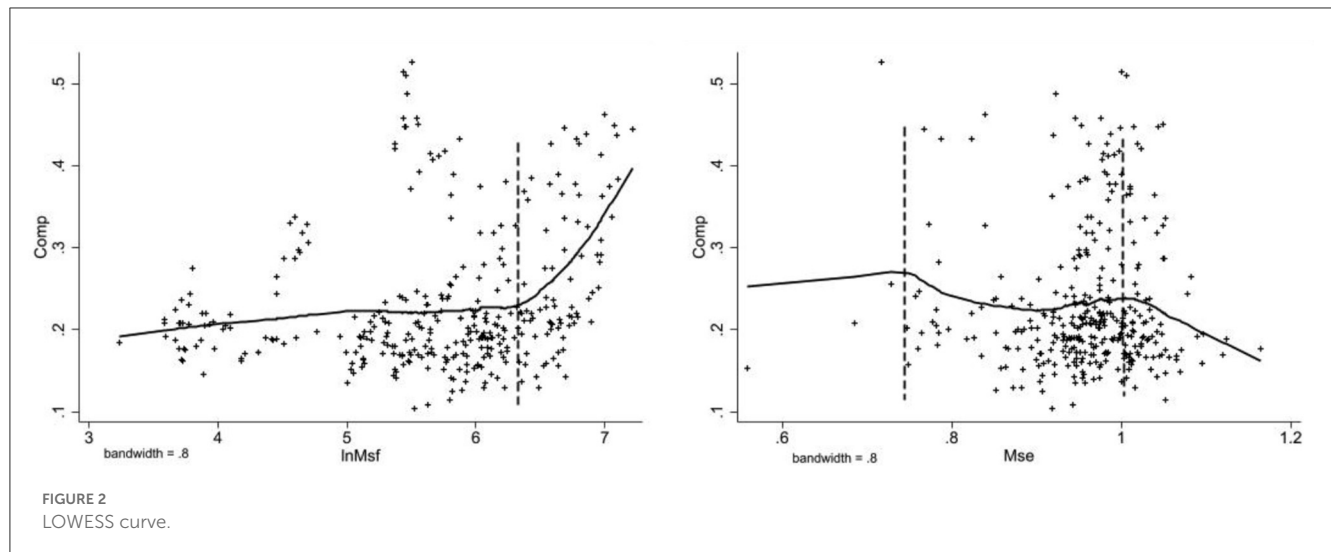


TABLE 4 Bootstrap test results.

Threshold	lnMsf		Mse	
	Fstat	Prob	Fstat	Prob
Single	49.670	0.000	54.370	0.000
Double	20.350	0.230	21.350	0.018
Triple	12.560	0.670	15.880	0.562

have different moderating effects on both, and the degree and timing of government participation need to be further analyzed.

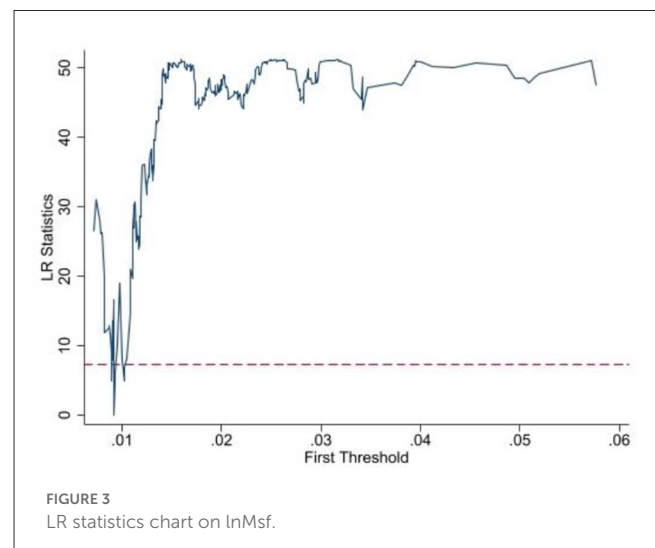
## 4.2. Threshold regression model construction and result analysis

### 4.2.1. Threshold regression model construction

According to the previous mechanism analysis and the regression results of the dynamic panel model, both aspects of equity and efficiency of medical services can contribute to the improvement of the level of common prosperity achievement, but the different degrees of government participation in the process will have different effects on the relationship between the two. In view of this, a double-threshold panel model of the form of Equations (8, 9) is developed by learning Hansen's (32) threshold regression method and using the degree of government involvement as the threshold variable.

$$\begin{aligned}
 Comp_{it} = & c + \tau_1 \ln Msf_{it} I(Govpart_{it} \leq \gamma_1) \\
 & + \tau_2 \ln Msf_{it} I(\gamma_1 < Govpart_{it} \leq \gamma_2) \\
 & + \tau_3 \ln Msf_{it} I(Govpart_{it} > \gamma_2) + \tau_4 Mse_{it} \\
 & + \tau_5 X_{it} + \varepsilon_{it}
 \end{aligned} \quad (8)$$

$$\begin{aligned}
 Comp_{it} = & c + \rho_1 Mse_{it} I(Govpart_{it} \leq \Omega_1) \\
 & + \rho_2 Mse_{it} I(\Omega_1 < Govpart_{it} \leq \Omega_2) \\
 & + \rho_3 Mse_{it} I(Govpart_{it} > \Omega_2) + \rho_4 \ln Msf_{it} \\
 & + \rho_5 X_{it} + \varepsilon_{it}
 \end{aligned} \quad (9)$$



In the equation:  $\tau\rho$  are model coefficients,  $\gamma\Omega$  are threshold values,  $c$  is the constant term,  $\varepsilon$  is the error term, and  $I(\cdot)$  is the indicator function. The construction, parameter estimation and testing process of the single-threshold panel model and the three-threshold panel model are similar to those of the double-threshold panel model, and are not repeated in this paper.

Before parameter estimation, the number of threshold values and significance of the model are first tested to determine the specific form of the model in this paper. In this paper, the asymptotic value of the F-statistic is obtained by the threshold effect bootstrap sampling (Bootstrap) test, and the  $p$ -value is obtained, and the threshold is tested at 400 grid searches as well as 300 bootstrap samples, respectively. According to the test results, there is a single threshold effect for the fairness of medical services when the degree of government participation is used as the threshold variable, and the threshold value is 0.9%, and there is a double threshold effect for the efficiency of medical services, and the threshold values are 1.1% and 1.4%, respectively. The results of the tests are shown in Table 4 and Figures 3, 4.

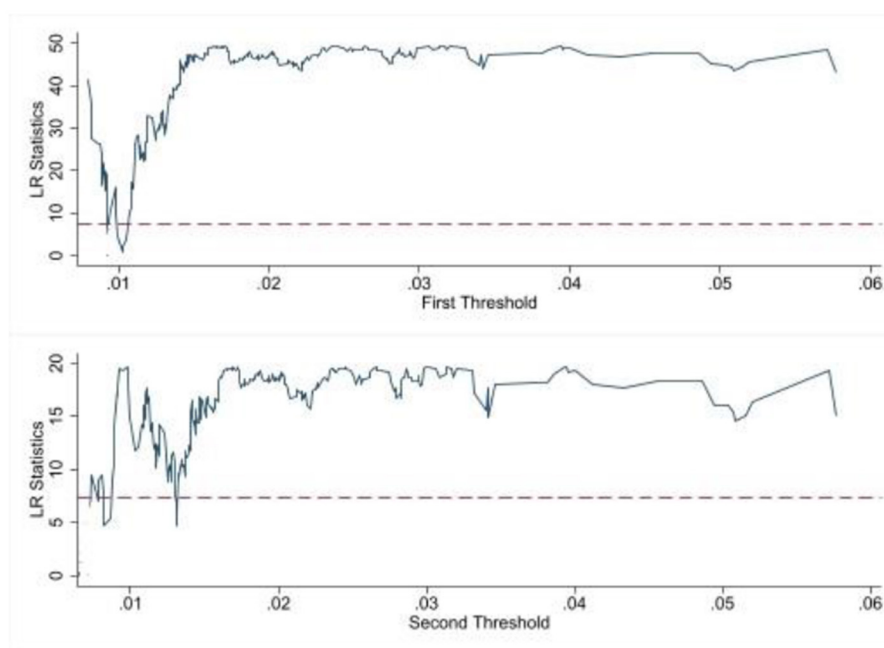


FIGURE 4  
LR statistics chart on Mse.

