INSIGHTS IN PUBLIC HEALTH POLICY: 2021

EDITED BY: Stefania Salmaso and Cathy Zimmerman
PUBLISHED IN: Frontiers in Public Health

frontiers Research Topics

frontiers

ISSN 1664-8714
ISBN 978-2-83250-263-1
DOI 10.3389/978-2-83250-263-1

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

INSIGHTS IN PUBLIC HEALTH POLICY: 2021

Topic Editors:
Stefania Salmaso, Independent Researcher, Italy
Cathy Zimmerman, University of London, United Kingdom

Citation: Salmaso, S., Zimmerman, C., eds. (2022). Insights in Public Health Policy: 2021. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-83250-263-1

Table of Contents

frontiers in Public Health

OPINION
published: 05 February 2021
doi: 10.3389/fpubh.2021.613484

The Reported Few Cases and Deaths of Covid-19 Epidemic in Africa Are Still Data Too Questionable to Reassure About the Future of This Continent

Maria Grazia Dente[1]*, *Carlo Vittorio Resti*[2], *Silvia Declich*[1] and *Giovanni Putoto*[3]

[1] National Center for Global Health, Istituto Superiore di Sanità, Rome, Italy, [2] Public Relations Office, San Camillo-Forlanini Hospital, Rome, Italy, [3] Planning and Operational Research Department, Doctors With Africa Collegio Aspiranti e Medici Missionari (CUAMM), Padova, Italy

Keywords: COVID-19, Africa, surveillance data, containment measures, health service access and utilization

INTRODUCTION

More than 10 months after the first case of COVID-19 in Africa was detected (in Egypt on February 14), prevalence and mortality are still relatively low and, although there are many hypotheses, the reasons remain unclear (1–3).

Reduced virulence of SARS-CoV-2 in Africa, genetic or trained immunity, and young population (3, 4) are among the main reasons being evaluated.

RELIABILITY OF THE DATA FOR HYPOTHESIS AND CONCLUSIONS

However, it should be considered that conclusions based on the limited available data might be misleading, also considering the fragility of the surveillance and health systems in many African countries and the possible weakness of their data. In addition, data governance in emergency contexts in Africa is historically difficult and some evidence shows that several African countries exert a tight control on public data and information (3, 5), particularly in the case of epidemics.

The WHO African Region reports that complete data on age and gender distribution are presently available only for around 1% of total confirmed cases and that the recent observed decline of cases should be interpreted with caution as many factors could explain this trend, including, but not limited to, changes in testing capacity and strategy, and reporting delays (6). In fact, low numbers of performed tests and high variability within national testing strategies (i.e., due to scarce resources, some countries are testing only symptomatic cases) do not allow monitoring the actual entity of the pandemic in the countries.

Although it increased since the starting of the pandemic, the total tests per population is still <10 per 1,000 in many countries. On December 7, the total daily COVID-19 tests in Africa oscillates between 0 and 1/1000 for around 20 countries with available data (7).

With limited testing, the positive rate might give some suggestions on the progression of the epidemic. Where the number of confirmed cases is high relative to the extent of testing, probably not enough tests are being carried out to properly monitor the outbreak. In such countries, the true number of infections may be far higher than the number of confirmed cases. "And where the positive rate is rising in a country, this can suggest the virus is actually spreading faster than the growth seen in confirmed cases" (7).

OPEN ACCESS

Edited by:
Jonathan Ling,
University of Sunderland,
United Kingdom

Reviewed by:
Shabir Madhi,
University of the Witwatersrand,
South Africa

***Correspondence:**
Maria Grazia Dente
mariagrazia.dente@iss.it

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

Received: *02 October 2020*
Accepted: *07 January 2021*
Published: *05 February 2021*

Citation:
Dente MG, Resti CV, Declich S and Putoto G (2021) The Reported Few Cases and Deaths of Covid-19 Epidemic in Africa Are Still Data Too Questionable to Reassure About the Future of This Continent. Front. Public Health 9:613484. doi: 10.3389/fpubh.2021.613484

Less than 5% of samples positive for COVID-19, at least for the last 2 weeks (assuming that surveillance for suspected cases is comprehensive), is one of the WHO criteria that indicate that the epidemic is under control (8).

In those African countries whose data are available, the positive rate on December 8 oscillates between 2.2 (Togo) and 28.2 (Democratic Republic of Congo), with increasing trend in some cases. However, how these values can be interpreted when very low number of tests are performed (Togo 0.11/1000 and DRC <0.01/1000)? (7).

In countries where data are collected, indications on the entity of this pandemic are provided by the excess of mortality, as reported by the South African Medical Research Council. From 6 May to 14 July, South Africa reported 4.453 COVID-19 deaths, but experienced 17.090 more deaths from all natural causes than would be expected based on historical averages. These excess deaths might be attributed to unreported COVID-19 deaths as well as due to other diseases, as health services are re-orientated, but South African researchers deem that COVID-19 underreporting has the biggest role in these unexplained excess deaths (9).

It is also challenging to understand what worked and what did not without reliable data that allow comparison (10). There has been limited testing of asymptomatic cases or of antibody titers to evaluate successes of early interventions in preventing transmission or possible differences in susceptibility between populations of different regions (3, 11). It is also plausible that not all countries have been able to implement and maintain the same containment and control measures for the epidemic over time. Therefore, comparisons are risky, and it is difficult to identify "winning and effective" strategies without considering specific national situations (12–15) as in the recent attempt done in Mali, Burkina Faso, Senegal, and Guinea (16). Often, as in these four countries, the strategies adopted are very similar to those applied in high-income countries, but the contexts are very different, and this seems to lead to suboptimal results. This is the case of measures that have had a strong impact on the existing social and cultural realities, compromising their acceptability within the communities.

In Nigeria, a multisectoral approach was planned including various levels of lockdowns and ban of gatherings. However, the envisaged mobilization of relevant stakeholders was partially missing, faith leaders were not appropriately engaged, and, despite the ban, they conducted congregation services (17); in Ghana, lockdown measures were activated from the earliest cases, but the epidemic was significant even if with a reported low case fatality ratio (0.6%) (6, 18).

IMPACT OF COVID-19 EPIDEMIC'S CONTAINMENT STRATEGIES AND MEASURES

On the basis of what has been reported and discussed in the previous section, the relatively low number of cases and deaths of COVID-19 reported in some African countries might be really far from the real situation. Moreover, the overall impact of the containment strategies and measures should not be underestimated.