#### 4.2.3. Analysis of threshold regression results

According to the results of the threshold effect test, different types of threshold models were used to estimate the threshold effects, and the results are shown in Table 5. The coefficient of fairness of medical service is always positive in line with the estimated results of dynamic panel model, which indicates that the improvement of fairness of medical service will always promote the level of common prosperity achievement. The coefficient of medical service efficiency changes from positive to negative with the change of the threshold variable, which verifies the inverse “U” non-linear relationship between medical service efficiency and the level of common prosperity in the system GMM model, and indicates that the degree of government participation plays an important moderating role in the process of medical service efficiency for common prosperity.

From the regression results of Equation (8) in Table 5, it is clear that there is a significant threshold effect between the fairness of medical services and the level of common prosperity achievement, when the degree of government participation is <0.9%, the fairness of medical services and the level of common prosperity achievement are significantly positively correlated at the 1% level, with a coefficient of 0.042; when the degree of government participation exceeds 0.9%, the level of medical services has a significantly stronger contribution to the increase of the level of common prosperity achievement. The result of Equation (8) indicates that the fairness of medical services is non-linearly positively correlated with the achievement of common prosperity, i.e., the stronger the fairness of medical services, the greater the effect on the enhancement of the achievement level of common prosperity.

The regression results of model (9) show that the relationship between medical service efficiency and common prosperity under government participation shows obvious multi-stage characteristics. When the degree of government participation is below 1.1%, the coefficient of medical service efficiency is 0.028, and at 1% significance level, the increase of common prosperity for each 1% increase in medical service efficiency is 0.029%; when the degree of government participation is between 1.1% and 1.4%, the coefficient of medical service efficiency becomes 0.056, and the promotion effect on common prosperity is significantly increased at 1% significance level; when the degree of government participation is over 1.4%, the coefficient of medical service efficiency changes from positive to positive. The coefficient of medical service efficiency changes from positive to negative at the 5% level of significance when the degree of government participation exceeds 1.4%. The results of model (9) show that the relationship between medical service efficiency and the achievement of common prosperity is in an inverted “U” shape, and the contribution of medical service efficiency to common prosperity increases gradually with the increase of government participation before the inflection point, but after the inflection point, the contribution of medical service efficiency to common prosperity The “shift” occurs after the inflection point. This “shift” phenomenon may be due to the limited resources, i.e., the increase of government expenditure on medical services has weakened the development of other basic public services; it may also be due to the increase of medical service efficiency without taking into account the fairness of medical services, resulting in the reduction of the overall level of medical services.

## 5. Research conclusions and policy recommendations

Health for all is an important support for the strategy of “Healthy China” and a prerequisite for achieving the goal of common prosperity, in which the high level of development of medical service industry plays a key role. Based on this, this paper firstly makes the necessary theoretical analysis on the path of improving medical services to promote the realization of common prosperity; secondly, it constructs a systematic GMM model with the fairness and efficiency of medical services as the core explanatory variables and a panel threshold regression model with the degree of government participation as the threshold variable, respectively.

The study found that:

First, in general, the improvement of medical service level has a significant contribution to the realization of common prosperity, and the efficiency of medical service has a more significant contribution to common prosperity. The government is both a market manager and a market participant, and government participation itself has a significant positive effect on the realization of common prosperity as well as the level of medical service development.

Second, the equity and efficiency of medical services are the concrete manifestation of the high level of development of medical services, and the impact of both on common services is non-linear and the mechanism of action is inconsistent. Specifically, there is an inverted U-shaped non-linear relationship between the level of common prosperity and the efficiency of medical services in China, before the inflection point, the improvement of medical efficiency can promote the level of common prosperity, but after the inflection point, the improvement of medical service efficiency will hinder the realization of common prosperity; the improvement of medical service fairness always has a positive effect on the realization of common prosperity. The improvement of fairness in medical services has always contributed to the realization of common wealth, but it shows a phased characteristic, the stronger the fairness of medical services, the greater the effect on the improvement of the level of common prosperity.

Third, when the degree of government participation is used as the threshold variable, there are single and double threshold effects on the level of equity and efficiency of medical services and the level of common prosperity, respectively. Government participation in the medical service market is an important reason for the inverted U-shaped relationship between medical service efficiency and common prosperity. However, when government participation exceeds 1.4%, the increase in efficiency of health care services hinders the achievement of common prosperity.

The improvement of medical service level can effectively promote the realization of common prosperity, but the relationship between fairness and efficiency of medical service is mutually constrained and mutually promoted. The limited fiscal revenue is an important reason for this constrained relationship, which requires local governments to strive to improve their own financial resources, closely integrate economic development with fiscal development, and pay attention to the construction of the fiscal system, especially in the context of the current

TABLE 5 Threshold regression results.

	(8)	(9)
lnMsf (govpart $\leq$ 0.009)	0.042*** (0.000)	
lnMsf (govpart $>$ 0.009)	0.049*** (0.000)	
Mse (govpart $\leq$ 0.011)		0.028*** (0.002)
Mse (0.011 $<$ govpart $\leq$ 0.014)		0.056*** (0.000)
Mse (govpart $>$ 0.014)		−0.008** (0.049)
lnMsf		0.043*** (0.000)
Mse	0.027** (0.035)	
Fd	0.006 (0.167)	0.007* (0.063)
Age	0.364*** (0.000)	0.338*** (0.000)
Edu	0.134* (0.068)	0.078 (0.377)
Is	0.275*** (0.000)	0.271*** (0.000)
Ind	0.054** (0.021)	0.056** (0.028)
cons	−0.283*** (0.000)	−0.248*** (0.000)

\*\*\*, \*\*, \* Significant at 1%, 5% and 10% statistical levels, F-statistic and p-value (in parentheses) obtained from 300 Bootstrap self-samplings.

macroeconomic growth decline, through the implementation of a series of economic incentive policies, and strive to improve local own financial resources and investment in health care spending.

The government plays a leading role in realizing the equity of medical services, and local governments should clearly position themselves in the process of participating in the medical service market, adhere to the basic function of “covering the bottom line” and “preserving the basics,” and ensure the availability and accessibility of basic medical services in all areas and among the population. The government should break the barriers of the system and mechanism to actively play the demand-led role of the market, encourage and support social forces to provide quality medical services to meet the public’s more diversified and multi-level demand for health services.

In the case of government participation, there is uncertainty about the contribution of the level of medical services to the common prosperity. The government’s participation should be

“localized” and “targeted.” Compared with the eastern region of China, the level of medical services in the central and western regions is still low, and increasing government participation can promote the overall improvement of the level of medical services in the central and western regions; the eastern region should analyze specific problems and not blindly increase medical and health expenditures, and policy making must adhere to the balance between medical equity and efficiency. The government’s participation in the medical service market should follow a goal-oriented approach, clarify the government’s responsibility in the regional medical business, optimize the structure of financial expenditures, and optimize the structure and management efficiency of the use of funds while increasing the scale of medical expenditures.

## 6. Limitations of the study

The following limitations may exist in the research process of this paper.

- (1) Most of the sample data in this paper come from the National Statistical Yearbook, and due to the change of statistical caliber of some data and inconsistent statistical time, this paper only selects the statistical data from 2010 to 2019 in the research process. Using only 10 years of data for balanced panel data analysis may lead to bias in the regression results.
- (2) Common prosperity is a relatively ambitious subject, and although a multidimensional index system is used in this paper to evaluate it, the selection of these indicators may still be insufficient to reflect the true level of common prosperity. The construction of the comprehensive evaluation system on common prosperity still needs further improvement.
- (3) The government’s participation in the level of medical services is multifaceted, including not only financial and taxation support but also the construction of public medical service system, but there is a lack of effective means to measure other means of participation. Therefore, in the empirical analysis of this paper, the indicator of government participation is only measured by the amount of government financial expenditure,

which may not be sufficient to truly reflect the degree of government participation.

- (4) The article only analyzes the situation in China, and the results of the empirical analysis may only be applicable to developing countries similar to China, but may not be applicable to the situation in other countries.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

BC: conceptualization and writing of the manuscript. XZ: critical review of the manuscript and data analyses. All authors contributed to the article and approved the submitted version.

## Funding

This research was funded by the Key Project of National Social Science Foundation of China (Grant No. 18ZDA077).

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher’s note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

1. Tang LN, Li YY, Xi H. Research on the impact of health expenditure on the quality of economic growth—an empirical test based on inter-provincial panel data. *East China Econ Manage.* (2020) 34:76–83. doi: 10.19629/j.cnki.34-1014/f.200304002
2. Wang DH, Cui XY, Gong LT. The role of health in economic growth and economic development—a perspective based on literature studies. *Dyn Econ.* (2015) 8:107–27.
3. Yao Y, Liu B, Liu G. Industrial structure effect of health investment: macro evidence from OECD and other countries. *Fin Res.* (2017) 43:102–16. doi: 10.16538/j.cnki.jfe.2017.05.008
4. Li L, Chang GY. The relationship between health services and rural residents’ well-being—an empirical analysis based on CGSS 2013 and CGSS 2015 survey data. *J Northwest Agric For Univ Sci Technol.* (2019) 19:85–95. doi: 10.13968/j.cnki.1009-9107.2019.01.11
5. Miao SL, Li M. Disparity between urban and rural medical and health services and residents’ well-being—an empirical analysis based on CGSS 2015 survey data. *J Yunnan Univ Fin Econ.* (2020) 36:36–45. doi: 10.16537/j.cnki.jynufe.000642
6. Zheng WS, Jiang HX, Ai HR, Luo J, Wang XF. Regional differences in the supply level of basic medical and health resources in China. *Geogr Res.* (2015) 34:2049–60.
7. Yu M. Productivity improvement in the medical industry: intrinsic mechanism and China’s experience. *Indus Econ Res.* (2021) 114–127. doi: 10.13269/j.cnki.ier.2021.02.009
8. Zhang X, Liu M, Wu X. Regional economic development, medical system characteristics and technical efficiency of health care. *J Xi’an Jiaotong Univ.* (2013) 33:9–17. doi: 10.15896/j.xjtusxb.2013.01.002
9. Wang J, Jia W. Analysis of the allocation and utilization efficiency of medical and health resources in China. *Finance Trade Econ.* (2021) 42:20–35. doi: 10.19795/j.cnki.cn11-1166/f.20210207.003
10. Zhou X, Liu J. Research on the effect of price control of medical services in the context of medical reform. *Econ Manage.* (2021) 35:8–14.
11. Tian S-Z, Tong M-M, Li X. Fiscal expenditure, government competition and health care service level—an empirical analysis based on provincial panel entropy Tobit model. *J Yunnan Univ Fin Econ.* (2022) 38:19–36. doi: 10.16537/j.cnki.jynufe.000807



12. Tao C, Jiao R. Does government health spending “crowd in” to residents’ health care consumption? An analysis based on panel threshold regression model. *J Jiangxi Univ Finance Econ*. (2020) 27–39. doi: 10.13676/j.cnki.cn36-1224/f.2020.04.004
13. Yang L. Health policy and health inequality: a critique of the Western neoclassical liberalism. *Fujian Forum*. (2021) 169–78.
14. Yuan XJ. A study on the impact of the level of public medical service supply on residents’ income in China. *Yunnan Univ Fin Econ*. (2022).
15. Arellano M, Bond S. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev Econ Stud*. (1991) 58:277–97.
16. Gao C. Path options for the development and governance of medical service industry in the stage of high quality development. *Soc Sci Front*. (2019) 222–229.
17. Chen YZ, Li SH, Huang Y. Several theoretical issues of China’s health care reform. *Financ Econ Sci*. (2018) 76–88.
18. Deng LF. Study on the association between workforce health and economic growth. *Acad Res*. (2012) 79–85.
19. Yu J, Yang S. Regional differences in the supply level of medical and health resources in China and the influencing factors. *Stat Decis Making*. (2021) 37:69–72. doi: 10.13546/j.cnki.tjyj.2021.06.015
20. Wang W, Bei D. Digital inclusive finance, government intervention and county economic growth: an empirical analysis based on threshold panel regression. *Econ Theory Econ Manage*. (2022) 42:41–53.
21. Gu X, Sun X. Social governance of universal health insurance: a social infrastructure towards common prosperity. *J Wuhan Univ Sci Technol*. (2022) 24:494–503.
22. Li X, Jiang C, Hu L. Study on the impact of financial health care expenditure on multidimensional poverty in China’s health. *China Popul Sci*. (2020) 128:84–97.
23. Yan T, Annie Y, Xu X. Internet finance, government intervention and economic growth quality—an empirical test based on a panel threshold regression model. *Fiscal Res*. (2019) 47–61. doi: 10.19477/j.cnki.11-1077/f.2019.09.005
24. Li Y, Zheng C. Benefit attribution of public health care services and its income distribution effect in China—a micro analysis based on household survey data. *Econ Res*. (2016) 51:132–46.
25. Yuan X, Wang X, Mao Z, Mao Z. Research on the linkage between national health and economic growth under the health China strategy—based on human, technological and industrial perspectives. *East China Econ Manage*. (2022) 36:89–95. doi: 10.19629/j.cnki.34-1014/f.211228002
26. Wang L. Study on Xi Jinping’s strategic thought of “Health China”—a two-dimensional perspective of ethics and economy. *J Tianjin Normal Univ*. (2018) 12–17.
27. Ying HK. Economic transition and reform of China’s health care system. *Contemp Econ Stud*. (2006) 52–4.
28. Blundell R, Bond S. Initial conditions and moment restrictions in dynamic panel data models. *J Econom*. (1998) 87:115–43.
29. Yu L, Liu H. Stakeholders, health care equity and health care system reform in China. *Shandong Social Sci*. (2020) 125–31. doi: 10.14112/j.cnki.37-1053/c.2020.07.019
30. Li Y. Mechanisms and precise improvement paths of Medicare’s impact on health equality. *Social Secur Rev*. (2022) 6:59–73.
31. Dong JK, Qian F, Xing YQ, et al. Research on the goal, connotation and realization path of promoting common prosperity in the field of health. *Health Econ Res*. (2022) 39:1–4. doi: 10.14055/j.cnki.33-1056/f.2022.09.023
32. Hansen BE. Threshold effects in non-dynamic panels: estimation, testing and inference. *J Econom*. (1999) 93:345–68.



## OPEN ACCESS

## EDITED BY

Timotej Jagric,  
University of Maribor, Slovenia

## REVIEWED BY

Kazumitsu Nawata,  
Hitotsubashi University, Japan  
Shazia Rehman,  
Central South University, China

## \*CORRESPONDENCE

Qiang Sun  
✉ qiangs@sdu.edu.cn

RECEIVED 13 October 2022

ACCEPTED 12 May 2023

PUBLISHED 01 June 2023

## CITATION

Ding Y, Yin J, Zheng C, Dixon S and Sun Q (2023) The impacts of diagnosis-intervention packet payment on the providers' behavior of inpatient care—evidence from a national pilot city in China.  
*Front. Public Health* 11:1069131.  
doi: 10.3389/fpubh.2023.1069131

## COPYRIGHT

© 2023 Ding, Yin, Zheng, Dixon and Sun. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# The impacts of diagnosis-intervention packet payment on the providers' behavior of inpatient care—evidence from a national pilot city in China

Yi Ding<sup>1,2</sup>, Jia Yin<sup>1,2</sup>, Chao Zheng<sup>1,2</sup>, Simon Dixon<sup>3,4</sup> and Qiang Sun<sup>1,2\*</sup>

<sup>1</sup>Center for Health Management and Policy Research, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China, <sup>2</sup>NHC Key Lab of Health Economics and Policy Research, Shandong University, Jinan, China, <sup>3</sup>Health Economics and Decision Science (HEDS), SchARR, University of Sheffield Regent Court, Sheffield, United Kingdom, <sup>4</sup>Wits Centre for Health Economics and Decision Science, University of the Witwatersrand, Johannesburg, South Africa

**Background:** In 2020, the Chinese government developed and implemented an innovative case-based payment method under the regional global budget called the diagnosis-intervention packet (DIP) payment to pay for inpatient care. This study aims to assess the changes to inpatient care provision in hospitals after the DIP payment reform was implemented.