Worldwide, lockdown and containment measures have posed major challenges, and the restrictive provisions needed to detect, test, isolate, and track positive cases of SARS-CoV-2 infection involve a very broad spectrum of activity and deeply affect national socio-economic dynamics.

The need for considerations on the impact of these measures is therefore fundamental and even more stringent as regards fragile states. For example, in order to flatten the outbreak curve, some African governments have imposed severe public health measures based on physical distancing to reduce transmission. However, the repercussions of this approach in poor communities may have been underestimated, and it is plausible that, ultimately, the lives lost due to the lockdown could outweigh those saved by COVID-19. In fact, some unwanted and potentially fatal consequences of social isolation are threatening the livelihood of African citizens, worsening the economic situation and increasing food insecurity, finally affecting also social stability and the genuine efforts of some countries in transition toward possible horizons of democracy (16, 19–23).

There is a need for targeted containment interventions monitored over time based on context-specific evidences that gradually consolidate. For example, outcomes from response to the COVID-19 epidemic in Zimbabwe suggest the restriction of the movement of people between different suburbs and between urban and rural areas while allowing some level of economic activity in association with active surveillance and testing for both imported and community cases (24, 25).

Some recent modeling studies show that before implementing travel restrictions, local COVID-19 incidence, local epidemic growth, and travel volumes should be considered, as restrictions seem to affect epidemic dynamics only in countries with low COVID-19 incidence and large numbers of arrivals from other countries, or where epidemics are at exponential growth (26).

The WHO "Pulse survey on continuity of essential health services during the COVID-19 pandemic" reported that all services were affected, including essential services, in nearly all countries, and more so in lower-income than higher-income countries (27, 28).

In many African countries, COVID-19 is "among" the country's epidemics, along with cholera, measles, malaria, and Ebola (29, 30). The COVID-19 epidemic response has exacerbated these fragile situations by reducing access and service delivery, as consequences of re-orientation of services, reduction of mobility, and fear of using the services. The focus on COVID-19 has diverted the attention away from the common pediatric infectious diseases, reproductive health care, the management of obstetric complications, and the provision of routine immunization services, which has been substantially blocked in at least 68 countries around the world, putting around 80 million children under the age of 1 at risk (31, 32).

Modeling estimations show that if the COVID-19 pandemic results in widespread disruption to health systems, childbirth care and child curative services will be the most affected and would account for the greatest number of additional maternal and child deaths (33).

Large numbers of patients in Africa with HIV and tuberculosis are dependent on functional health services, and if access to treatment is reduced or interrupted, the consequences for individual and public health can be substantial (34, 35).

The phenomenon is well-known, especially in Africa. The results from the modeling estimations done after the West African Ebola outbreak of 2014 are emblematic. They showed how dramatic was the impact on malaria, HIV/AIDS, and tuberculosis mortality rates through reduced access to treatment for varying reductions in treatment coverage. The modeling study indicated that 11,300 deaths from the Ebola virus had been nearly matched by 10,600 excess deaths from other diseases, especially malaria, HIV/AIDS, and tuberculosis (9, 36).

Fortunately, there is now awareness on these critical unwanted consequences, and efforts are ongoing to identify viable solutions (37). At this point, the hope is that health systems will not disrupt, but rather strengthen themselves to face the imminent challenges posed by COVID-19 vaccinations (38).

DISCUSSION

The monitoring of the progression of the COVID-19 pandemic in Africa is presently very challenging, mainly due to the very fragile health systems involved, which are struggling to implement containment strategies and to collect data to monitor the situation.

However, even if over time we had more data to monitor the pandemic in the continent, the overall consequences are easily predictable now, even without further modeling studies.

In this critical situation, the health workforce has also decreased, considering that, as per september 2020, more than 42,000 health workers were infected in Africa since the start of the pandemic with around 880 deaths (2.1% CFR) (6).

In addition, the deterioration of the global economy because of the COVID-19 pandemic predicts an increase in absolute poverty (39, 40) and compromises the achievements of the Sustainable Development Goals (41) with additional harsh repercussions on the African continent.

In this situation, an unprecedented and participatory effort involving all stakeholders is requested to identify strategies that can contain the extent of this current protracted emergency without affecting the delivery of primary health care services. The African continent cannot afford the further weakening of its already fragile health system, and the tightness of the system will both increase the availability of reliable data and help to cope with the other dire consequences of this epidemic. Now, more than ever, effective aid and sound cooperation are to be sustained.

AUTHOR CONTRIBUTIONS

MGD drafted the first version of the article. CVR, SD, and GP revised and integrated it. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

We thank the reviewer for his/her useful comments and suggestions.