**Methods:** This study used inpatient medical costs per case, the proportion of the out-of-pocket (OOP) expenditure in inpatient medical costs, and the average length of stay (LOS) of inpatient care as outcome variables, and conducted an interrupted time series analysis to evaluate changes after the DIP payment reform. January 2021 was taken as the intervention point when a national pilot city of the DIP payment reform in the Shandong province began using the DIP payment to pay for inpatient care of secondary and tertiary hospitals. The data used in this study were obtained from the aggregated monthly claim data of inpatient care of secondary and tertiary hospitals.

**Results:** Compared to the pre-intervention trend, the inpatient medical costs per case, the proportion of the OOP expenditure in inpatient medical costs both in tertiary and secondary hospitals significantly decreased after the intervention. After the intervention, the reduction in the inpatient medical costs per case, the proportion of the OOP expenditure in inpatient medical costs in tertiary hospital were both higher than those in secondary hospital ( $p < 0.001$ ). The average LOS of inpatient care in secondary hospital significantly increased after the intervention, and it immediately increase 0.44day after intervention ( $p = 0.211$ ). Moreover, the change of average LOS of inpatient care in secondary hospital after intervention was opposite to that in tertiary hospital, it had no statistical difference ( $p = 0.269$ ).

**Conclusion:** In the short term, the DIP payment reform could not only effectively regulate provider behavior of inpatient care in hospitals, but also improves the rational allocation of the regional healthcare resources. However, the long-term effects of the DIP payment reform need to be investigated in the future.

## KEYWORDS

case-based payment method, diagnosis-intervention packet (DIP) payment, inpatient care provision, interrupted time series analysis, China

## Introduction

The growth of health expenditure has become a critical issue for healthcare policymakers and governments in many countries. To remedy this, countries have sought to improve the efficiency of healthcare delivery and reduce the growth rate of health expenditure by implementing healthcare provider payment reforms (1). Among the global empirical evidence of provider payment methods reforms, case-based payment approaches, such as the diagnosis-related group (DRG) system, have been widely adopted to pay for inpatient care (2, 3). Moreover, previous research has highlighted that case-based payment methods not only promoted the transparency and quality of healthcare services, but also enabled policymakers to not accurately compare the healthcare service performance of different hospitals (4).

Over past decades, total health expenditure (THE) in China has rapidly increased (5). This is thought to be a result of the prolonged use of fee-for-service (FFS) payments for inpatient care (6, 7), which has been associated with over-treatment and induced demand (8, 9). In an effort to curb the increase of the health expenditure, many cities throughout China have tried to design and implement various case-based payment methods (10, 11). The design frameworks of these case-based payments were based on the characteristics of local healthcare service markets, and as a result, it is difficult to generate generalizable findings from their implementation. Consequently, the Chinese government initiated DRG payment system reform in 2019 to control the growth of health expenditure (12). When developing the reforms, it was noted that a number of studies showed that the DRG payment system cannot cover all forms of healthcare services, and it also leads to unintended provider behaviors, such as up-coding, cream skinning, or induced demand behavior (13, 14). In addition, it was recognized that the operation of the DRG payment system requires a high administrative cost and advanced information system (15). Accordingly, the Chinese government decided to develop an innovative case-based payment system with a uniform design framework, which was intended to avoid some of the problems associated with existing DRG payment systems (16). Eventually, in 2020, the Chinese government launched an innovative case-based payment method under the regional global budget called the diagnosis-intervention packet (DIP) payment.

However, as the DIP payment is a recent initiative. There are few studies about the effect evaluation of the DIP payment, which leads that the current studies have not been able to adequately demonstrate its impact on changes to inpatient care provision until now. Among the few related studies, Lai et al. (17) discovered that the inpatient medical costs per case and the medication costs of inpatient care were significantly decreased after the DIP payment was implemented in

Guangzhou. However, Qian et al. (18) outlined that the implementation of DIP yet increases the inpatient medical costs per case. Accordingly, this study selects the pilot city of the DIP payment in Shandong province as case city and aims to explore the changes to inpatient care provision in secondary and tertiary hospitals after the DIP payment reform was implemented, which can comprehensively demonstrate the impacts of diagnosis-intervention packet payment on the providers' behavior of inpatient care.

## The design framework of the DIP payment

As with the DRG payment system, the DIP payment includes a series of classifications of DIP disease groups. Based on the same major diagnosis principles and similar treatment procedures, the National Healthcare Security Administration firstly enacted the uniform score catalogue and classification standards of the DIP disease groups, containing 11,553 core disease groups and 2,499 comprehensive disease groups. Subsequently, according to the uniform classification standards of the DIP disease groups, the 71 pilot cities of the DIP payment reform throughout China were required to enact the catalog of core disease groups and comprehensive disease groups. Meanwhile, the pilot cities needed to formulate the average score of each local DIP disease group by using the average medical cost of all inpatient care cases in the last 3 years.

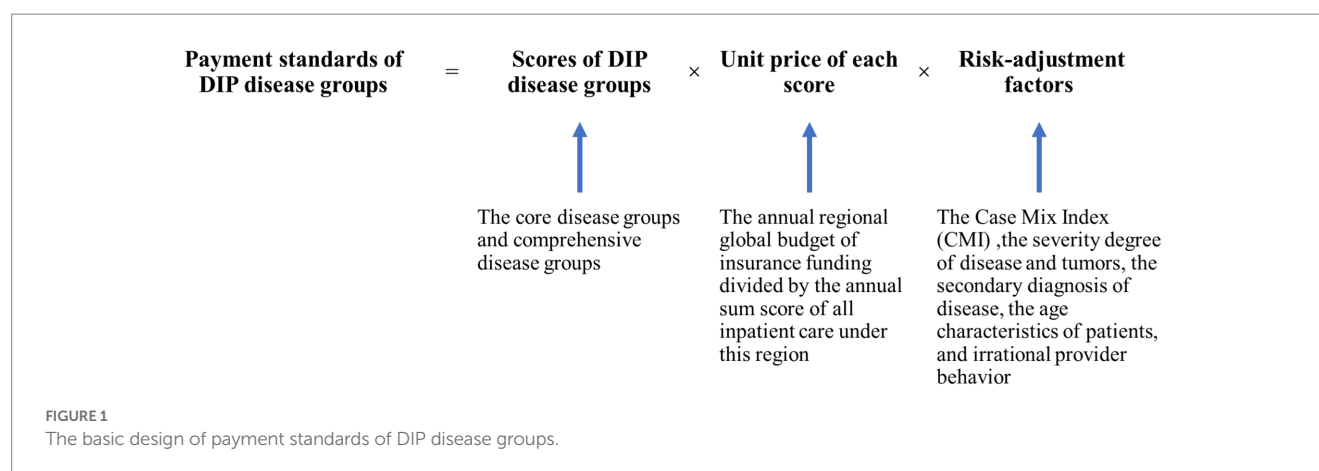
Although the DIP payment has several differences with the DRG payment (Table 1), however the most significant feature of the new system is the design of payment standards of DIP disease groups (Figure 1). Unlike predetermined DRG payment systems, the payment standards of

TABLE 1 The differences between the DIP and DRG payment.

Differences	DIP	DRG
The number of disease groups	≥10,000	≤1,000
Grouping basis	Historical medical records	Clinical pathways (based on the experts' experience)
Referring factors of formulating disease groups	Major diagnosis, related surgery	Patients' gender, age, length of stay, clinical diagnosis, surgery, the severity of disease, complication and comorbidity, etc.
Variation between groups	Unobvious	Obvious
Payment unit	DIP groups	DRG groups
Payment standard	Unit price of each score	Relative weight of DRG groups

[http://zzsybj.zaozhuang.gov.cn/ztlz/djqzpb/202204/t20220412\\_1415550.html](http://zzsybj.zaozhuang.gov.cn/ztlz/djqzpb/202204/t20220412_1415550.html).