REFERENCES

1. Nordling L. Africa's pandemic puzzle: why so few cases and deaths? *Science*. (2020) 369:756–7. doi: 10.1126/science.369.6505.756
2. Njenga MK, Dawa J, Nanyingi M, Gachohi J, Ngere I, Letko M, et al. Why is there low morbidity and mortality of COVID-19 in Africa? *Am J Trop Med Hyg*. (2020) 103:564–9. doi: 10.4269/ajtmh.20-0474
3. Mbow M, Lell B, Jochems SP, Cisse B, Mboup S, Dewals BG, et al. COVID-19 in Africa: dampening the storm? COVID-19 in Africa: dampening the storm? *Science*. (2020) 369:624–. doi: 10.1126/science.abd3902
4. Diop BZ, Ngom M, Pougué Biyong C, Pougué Biyong JN. The relatively young and rural population may limit the spread and severity of COVID-19 in Africa: a modelling study. *BMJ Glob Health*. (2020) 5:e002699. doi: 10.1136/bmjgh-2020-002699
5. Quaglio GL, Putoto G, Brant H, Preiser W. COVID-19 in Africa: what is at stake? European Parliamentary Research Service (EPRS). European Science Media Hub (ESMH). Available online at: https://sciencemediahub.eu/2020/05/22/covid-19-in-africa-what-is-at-stake/ (accessed September 11, 2020).
6. WHO AFRO region- Situation reports on COVID-19 outbreak n. 28-8. (2020).
7. Our Word in data. Available online at: https://ourworldindata.org/coronavirus
8. WHO. Public health criteria to adjust public health and social measures in the context of COVID-19-. Available online at: https://apps.who.int/iris/bitstream/handle/10665/332073/WHO-2019-nCoV-Adjusting_PH_measures-Criteria-2020.1-eng.pdf?sequence=1&isAllowed=y (accessed May 12, 2020).
9. Dyer O. Covid-19: excess deaths point to hidden toll in South Africa as cases surge. *BMJ*. (2020) 370:m3038. doi: 10.1136/bmj.m3038
10. Bo Y, Guo C, Lin C, Zeng Y, Li HB, Zhang Y, et al. Effectiveness of non-pharmaceutical interventions on COVID-19 transmission in 190 countries from 23 January to 13 April 2020. *Int J Infect Dis*. (2020) 102:247–53. doi: 10.1016/j.ijid.2020.10.066
11. Nordlingaug L. The pandemic appears to have spared Africa so far. Scientists are struggling to explain why. *Science*. (2020). doi: 10.1126/science.abe2825
12. Rutayisire E, Nkundimana G, Mitonga HK, Boye A, Nikwigize S. What works and what does not work in response to COVID-19 prevention and control in Africa. *Int J Infect Dis*. (2020) 97:267–9. doi: 10.1016/j.ijid.2020.06.024
13. Mukwege D, Cadière GB, Vandenberg O. COVID-19 response in sub-saharan low-resource setting: healthcare soldiers need bullets. *Am J Trop Med Hyg*. (2020). 103:549–50. doi: 10.4269/ajtmh.20-0543
14. Blanton RE, Mock NB, Hiruy HN, Schieffelin JS, Doumbia S, Happi C, et al. African resources and the promise of resilience against COVID-19. *Am J Trop Med Hyg*. (2020) 103:539–41. doi: 10.4269/ajtmh.20-0470
15. Taddele Maru M. Africa's Scorecard in Countering Covid-19. Available online at: https://www.ispionline.it/it/pubblicazione/africas-scorecard-countering-covid-19-26520 (accessed June 12, 2020).
16. Ag Ahmed MA, Ly BS, Millimouno TM, Alami H, Faye CL, Boukary S, et al. Willingness to comply with physical distancing measures against COVID-19 in four African countries. *BMJ Global Health*. (2020) 5:e003632. doi: 10.1136/bmjgh-2020-003632
17. Amzat J, Aminu K, Kolo VI, Akinyele AA, Ogundairo JA, Danjibo MC. Coronavirus outbreak in Nigeria: Burden and socio-medical response during the first 100 days. *Int J Infect Dis*. (2020) 98:218–24. doi: 10.1016/j.ijid.2020.06.067
18. Gyader G. Covid-19 in Africa: The Ghanaian Case. Available online at: https://www.ispionline.it/it/pubblicazione/covid-19-ghanaian-case-26459 (accessed June 12, 2020).

19. Carbone G, Casola C. Covid-19 In Africa: Disruptions and Post-Pandemic Scenarios. Available online at: https://www.ispionline.it/it/pubblicazione/covid-19-africa-disruptions-and-post-pandemic-scenarios-26457 (accessed June 16, 2020).
20. Resti J. Sudan's Revolution: One Year On Ispi. Available online at: https://www.ispionline.it/it/pubblicazione/sudan-transition-democracy-far-behind-26273 (accessed May 22, 2020).
21. Barnett-Howell Z, Mushfiq Mobarak A. Should Low-Income Countries Impose the Same Social Distancing Guidelines as Europe and North America to Halt the Spread of COVID-19? Yale School of Management. (2020).
22. Lambert H, Gupte J, Fletcher H, Hammond L, Lowe N, Pelling M, et al. COVID-19 as a global challenge: towards an inclusive and sustainable future. *Lancet Planet Health*. (2020) 4:e312–4. doi: 10.1016/S2542-5196(20)30168-6
23. UN Policy Brief: The Impact of Covid-19 on Food Security And Nutrition (2020). Available online at: https://reliefweb.int/sites/reliefweb.int/files/resources/sg_policy_brief_on_covid_impact_on_food_security.pdf
24. Katsidzira L, Gwaunza L, Hakim JG. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) Epidemic in Zimbabwe: Quo Vadis? *Clin Infect Dis*. (2020) 71:2180–3. doi: 10.1093/cid/ciaa552
25. African Scientific, Research and Innovation council (ASRIC). Afro-Centered Non-Pharmaceutical Interventions for COVID-19. (2020).
26. Russel T, Wu JT, Clifford S, Edmunds WJ, Kucharski AJ, Jit M. Effect of internationally imported cases on internal spread of COVID-19: a mathematical modelling study. *Lancet Public Health*. (2020) 6:e12–20. doi: 10.1016/S2468-2667(20)30263-2
27. WHO. Pulse survey on continuity of essential health services during the COVID-19 pandemic. Interim report. Available online at: https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS_continuity-survey-2020.1
28. The Lancet. Editorial, Covid-19: a new lens for non communicable diseases. *Lancet*. (2020) 396:649. doi: 10.1016/S0140-6736(20)31856-0
29. Nachega JB, Mbala-Kingebeni P, Otshudiema J, Zumla A, Tam-Fum JM. The colliding epidemics of COVID-19, Ebola, and measles in the Democratic Republic of the Congo. *Lancet Glob Health*. (2020) 8:e991–2. doi: 10.1016/S2214-109X(20)30281-3
30. Munyaradzi M. COVID-19 worsens Zimbabwe's health crisis. *Lancet*. (2020) 396:457. doi: 10.1016/S0140-6736(20)31751-7
31. At least 80 million children under one at risk of diseases such as diphtheria, measles and polio as COVID-19 disrupts routine vaccination efforts, warn Gavi, WHO and UNICEF. Available online at: https://www.who.int/news-room/detail/22-05-2020-at-least-80-million-children-under-one-at-risk-of-diseases-such-as-diphtheria-measles-and-polio-as-covid-19-disrupts-routine-vaccination-efforts-warn-gavi-who-and-unicef (accessed May 22, 2020).
32. Hungerford D, Cunliffe NA. Coronavirus disease (COVID-19) – impact on vaccine preventable diseases. *Euro Surveill*. (2020) 25:2000756. doi: 10.2807/1560-7917.ES.2020.25.18.2000756
33. Roberton T, Carter ED, Chou VB, Stegmuller AR, Jackson BD, Tam Y, et al. Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-income countries: a modelling study. *Lancet Global Health*. (2020) 8:e901–8. doi: 10.1016/S2214-109X(20)30229-1
34. Divala T. Africa faces difficult choices in responding to COVID-19. *Lancet*. (2020) 395:1611. doi: 10.1016/S0140-6736(20)31056-4
35. The Lancet. An African plan to control COVID-19 is urgently needed. *Lancet*. (2020) 396:1777. doi: 10.1016/S0140-6736(20)32580-0
36. Ogunleye OO, Basu D, Mueller D, Sneddon J, Seaton RA, Yinka-Ogunleye AF, et al. Response to the Novel Corona Virus (COVID-19) pandemic across Africa: successes, challenges, and implications for the future. *Front Pharmacol*. (2020) 11:1205. doi: 10.3389/fphar.2020.01205
37. Sands P. HIV, tuberculosis, and malaria: how can the impact of COVID-19 be minimised? *Lancet Glob Health*. (2020) 8:e1102–3. doi: 10.1016/S2214-109X(20)30317-X
38. Parpia AS, Ndeffo-Mbah ML, Wenzel NS, Galvani AP. Effects of response to 2014-2015 Ebola outbreak on deaths from Malaria, HIV/AIDS, and tuberculosis, West Africa. *Emerg Infect Dis*. (2016) 22:433–41. doi: 10.3201/eid2203.150977
39. Gerszon Mahler D,Lakner C, Castaneda Aguilar RA, Wu H. Updated estimates of the impact of COVID-19 on global poverty. Published on Data Blog. World Bank. Available online at: https://blogs.worldbank.org/opendata/updated-estimates-impact-covid-19-global-poverty (accessed June 8, 2020).
40. ILO Monitor: COVID-19 and the world of work. 5th edition. Available online at: https://www.ilo.org/global/topics/coronavirus/impacts-and-responses/WCMS_749399/lang--en/index.htm (accessed June 30, 2020).
41. The Lancet Public Health. Will the COVID-19 pandemic threaten the SDGs? *Lancet Public Health*. (2020) 5:e460. doi: 10.1016/S2468-2667(20)30189-4

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 17 February 2021
doi: 10.3389/fpubh.2021.609949

A Survey on One Health Perception and Experiences in Europe and Neighboring Areas

Francesco Chiesa[1†], Laura Tomassone[1†], Sara Savic[2], Alessandro Bellato[1], Andrei Daniel Mihalca[3], David Modry[4,5,6], Barbara Häsler[7] and Daniele De Meneghi[1]*

[1] Department of Veterinary Science, University of Turin, Grugliasco-Turin, Italy, [2] Scientific Veterinary Institute "Novi Sad", Novi Sad, Serbia, [3] Faculty of Veterinary Medicine, University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Cluj Napoca, Romania, [4] Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czechia, [5] Institute of Parasitology, Biology Centre, Czech Academy of Sciences, Ceske Budejovice, Czechia, [6] Department of Veterinary Sciences, Faculty of Agrobiology, Food and Natural Resources/CINeZ, Czech University of Life Sciences Prague, Prague, Czechia, [7] Royal Veterinary College, London, United Kingdom

A questionnaire survey was promoted under the COST Actions *"Network for Evaluation of One Health-NEOH"* and *"European Network for Neglected Vectors and Vector-Borne Infections-EURNEGVEC"*, from June 2016 to April 2017, to collect information on the existence of One Health (OH) collaboration and implementation of OH initiatives in 37 EU COST Countries. The questionnaire was to be answered by key respondents representing the three major OH components: (i). Animal Health; (ii). Human Health/Public Health; (iii). Environmental Health. A target respondent rate of nine respondents/country was aimed for, representing the following categories: (i). ministries; (ii). academia-research; (iii). private sector and NGOs, associations and scientific societies. The questionnaire, composed of 27 questions organized in six sections, was circulated to target respondents by Committee Members of the two COST actions. A total of 171 respondents from 34 countries completed the questionnaire, mainly belonging to academic and research institutions (55.5%), and to Animal Health/Animal Science fields (53.8%). Although the majority (57.9%) declared they had heard about OH, few respondents (10.7%) provided a complete definition. The "human" and "animal" elements prevailed over other key elements of OH definition (ecosystem, intersectoral, transdisciplinary, holistic, collaboration). Overall, 62.6% respondents declared to take part in OH initiatives. Antimicrobial resistance, avian influenza and environmental pollution were cited as the top three OH issues over the past 5 years. Limitations and gaps in intersectoral collaboration included communication and organizational problems resulting in poor networking, differing priorities and a lack of understanding between sectors. Regarding control and monitoring of zoonotic diseases, respondents from different sectors preferentially selected their own directorates/ministries while actually in most countries both Ministry of Health and Ministry of Agriculture are engaged. According to respondents, the level of awareness of OH amongst the general public is limited. Similarly, a dearth of opportunities of collaborations at different institutional and/or professional levels was described. Our survey provided an overview of how respondents in COST countries perceived and experienced OH and current limits to OH implementation. Identifying how initiatives are

OPEN ACCESS

Edited by:
Aleksandra Barac,
University of Belgrade, Serbia

Reviewed by:
Chiara Frazzoli,
National Institute of Health (ISS), Italy
Hans Keune,
Belgian Biodiversity Platform, Belgium

****Correspondence:***
Daniele De Meneghi
daniele.demeneghi@unito.it

† These authors have contributed equally to this work and share first authorship

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

Received: *09 November 2020*
Accepted: *22 January 2021*
Published: *17 February 2021*

Citation:
Chiesa F, Tomassone L, Savic S, Bellato A, Mihalca AD, Modry D, Häsler B and De Meneghi D (2021) A Survey on One Health Perception and Experiences in Europe and Neighboring Areas. Front. Public Health 9:609949. doi: 10.3389/fpubh.2021.609949

currently working and knowing the promoting and hindering factors allowed suggesting strategies to promote efficiency and effectiveness of OH implementation in the future.

Keywords: questionnaire survey, One Health, EU COST countries, intersectoral collaboration, interdisciplinary/multidisciplinary, OH strategies and policies

INTRODUCTION

The collaboration between human, animal and environmental health sectors is considered crucial; a need highlighted by recent financial, economic, social, environmental and health crises. The complexity of health determinants, makes it difficult for single disciplines and institutions to deal with all health problems and challenges related to animal, public and environmental health (1, 2).