Abbreviations: DIP, diagnosis-intervention packet; OOP, out-of-pocket; DRG, diagnosis-related group; ITS, interrupted time series analysis; OLS, ordinary least squares; LOS, length of stay.



DIP payments are not fixed. Although the scores that reflect the consumption of healthcare resources of DIP disease groups are certain, the monetary value, or unit cost, of each score is not predefined. The value of the DIP payment depends on the regional global budget of insurance funding and the regional sum score of all inpatient care in the pilot cities (19). More specifically, the annual unit price of each score equals the annual regional global budget divided by the annual sum score of all inpatient care under this region, together with a further risk-adjustment (Equation 1). As such, if the healthcare service volumes increase, then the unit price of each score will be devalued, which will affect the revenue of the hospitals. The aforementioned risk-adjustment includes the Case Mix Index (CMI), the status of the hospital and the type of health insurance, are brought into the calculation of the reimbursements of hospitals.

Reimbursements to hospitals are further adjusted based on several indicators of performance. These include, quality of medical records, readmission rate, length of stay (LOS) and mortality. These adjustments are made in the form of organization level 'fines' (Equation 2).

$$\text{Unit price of each score} = \frac{\text{regional global budget of insurance funding}}{\text{regional sum score of all inpatient care}} \quad (1)$$

$$\begin{aligned} \text{Reimbursements of hospitals} = & \text{sum score of all inpatient care} \\ & \times \text{unit price of each score} \\ & \times \text{rank coefficient} \\ & \times \text{risk - adjustment factors - fines} \end{aligned} \quad (2)$$

Through this design, the policymakers hope that the DIP payment can effectively incentivize individual hospitals to improve the efficiency and quality of their services, while promoting the allocative efficiency of regional healthcare resources.

## Methods

### Study design

As one of the 71 pilot cities in China, City A is the only pilot and typical city of the DIP payment reform in the Shandong province. It

has three urban areas and two country areas. In 2021, the number of the resident population is 2.20 million residents, and the Gross Domestic Product *per capita* is 156.90 CNY which is the highest in Shandong province (20). Moreover, City A has seven tertiary hospitals and thirty-nine secondary hospitals that used the single case-based payment system under the regional global budget to pay for inpatient care before the DIP payment was introduced. The single case-based payment system in City A had many similarities to the DIP system that replaced it, however, important differences can be seen in relation to the number of disease groups, risk adjustment and payment ceilings for individual hospitals (Table 2).

In 2020, City A introduced the DIP payment system to categorize inpatient care without changing the reimbursement policies of inpatient care. From January 2021, City A started to use the DIP payment to pay for all inpatient care of local secondary and tertiary hospitals.

As such, the implementation of the DIP payment reform in City A was conceptualized as a quasi-experiment, with January 2021 serving as the intervention point in this study. An interrupted time series (ITS) design was used to assess whether the DIP payment reform produced significant changes to inpatient care provision in secondary and tertiary hospitals.

### Data sources

Fortunately, City A is the only one in Shandong province that did not have a COVID-19 pandemic before May 2022. All the residents' healthcare consumption always can be satisfied in local hospitals. Therefore, we collected and aggregated the monthly medical claim data of inpatient care for secondary and tertiary hospitals in City A during January 2019 to April 2022, which was obtained from the Healthcare Security Administration in City A.

### Variables

To accurately quantify the change to inpatient care provision in hospitals, several variables were selected for measurement during the study observation, including inpatient medical costs per case, proportion of the out-of-pocket (OOP) expenditure in inpatient

TABLE 2 The design difference between the single case-based payment and the DIP payment in City A.

Elements of the payment	Single case-based payment	DIP payment
Payment scope	All local inpatient care cases	All local inpatient care cases of secondary and tertiary hospitals
Number of disease groups of payment	5,500 disease groups	3,210 DIP disease groups, comprising 2,765 core disease groups and 445 comprehensive disease groups
Principle of formulating disease groups	Major diagnosis	Same major diagnosis and similar treatment procedure
Principle of formulating scores of disease groups	Average medical cost of previous cases of all inpatient care in last 3 years	Average medical cost of previous cases of all inpatient care in last 3 years and experts' suggestions
Calculation of the unit price of each score	Annual regional global budget/regional sum score of inpatient care	Annual regional global budget/regional sum score of inpatient care with a risk-adjustment mechanism
Annual ceiling of scores of hospitals	Setting the annual scores ceiling to different hospitals	Setting no annual scores ceiling to hospitals

medical costs, and average LOS of inpatient care. All data in the study was adjusted using the related consumer price index, with 2019 serving as the base year (20). A log transformation was performed for the skewed data distribution in this study. Additionally, the ordinary least squares (OLS) regressions incorporated seasonal adjustments for the variables that displayed conspicuous seasonal effects (21).

## Statistical analysis

The ITS analysis was used to assess the changes to inpatient care provision. In the ITS analysis, a segmented OLS regression model with a Newey-West test was used to assess the impacts of the DIP payment reform on the change to inpatient care provision in hospitals (22). The segmented regression model we adopted is shown below:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 T_t X_t + \varepsilon_t$$

$Y_t$  is the dependent variable we measured at every monthly point  $t$ ,  $T_t$  is the time series variable representing the time in months since the start of observation until to the time  $t$ ,  $X_t$  is a dummy variable representing the intervention point (pre-intervention period is 0 and the post-intervention period is 1),  $T_t X_t$  is an interaction term of the time and intervention, and  $\varepsilon_t$  is the residual term representing the unknown variation component of the regression model.  $\beta_0$  represents the baseline level;  $\beta_1$  represents the baseline trend prior to intervention;  $\beta_2$  represents the immediate level of change after the intervention compared to the pre-intervention;  $\beta_3$  represents the trend change after the intervention compared to the pre-intervention; and  $\beta_1 + \beta_3$  represents the trend after the intervention (23). The *actest* command was conducted to assess autocorrelation and the autocorrelation results were both present at lag1 (24). STATA 16.0 was used to perform all statistical analysis. Two-sided hypothesis tests of no effect, with  $p < 0.05$  were considered statistically significant.

## Results

### Changes to the inpatient medical costs per case

Figure 2 demonstrates that the inpatient medical costs per case in tertiary hospitals perceptibly decreased after the intervention. The inpatient medical costs per case in tertiary hospital decreased by 150

CNY per month compared to the pre-intervention trend ( $p < 0.001$ ) (Table 3). Moreover, compared to the pre-intervention trend, the inpatient medical costs per case in secondary hospital decreased only slightly after the intervention, having no statistically significant difference ( $p = 0.307$ ). However, the inpatient medical costs per case in tertiary hospitals keep decreasing by 0.07 CNY per month, which is opposite to that in secondary hospitals ( $p < 0.05$ ) (Table 3).

### Changes to the proportion of the OOP expenditure in inpatient medical costs

After the intervention, the proportion of the OOP expenditure in inpatient medical costs in secondary and tertiary hospitals both decreased slightly ( $p < 0.001$ ) (Figure 3). The proportion of the OOP expenditure in inpatient medical costs in secondary decreasing by 0.09 percentage points per month compared to the pre-intervention trend ( $p < 0.01$ ). Furthermore, the reduction in the proportion of the OOP expenditure in inpatient medical costs in tertiary hospital was more pronounced than that in secondary hospital (Table 3), decreasing by 0.17 percentage points per month compared to the pre-intervention trend ( $p < 0.001$ ) (Table 3).

### Changes to the average LOS of inpatient care

Prior to intervention, the baseline trend of the average LOS of inpatient care in secondary and tertiary hospitals had no obvious difference (Figure 4). After the intervention, the average LOS of inpatient care in secondary immediately increase 0.44 day in February 2021 which is significantly obvious than that in tertiary hospitals ( $p = 0.211$ ). However, the change in average LOS of inpatient care in secondary and tertiary hospitals were opposite. Compared to the pre-intervention trend, the average LOS of inpatient care in tertiary hospital decreased by 0.05 day ( $p < 0.001$ ), and the average LOS of inpatient care in secondary hospital increased 0.04 day ( $p < 0.001$ ) (Table 3).