Changes in land use, habitat fragmentation, ecosystem invasion, direct and indirect interactions between animal species, including ourselves, have increased, and this has led to changes to ecological or biological systems. This fact has greatly contributed to the emergence of zoonotic pathogens: changes in patterns of contact between wild and domestic animals (e.g., Nipah virus), direct human and wild animal contact (e.g., HIV, Ebola), and changes in species abundance or diversity (e.g., Hantavirus, Lyme disease) (3). New pathogens might have the capacity for inter-human spread and even pandemic potential among humans, as observed in the current COVID-19 global emergency. Outbreaks of highly infectious diseases, including zoonoses, but also antibiotic resistance, interrelated obesity in humans and pets, food security and food safety, problems related to growing urbanization, lack of green spaces in the cities, uncontrolled environmental pollution and biodiversity loss, are only few examples where an integrated approach to health, such as One Health (OH), can be effectively employed (1, 2). Not only "classical zoonoses" can be tackled using a OH approach, but also other hazards occurring at the human, animal, ecosystem interface, such as exposure to toxicants through the environment and foods of animal origin. Some authors even advocate this new perspective as "toxicant-related zoonoses" highlighting the importance of new food safety issues within the environment-feed-food chain (4). Also, climate change adds uncertainty and contributes to health crises, affecting biological systems through various mechanisms, such as modifying the lifecycle of vectors, host species and pathogens, disrupting the synchrony among species, destructing habitats, etc. (5). Since species experience environmental changes differently, the expertise from veterinary, environmental and public health professionals are needed to understand ecological interactions and to forecast plausible reactions. The integration of expertise from environmental and life sciences can help to deepen knowledge and to understand each aspect of an issue, combining different perspectives (6).

In Europe, but also elsewhere, the degree and quality of collaboration amongst various health disciplines and institutions varies substantially. Integrated approaches to health are challenging because they require complex systems of communication and collaboration that are difficult to delimit (1). Despite the above-mentioned difficulties, in many European countries, a large number of integrated health initiatives has been implemented, some of them described or reported as "One Health." Several studies investigated OH characteristics, provided proof of concept, demonstrated its added value, or established how to evaluate OH initiatives (7–14). Moreover, the World Bank published guidance on how to operationalize OH (15). Similarly, national action plans to combat AMR are encouraged to use OH principles (16). These efforts have generated momentum in OH and led to many different initiatives worldwide. A study looking at OH networks globally found a multitude of different networks, but generally a lack of direction and institutionalization (17). There is currently no register in Europe that would allow gaining a systematic understanding of the OH landscape in Europe.

In order to explore existing collaboration amongst the animal health, human/public health, environmental health and sectors, and to collect information on the existence and implementation of OH actions and initiatives in EU countries, a questionnaire-based survey was designed and circulated amongst EU COST Member Countries, associated and near-neighbor countries (https://www.cost.eu); there were 37 countries at the time the survey was initiated. The questionnaire was designed and promoted under the initiatives of the COST Actions TD1404 "Network for Evaluation of One Health-NEOH" (http://neoh.onehealthglobal.net) and TD1303 "European Network for Neglected Vectors and Vector-Borne Infections-EURNEGVEC" (https://www.eurnegvec.org).

MATERIALS AND METHODS

The questionnaire was developed in Google forms and structured in six sections: (1). *general information*; (2). *about "One Health"*; (3). *zoonotic diseases, environmental health and AMR: examples of "burning" OH issues/initiatives*; (4). *aspects limiting interdisciplinarity and intersectorality in OH*; (5). *conclusions*; (6). *end of questionnaire* (including comments, remarks and/or suggestions).

The survey consisted of 27 questions addressing the above mentioned objectives (i.e., to explore the existing collaboration amongst animal health, human/public health, environmental health sectors, to collect information on the existence and implementation of OH actions and initiatives in EU COST countries). Twenty-one were closed-ended questions, of which six in Likert-scale format, and six were open-ended questions. An informed consent form was provided at the beginning of the questionnaire where respondents were advised that the questionnaire was anonymous and that, by completing and submitting it, they voluntarily agreed to participate. Assurance of privacy and confidentiality is highly valued in e-mail

questionnaire surveys, as reported by Saleh and Bista (18). Ethical approval was sought and granted by the Clinical Research and Ethical Review Board at the Royal Veterinary College, grant holder of COST Action TD1404 NEOH (ref. n. URN 2016 1554). Respondents were to be contacted by the Management Committee (MC) members and MC substitutes of the two COST Actions in each country. Key respondents were meant to represent the three components of OH (animal health, human health/public health and environmental health). MC members and MC substitutes contacted by email the target institutions through the official institutional contact email address, providing the link to the online questionnaire, and explaining to potential respondents the scope and the importance of the survey. Where deemed necessary, the COST Action members translated the message to their local language before reaching out to their contacts in the different institutions.

We expected nine respondents per country, one for each OH component, per each one of the following categories:

i. Public institutions/ministries, that is, the Directors/Heads of Veterinary Services, Ministry of Agriculture (MoA), Ministry of Health (MoH); Directors/Heads of Human Health & Public Health Services, MoH; Environmental Health Services, Ministry of Environment or other applicable Ministries/Directorates, according to the national organization/system of each COST countries;
ii. Academia/research (i.e., Deans/Directors of the Schools/Universities and of National Research Centers on Veterinary Medicine, Human Medicine and Public Health, and Environmental/Earth Sciences, under Ministry of Education;
iii. Private sector (i.e., presidents of the National Boards/Colleges of Veterinarians, Medical Surgeons & Public Health doctors, and Environmental Earth Sciences doctors.

In addition, NGOs, associations, scientific societies involved in OH initiatives and activities were asked to participate in the survey.

The overall expected respondents were 333 (three respondents representing human, animal and environmental health each from at least three of the four categories listed per 37 COST countries).

The questionnaire was accessible for 10 months (June 2016–April 2017); it was subsequently closed, and the data collected were downloaded. Answers were checked for consistency, cleaned for analysis and the questionnaire was removed from the hosting platform.

A blank version of the questionnaire (.pdf) is available in the **Supplementary Material**.

Data were analyzed with R software (19). We computed descriptive statistics of questions answers and scores. In order to analyze qualitative data, open answers were categorized into classes. Non-parametric tests (Wilcoxon test and Kruskal-Wallis rank sum test) were used to detect significant differences in scores among categorical variables; Chi-square and Fisher Exact tests were employed to evaluate associations among categorical variables. For all statistical tests, a two-tailed significance level of $\alpha = 0.05$ was adopted.

As regards the "definition of One Health" (question in section 2), answers were analyzed in order to detect five key words categories in the definition given by respondents, and a score was attributed, being five the maximum (all key words and key word categories included in the definition). The five key words were human health, environmental health, animal health, intersectoral/transdisciplinary/holistic, collaboration/sharing, as described in literature (2, 20). Advantages of OH, which respondents were asked to score (question in section 2), are described in Häsler et al. (21).