## Discussion

The rapid growth of the inpatient health expenditure poses a serious challenge for the Chinese government (25). Faced with this predicament, the Chinese government has implemented a series of



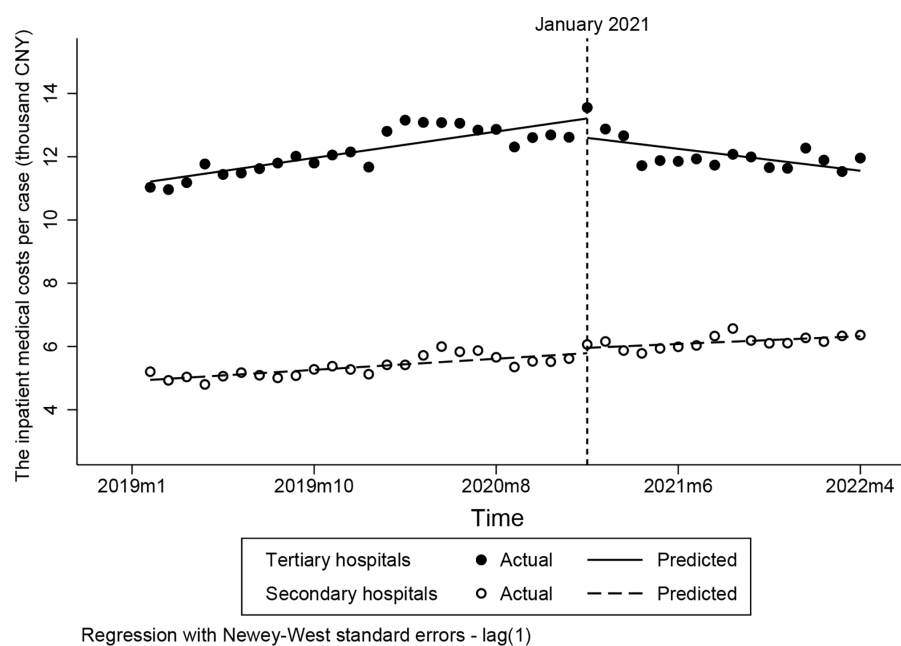


FIGURE 2  
Changes to inpatient medical costs per case.

TABLE 3 The change of levels and trends of variables before and after intervention.

Variables	Tertiary hospital			Secondary hospital		
	Coefficient	P	95% CI	Coefficient	P	95% CI
The inpatient medical costs per case (thousand CNY)						
$\beta_0$	11.21	0.000	[10.97, 11.46]	4.94	0.000	[4.81, 5.08]
$\beta_1$	0.08	0.000	[0.06, 0.11]	0.04	0.000	[0.02, 0.05]
$\beta_2$	-0.61	0.167	[-1.50, 0.27]	0.17	0.287	[-0.15, 0.48]
$\beta_3$	-0.15	0.000	[-0.22, -0.09]	-0.01	0.307	[-0.03, 0.01]
$\beta_1 + \beta_3$	-0.07	0.038	[-0.13, 0.00]	0.02	0.003	[0.01, 0.04]
The proportion of the OOP expenditure in inpatient medical costs (%)						
$\beta_0$	45.02	0.000	[44.50, 45.53]	38.88	0.000	[38.57, 39.19]
$\beta_1$	0.02	0.354	[-0.02, 0.07]	-0.06	0.001	[-0.09, -0.03]
$\beta_2$	0.61	0.183	[-0.30, 1.53]	-0.32	0.419	[-1.13, 0.48]
$\beta_3$	-0.17	0.000	[-0.23, -0.11]	-0.09	0.007	[-0.15, -0.03]
$\beta_1 + \beta_3$	-0.15	0.000	[-0.20, -0.11]	-0.15	0.000	[-0.20, -0.09]
The average LOS of inpatient care (day)						
$\beta_0$	9.89	0.000	[9.73, 10.05]	8.57	0.000	[8.10, 9.04]
$\beta_1$	-0.02	0.000	[-0.03, -0.01]	0.00	0.845	[-0.03, 0.03]
$\beta_2$	0.09	0.356	[-0.11, 0.30]	0.44	0.211	[-0.26, 1.14]
$\beta_3$	-0.05	0.000	[-0.07, -0.02]	0.04	0.337	[-0.04, 0.12]
$\beta_1 + \beta_3$	-0.07	0.002	[-0.09, -0.05]	0.04	0.269	[-0.03, 0.12]

$\beta_0$ , the baseline level;  $\beta_1$ , the baseline trend prior to intervention;  $\beta_2$ , the immediate level of change after the intervention compared to the pre-intervention;  $\beta_3$ , the trend change after the intervention compared to the pre-intervention;  $\beta_1 + \beta_3$ , the trend after the intervention.

healthcare provider payment reform policies including the DIP payment reform, especially since the National Healthcare Security Administration was established in 2018 (26).

In this study, we found that the inpatient medical costs per case decreased after the implementation of the DIP payment reform, which was aligned to the related studies (17). Consequently, this result is

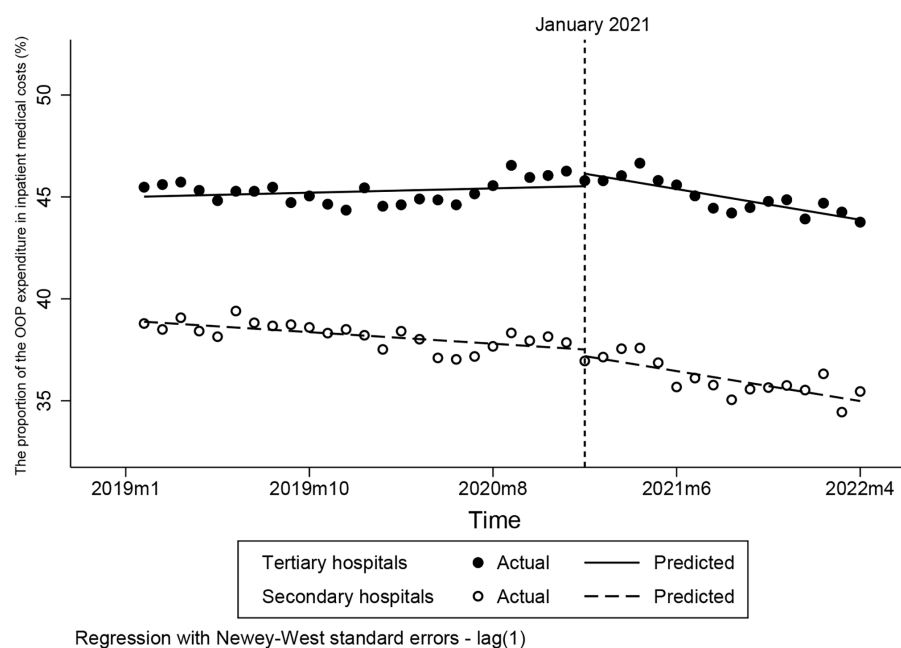


FIGURE 3

Changes to the proportion of the OOP expenditure in inpatient medical costs. OOP, out-of-pocket.

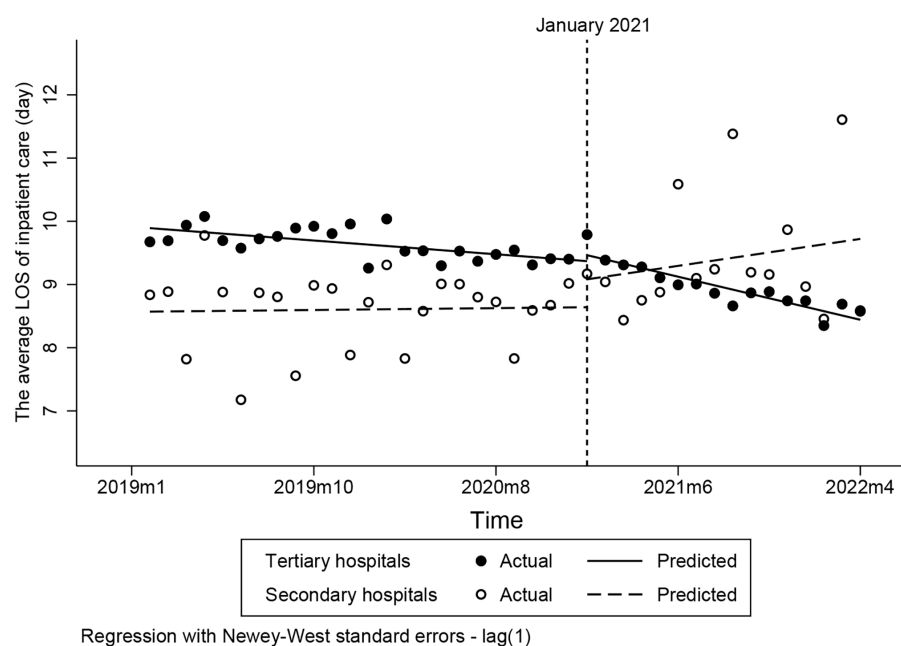


FIGURE 4

Changes to the average LOS of inpatient care. LOS, length of stay.

believed to illustrate the advantage of the DIP payment reform design in controlling the inpatient medical costs, especially for tertiary hospitals. Based on the design of the DIP payment, in the situation where the unit price of each score in the DIP payment was unknown before the end of a year, hospitals under the DIP payment had to improve the efficiency of their inpatient care in order to prevent the potential money devaluation of scores of DIP disease groups.

Furthermore, although the detailed classifications of DIP disease groups make the provider payment more rational and scientific, however it also brings higher requirement to capacity of cost containment and management of different hospitals. In this case, the hospitals especially tertiary hospitals under the DIP payment will have more initiatives to control the medical costs to ensure the normal revenue of hospitals.

Previous studies highlight that the single healthcare provider payment reforms occasionally result in the increase in the proportion of the OOP expenditure or other medical costs of healthcare services (27, 28). In China, the healthcare service purchasers, such as the Healthcare Security Administration, preferred to use the single healthcare provider payments, such as the global budget or quota payments to pay for hospitals through “premium packages” (7, 29). Additionally, the payment standards of single healthcare provider payments used in China commonly lack the detailed risk-adjustment mechanisms that generate payment standards, which cannot satisfy the practical demand of different hospitals (30). Therefore, hospitals have had to decrease the provision of healthcare services reimbursed by medical insurance to prevent overspending of the medical insurance budget. In China, due to the service volume in tertiary hospitals is much larger than that in secondary hospitals, therefore that phenomenon is more obvious in tertiary hospitals (31). Surprisingly, for both secondary and tertiary hospitals, the proportion of the OOP expenditure in inpatient medical costs was found to significantly decrease after the intervention, fully illustrating that the implementation of the DIP payment reform could effectively promote hospitals to increase the provision of healthcare services covered by medical insurance and regulate the provider behavior in hospitals. It is concluded that the average score of the disease groups, along with the risk-adjustment mechanism of payment standards, are the key factors contributing to this effect. The establishment of the risk-adjustment mechanism aligns the payment standards more closely with the practical demand of secondary and tertiary hospitals, thereby alleviating the pressure of cost containment while providing more rational treatments and services to patients. In addition, this result convincingly proves that the risk-adjustment factors mechanism can promote payment standards more reasonable, which can better satisfy the actual operation costs of hospitals with different statuses.

It is worth noting that the average LOS in secondary hospital experienced an obvious increase after the DIP payment reform was implemented, which was opposite to that in tertiary hospital. We consider that this opposite result is a positive reaction to the implementation of the DIP payment. In order to better reflect the service capacity of hospitals, the reimbursements of hospitals in the DIP payment are relevant to the severity degree of inpatient cases and the status of hospitals. It not only promoted hospitals have more initiatives to treatment the sicker cases, but also achieved that the hospitals under the DIP payment have no necessary to strictly control the LOS of inpatient care due to the cost containment. Accordingly, the reasons we conclude behind the change of the average LOS in this study was that the implementation of the DIP payment enhanced the enthusiasm of inpatient care provision in secondary hospitals, which made some patients who can be treated in secondary hospitals accept more treatments. Additionally, the number of secondary hospitals is more than that of tertiary hospitals, and the copayment ratio of inpatient care in City A is increased with the status of hospitals increases. In this case, the patients got more inpatient care in secondary hospitals also led to the LOS in tertiary hospitals decreasing. Furthermore, the reduction of the proportion of the OOP expenditure in inpatient medical costs in tertiary hospitals compared to the pre-intervention trend is more obvious than that in secondary hospitals after the DIP payment reform was implemented, which further illustrates that the DIP payment reform can effectively alleviate the cost-control pressure of inpatient care in tertiary hospitals.

Therefore, combined with the change in the proportion of OOP expenditure in inpatient medical costs and average LOS in secondary and tertiary hospitals, we believe that the DIP payment reform not only alleviated the provision pressure of inpatient care in tertiary hospitals but also improved the rational allocation of the regional healthcare resources. However, Vuagnat et al. outlined that case-based payments, such as the DRG payment, could indirectly lead hospitals to increase the average LOS and readmission rates of inpatient care for the sake of getting more premium (32). Furthermore, related study highlighted that the implementation of the DIP payment could potentially increase the frequency of up-coding behavior in hospitals (17). According to the change in average LOS in this study, we cannot rule out the possibility that the implementation of the DIP payment reform might also generate unintended consequences for inpatient care in secondary hospitals.

## Limitations

This study has several limitations that needed to be addressed: First, this study did not introduce a control group which means that we cannot rule out the possibility that the estimated changes are due to the impact of other phenomena, that changed patient and hospital behavior. Second, due to its recent introduction, we were only able to assess the short-term effects of the DIP payment reform, yet it is possible that there may be a lag in realizing the full effect of policy changes as patients and providers adapt to the new incentives. Third, this study did not involve patient outcomes, such as patient satisfaction or readmission rate, which could indicate a potential impact of the DIP payment on quality of inpatient care.

## Conclusion

The DIP payment could effectively regulate provider behavior of inpatient care in hospitals in the short term, both of which are clearly reflected in the decrease of inpatient medical costs per case and the proportion of the OOP expenditure in inpatient medical costs in secondary and tertiary hospitals. Meanwhile, the implementation of the DIP payment could improve the rational allocation of the regional healthcare resources, which is reflected in the significant increase of the average LOS of inpatient care in secondary hospital and the decrease of average LOS of inpatient care in tertiary hospital. However, the long-term effects of the DIP payment reform still need to be evaluated in the future. In summary, we suggest the countries that are using the case-based payment or ongoing provider payment reform of inpatient care refer to the design elements of the DIP payment to further improve the design of case-based payments.

## Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: the data that support the findings of this study are available from the Healthcare Security Administrations but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Requests to access these datasets should be directed to YD, 201920724@mail.sdu.edu.cn.

## Author contributions

YD, CZ, and QS: conceptualization. JY, SD, and QS: project administration and supervision. YD and CZ: data curation, methodology, and software. YD: writing—original draft. YD, SD, and QS: writing—review and editing. All authors contributed to the article and approved the submitted version.