Interviewees were asked to select health hazards (mainly zoonotic diseases) that are controlled and monitored by the Ministry of Health and/or Agriculture (question in section 3); the list of major health hazards/zoonoses was taken from the Public Health England website (https://www.gov.uk/government/publications/list-of-zoonotic-diseases/list-of-zoonotic-diseases).

In section 4, interviewees were asked to score the level and opportunities for OH collaborations in their countries at different institutional and/or professional levels, choosing among: "poor," "fair," "good," "excellent," and "n/a": not applicable.

RESULTS

Overall, 171 key respondents from 34 countries answered the questionnaire with at least one respondent per country.

Few countries -namely Belgium, Bosnia & Herzegovina, Hungary, Italy, The Netherlands, and Portugal- reached or even exceeded, the expected minimum number of questionnaires answered ($n = 9$/country), other countries reached or slightly exceeded six questionnaires answered (Austria, Czech Republic, Lithuania, Serbia and Switzerland), while the remaining others answered less. No responses were received from Iceland, Montenegro, and Cyprus. The number of respondents by country is shown in **Figure 1**.

Results are reported by questionnaire section.

Questionnaire Section 1—General Information

The majority of respondents declared to have training or a professional background in Animal Health or Animal Sciences ($n = 92$; 53.8%), followed by Public Health or Human Health ($n = 51$; 29.8%). Those having a professional background in Environmental Sciences and Life Sciences (including biologists, chemists and basic science disciplines) were respectively 12 (9.3%) and 5 (2.9%). Five respondents (2.9%) had a professional background in Food Safety, while two respondents were trained outside the "traditional" health disciplines, one of them in Sociology (0.6%) and the other one in Engineering (0.6%).

Most respondents worked at Higher Education Institutions/Universities ($n = 66$; 38.6%) and Research Centers ($n = 29$; 17.0%), followed by Governmental Institutions/Ministries ($n = 44$; 25.7%). Those working in the private sector and NGOs were 14 (8.2%) and 9 (5.3%), respectively. Two respondents were

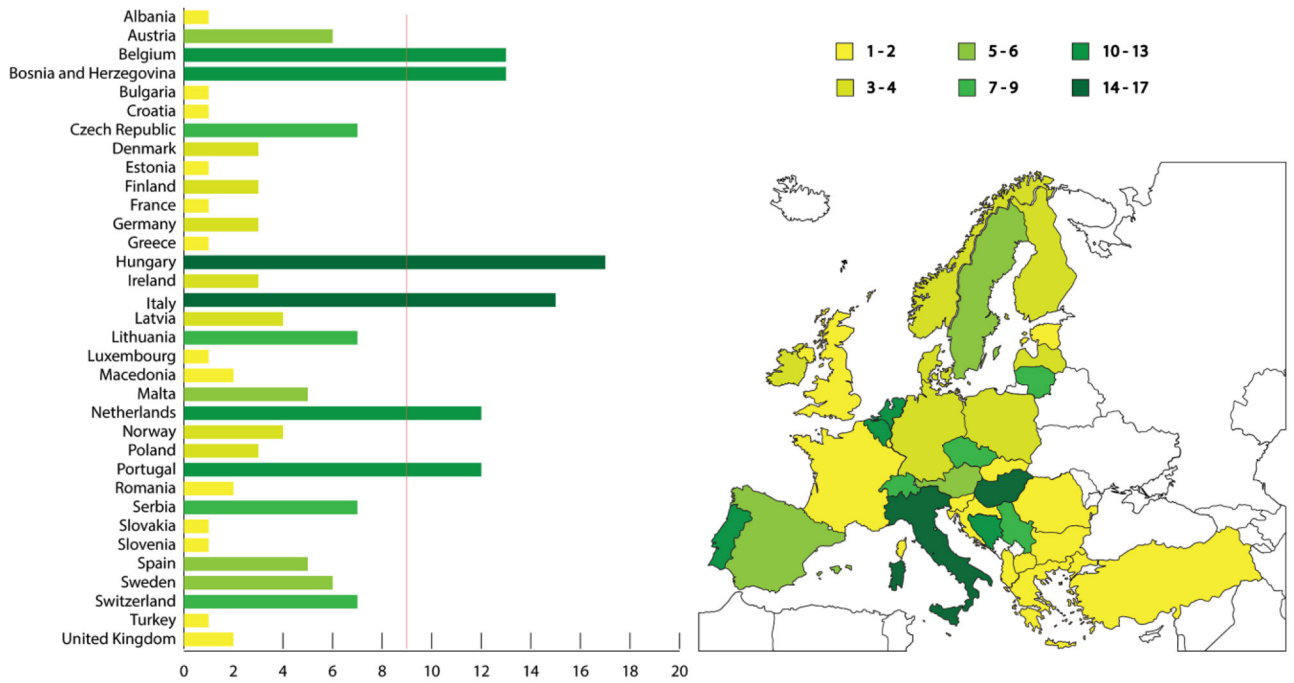


FIGURE 1 | Map illustrating the number of respondents to the questionnaire per country, and bar chart with the number of questionnaires answered considering the number of expected respondents (red line). Colors grade from yellow (low number of questionnaires answered) to dark green (high number).

employed in International Organizations, and seven respondents did not give details.

The above-mentioned institutions work on Animal Health (n = 77; 45.0%), Public Health (n = 50; 29.2%), Human Health (n = 23; 13.4%) and Environmental Health (n = 17; 9.9%). Four respondents did not provide enough details to attribute the discipline of the institution to any of the above categories (hence aggregated under "Other") (**Figure 2**).

Most of the respondents stated to be heads/directors (n = 57; 33.9%), professors (n = 44; 26.1%) and researchers (n =18; 10.7%). Thirteen were officers (7.7%) and another 13 respondents were consultants (7.7%). The remaining respondents detailed their positions as medical doctors (n = 5; 2.9%), PhD students (n = 5; 2.9%), epidemiologists (n = 4; 2.3%) and vet clinicians (n = 3; 1.7%). Six persons (3.5%) did not answer.

Questionnaire Section 2—*About one health*

Ninety-nine respondents (57.9%) declared they had heard about One Health, while 36 (21.1%) declared that they had never heard about it; 36 people did not respond to the question.

Respondents were asked to define OH in one sentence. Amongst the 149 answers (87.1% of respondents), only 16 (10.7%) were considered to be a "complete definition." The "human" component was mentioned by 129 respondents (86.6%), the "animal" component by 110 (73.8%), and the "environmental" one by 63 (42.3%). Fifty-nine respondents (39.6%) included a term among "intersectoral/transdisciplinary/holistic" in the definition, and 34 named "collaboration/sharing" (22.8%).