## Funding

This work was undertaken as part of the UK China Health and Economy Partnership, a higher education programme funded by the GlaxoSmithKline (GSK) and supported by the British Council through an unrestricted grant. The funder was not involved in the

study design, collection, analysis, interpretation of data, the writing of this article or the decision to submit it for publication.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Caryn B, Sarah B, Kristiina K. *Transition to diagnosis related group (DRG) payments for health: lessons from case studies*. World Bank Group (2020). doi: 10.1596/978-1-4648-1521-8
- Kim S, Jung C, Yon J, Park H, Yang H, Kang H, et al. A review of the complexity adjustment in the Korean diagnosis-related group (KDRG). *Health Inf Manag J*. (2020) 49:62–8. doi: 10.1177/1833358318795804
- Kone I, Maria ZB, Nordstrom K, Simone EB, Wangmo T. A scoping review of empirical evidence on the impacts of the DRG introduction in Germany and Switzerland. *Int J Health Plan Manag*. (2019) 34:56–70. doi: 10.1002/hpm.2669
- Peter Leslie A, Dale H. *Case-based payment systems for hospital funding in Asia: an investigation of current status and future directions*. Geneva, World Health Organization (2015). doi: 10.1787/9789264173446-en
- Wang L, Chen Y. Determinants of China's health expenditure growth: based on Baumol's cost disease theory. *Int J Equity Health*. (2021) 20:213. doi: 10.1186/s12939-021-01550-y
- Zhou W, Jian W, Wang Z, Pan J, Hu M, Yip W. Impact of global budget combined with pay-for-performance on the quality of care in county hospitals: a difference-in-differences study design with a propensity-score-matched control group using data from Guizhou province, China. *BMC Health Serv Res*. (2021) 21:1296. doi: 10.1186/s12913-021-07338-8
- Guan X, Zhang C, Hu H, Shi L. The impact of global budget on expenditure, service volume, and quality of care among patients with pneumonia in a secondary hospital in China: a retrospective study. *BMC Public Health*. (2020) 20:522. doi: 10.1186/s12889-020-08619-3
- Gao C, Xu F, Liu GG. Payment reform and changes in health care in China. *Soc Sci Med*. (2014) 111:10–6. doi: 10.1016/j.socscimed.2014.03.035
- Yu J, Qiu Y, He Z. Is universal and uniform health insurance better for China? Evidence from the perspective of supply-induced demand. *Health Econ Policy Law*. (2020) 15:56–71. doi: 10.1017/S1744133118000385
- Shi M, Wang J, Zhang L, Yan Y, Miao YD, Zhang X. Effects of integrated case payment on medical expenditure and readmission of inpatients with chronic obstructive pulmonary disease: a nonrandomized, comparative study in Xi County, China. *Curr Med Sci*. (2018) 38:558–66. doi: 10.1007/s11596-018-1914-1
- Liu S, Wang J, Zhang L, Zhang X. Caesarean section rate and cost control effectiveness of case payment reform in the new cooperative medical scheme for delivery: evidence from Xi County, China. *Bmc Pregnancy Childbirth*. (2018) 18:66. doi: 10.1186/s12884-018-1698-0
- National Healthcare Security Administration. Notification about publishing the technical specification and catalogue scheme of the diagnosis-related groups payment (DRG) (in Chinese). (2019). Available at: ([http://www.nhsa.gov.cn/art/2019/10/24/art\\_104\\_6464.html](http://www.nhsa.gov.cn/art/2019/10/24/art_104_6464.html)).
- Yu L, Lang J. Diagnosis-related groups (DRG) pricing and payment policy in China: where are we? *Hepatobil Surg Nutr*. (2020) 9:771–3. doi: 10.21037/hbsn-2020-8
- Zhao C, Wang C, Shen C, Wang Q. Diagnosis-related group (DRG)-based case-mix funding system, a promising alternative for fee for service payment in China. *Biosci Trends*. (2018) 12:109–15. doi: 10.5582/bst.2017.01289
- Inke M, Friedrich W. *DRG-based payment systems in low- and middle-income countries: implementation experiences and challenges*. World Health Organization (2012)
- National Healthcare Security Administration. Notification about publishing the pilot implementation scheme of the regional points of global budget and the case-based payment methods (in Chinese). (2020). Available: ([http://www.nhsa.gov.cn/art/2020/10/19/art\\_37\\_3752.html](http://www.nhsa.gov.cn/art/2020/10/19/art_37_3752.html)).
- Lai Y, Fu H, Li L, Yip W. Hospital response to a case-based payment scheme under regional global budget: the case of Guangzhou in China. *Soc Sci Med*. (2022) 292:114601. doi: 10.1016/j.socscimed.2021.114601
- Qian M, Zhang X, Chen Y, Xu S, Ying X. The pilot of a new patient classification-based payment system in China: the impact on costs, length of stay and quality. *Soc Sci Med*. (2021) 289:114415. doi: 10.1016/j.socscimed.2021.114415
- National Healthcare Security Administration. Notification about publishing the technical specification and catalogue of diseases of the diagnosis-intervention packet (DIP) payment for National Healthcare Security (in Chinese). (2020). Available at: ([http://www.nhsa.gov.cn/art/2020/11/20/art\\_37\\_3987.html](http://www.nhsa.gov.cn/art/2020/11/20/art_37_3987.html)).
- Shandong Provincial Bureau of Statistics. *Shandong statistical yearbook 2021 (in Chinese)*. Jinan: China Statistics Press (2021).
- Kim H, Lee JT, Fong KC, Bell ML. Alternative adjustment for seasonality and long-term time-trend in time-series analysis for long-term environmental exposures and disease counts. *BMC Med Res Methodol*. (2021) 21:2. doi: 10.1186/s12874-020-01199-1
- Jandoc R, Burden AM, Mamdani M, Levesque LE, Cadarette SM. Interrupted time series analysis in drug utilization research is increasing: systematic review and recommendations. *J Clin Epidemiol*. (2015) 68:950–6. doi: 10.1016/j.jclinepi.2014.12.018
- Fuller D, Sahlqvist S, Cummins S, Ogilvie D. The impact of public transportation strikes on use of a bicycle share program in London: interrupted time series design. *Prev Med*. (2012) 54:74–6. doi: 10.1016/j.ypmed.2011.09.021
- Lopez Bernal J, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: a tutorial. *Int J Epidemiol*. (2016) 46:dyw098. doi: 10.1093/ije/dyw098
- Zhai T, Goss J, Dmytraczenko T, Zhang Y, Li J, Chai P. China's health expenditure projections to 2035: future trajectory and the estimated impact of reforms. *Health Affair*. (2019) 38:835–43. doi: 10.1377/hlthaff.2018.05324
- National Healthcare Security Administration. Notification about enacting the implementation scheme of three years for reform of DRG/DIP payment methods (in Chinese). (2021). Available at: ([http://www.nhsa.gov.cn/art/2021/11/26/art\\_37\\_7406.html](http://www.nhsa.gov.cn/art/2021/11/26/art_37_7406.html)).
- Yan J, Lin HH, Zhao D, Hu Y, Shao R. China's new policy for healthcare cost-control based on global budget: a survey of 110 clinicians in hospitals. *BMC Health Serv Res*. (2019) 19:84. doi: 10.1186/s12913-019-3921-8
- Dong Y, Chen J, Jing X, Shi X, Chen Y, Deng X, et al. Impact of capitation on outpatient expenses among patients with diabetes mellitus in Tianjin, China: a natural experiment. *BMJ Open*. (2019) 9:e24807. doi: 10.1136/bmjopen-2018-024807

29. Li HM, Chen YC, Gao HX, Zhang Y, Su D, Chang JJ, et al. Changes in inpatients' distribution and benefits under institution level-based quota payment for specific diseases in rural China: an interrupted time-series analysis. *Int J Health Plan Manag.* (2019) 34:e436–46. doi: 10.1002/hpm.2660
30. Feng C, Meiyan J, Jianyun Z. Payment mode of foreign medical insurance and its enlightenment (in Chinese). *Chin J Pharmaceuticals.* (2017) 48:936–42.
31. He R, Miao Y, Zhang L, Yang J, Li Z, Li B. Effects of expanding outpatient benefit package on the rationality of medical service utilization of patients with hypertension: a quasi-experimental trial in rural China. *BMJ Open.* (2019) 9:e25254. doi: 10.1136/bmjopen-2018-025254
32. Vuagnat A, Yilmaz E, Roussot A, Rodwin V, Gadreau M, Bernard A, et al. Did case-based payment influence surgical readmission rates in France? A retrospective study. *BMJ Open.* (2018) 8:e18164. doi: 10.1136/bmjopen-2017-018164



# Frontiers in Public Health

Explores and addresses today's fast-moving healthcare challenges

One of the most cited journals in its field, which promotes discussion around inter-sectoral public health challenges spanning health promotion to climate change, transportation, environmental change and even species diversity.

## Discover the latest Research Topics

[See more →](#)

### Frontiers

Avenue du Tribunal-Fédéral 34  
1005 Lausanne, Switzerland  
[frontiersin.org](https://frontiersin.org)

### Contact us

+41 (0)21 510 17 00  
[frontiersin.org/about/contact](https://frontiersin.org/about/contact)



### Frontiers in Public Health