Considering the disciplinary background of respondents, the best median score for the OH definition (one point for each element) was obtained by "Life Sciences" respondents (3.5, Q1–Q3: 3.25–3.75), followed by "Human Health" respondents (3; Q1–Q3: 3–3). The median score of the other categories (excluding the two respondents with a disciplinary background in Sociology and Engineering, who did not answer) was two. However, the difference in median scores among different disciplinary backgrounds was not significant (Kruskal Wallis rank sum test, $p = 0.08$).

When interviewees were asked if they were currently involved in OH initiatives, the large majority stated to be involved (n = 107; 62.6%), while 64 respondents stated that were not. Most people involved had a background in "Animal Sciences" (n = 70, 65.4%), followed by "Public Health" (n = 16, 15.0%) and "Human Health" (n = 12, 11.2%). The involvement significantly differed among disciplinary backgrounds (Fisher Exact test, $p <$ 0.01), with 76.1% of the "Animal Sciences" respondents being involved, vs. 55.2% of "Public Health", 54.5% of "Human Health," 40% of "Food Safety," 37.5% of "Environmental Sciences" and 20% of "Life Sciences." The two respondents with background in Sociology and Engineering declared not to be involved in OH initiatives.

The interviewees were also asked to briefly describe the OH initiatives. Since this was an open answer, it was categorized in: zoonoses (54 answers, 50.4%); OH in general (i.e., a broad comprehensive category that includes activities or initiatives

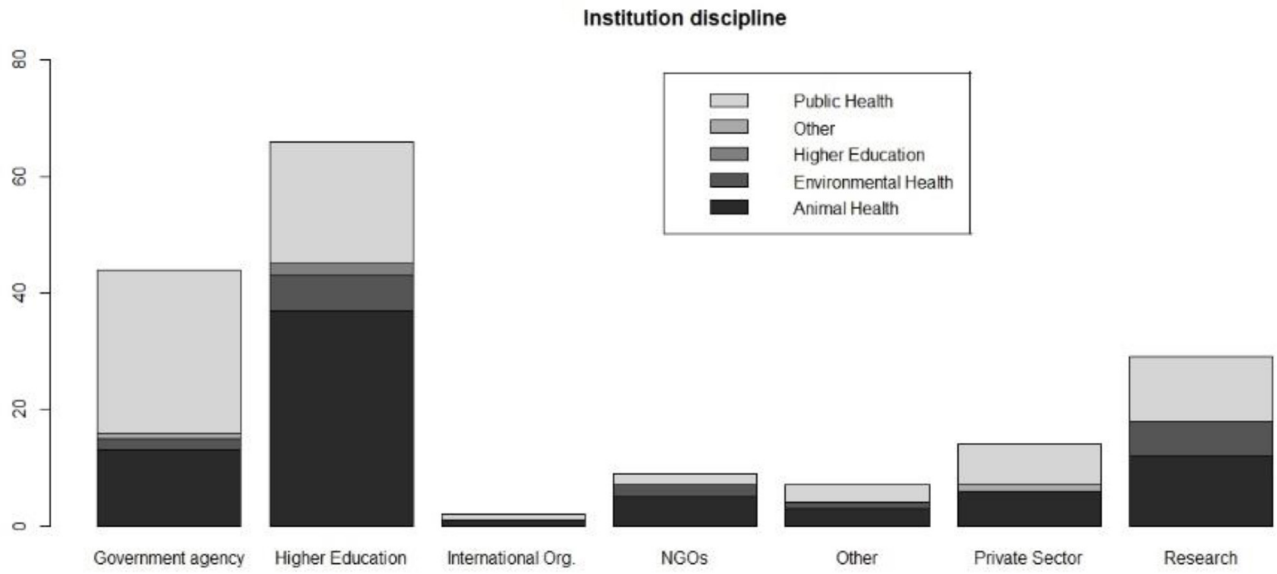


FIGURE 2 | Type of institution and sector where respondents are employed.

having the scope to promote intersectoral working spaces) (n = 12, 11.2%); food hygiene (n = 11, 10.2%); antimicrobial resistance (AMR) (n = 9, 8.4%); education (n = 5, 4.6%); animal health (n = 3, 2.8%); human health (n = 2, 1.8%); AMR and zoonoses, and AMR and food hygiene (one answer each, 0.9%). Nine interviewees did not specify the characteristics of the OH initiatives they were involved in. OH initiatives on zoonoses were mostly cited by people with a background in "Animal Sciences" (n = 36), followed by "Public Health" (n = 8) and "Human Health" (n = 6). "Environmental Health" respondents were involved in initiatives on zoonoses (n = 3), OH in general (n = 2) and food safety (n = 1). Education activities were cited by "Animal Sciences" respondents only (n = 5).

Sixty-one respondents stated that OH had been officially endorsed by their respective Institutions, while 51 Institutions did not endorse; 59 respondents did not answer. No differences in endorsing or not OH initiatives were found among institution types (Fisher Exact Test, p = 0.7) (**Figure 3**). The institutions reportedly endorsed OH by implementing initiatives regarding education (n = 16), OH in general (n = 16), animal health (n = 7), zoonoses (n = 5), AMR, human health, and food safety (n = 2 each). Less than half (47.7%) of respondents involved in OH initiatives worked in institutions that officially endorsed OH.

The respondents quoted various examples of programs for which a OH approach was adopted in their institutions. These examples mostly referred to zoonoses surveillance and control (n = 24), health education (n = 20), AMR (n = 17) and food hygiene (n = 15). Other cited examples were research (n = 9), animal health (n = 7), brucellosis and OH in general (n = 5), vector-borne diseases (n = 4), drawing/writing legislation (n = 4), rabies, salmonella, WNV (n = 3 each), Campylobacter, Q Fever, HPAI, info sharing and preventive medicine (n = 2 each). Air quality, climate change, risk analysis, drinking water quality, human health, mastitis, leishmaniasis, leptospirosis, Lyme disease, rodent-borne diseases, tuberculosis, toxoplasmosis, TSE, and tularemia were cited once.

When asked to score -from 1 (low) to 5 (high)- some advantages of OH described in literature, "Early detection of threat and timely, effective or rapid response" was considered the major advantage (median score: 5.0), followed by "Better/improved/more effective disease control and/or biosecurity measures" (4.5), thus suggesting that respondents attributed the greatest importance to preventative measures. A lower score was given to "Economic benefit/increase in economic efficiency" (4.0), "Improvement in human or animal health or well-being" (4.0), "Higher quality or larger quantity of information and data and improved knowledge or skills" (4.0), "Ecosystem benefit" (4.0'), "Design of health policies" (4.0) and "Personal or social benefits" (3.0) (**Figure 4**).

When asked about the existence of boards/committees/associations actively dealing with OH issues/initiatives in their country, 69 respondents answered affirmatively, while 15 stated "no." Some respondents provided details, stating that such boards mainly deal with AMR, zoonoses, food hygiene, vector-borne diseases and outbreak management.

One hundred fourteen (66.7%) respondents declared that, in their countries, there are formal connections between veterinary/animal health and public health administrations (governmental institutions or services). Conversely, 55 respondents answered "no"; two answers were missing. The answer significantly differed among respondents with different disciplinary backgrounds (Fisher Exact test, p = 0.01). The highest "yes" frequency was registered among Food Safety people

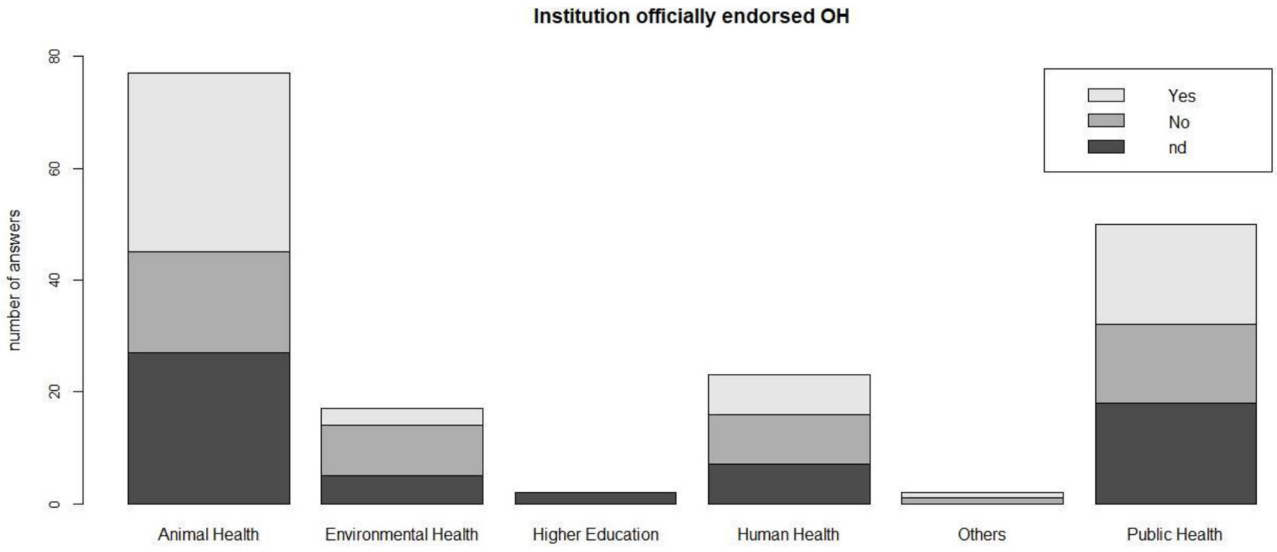


FIGURE 3 | Endorsement of OH initiatives by different types of institutions where respondents are employed.

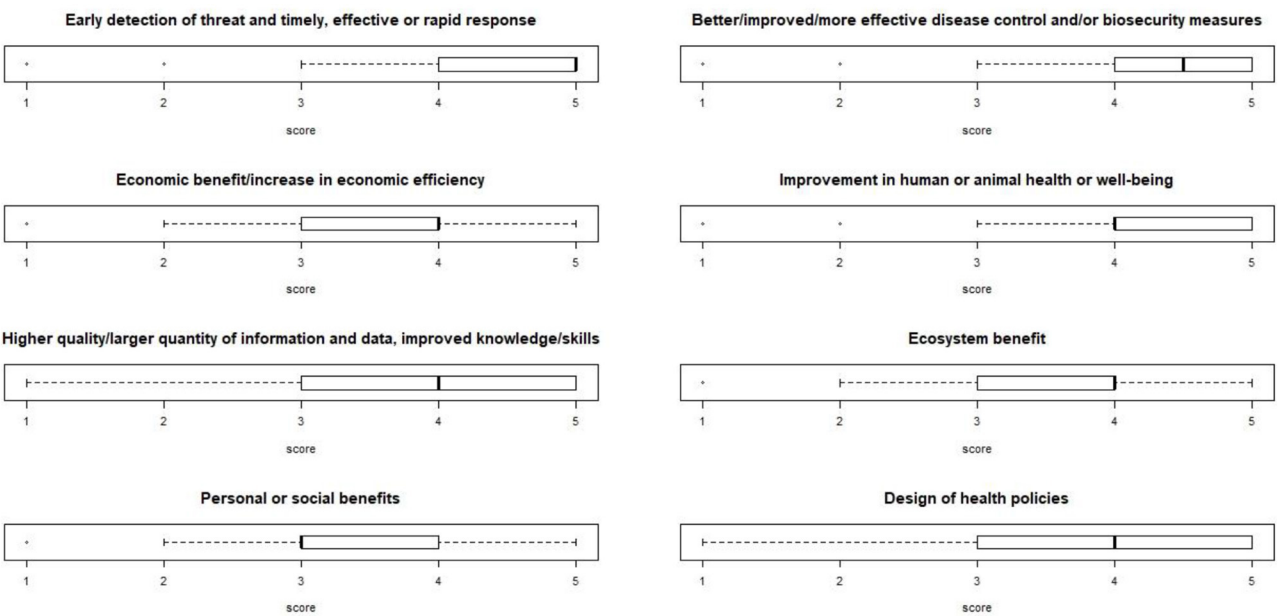


FIGURE 4 | Boxplot of the scoring of the OH advantages, described in literature. Respondents could score each from one (low) to five (high).

(all five respondents), Public Health (86.2%), Animal Sciences (69.2%), Human Health (57.1%). "No" answers prevailed among Environmental Sciences (43.8%) and Life Sciences (40%) people, and were given by the two respondents with disciplinary background in Sociology and Engineering.

The respondents were then asked to answer a subset of questions on the level, nature and duration of such cooperation. Most connections were reported to be at national level ($n = 72$ answers, 63.2%), but some respondents indicated national—subnational and local ($n = 20$), national and subnational ($n = 14$), and national and local ($n = 3$) formal connections. Subnational, that is, regional, provincial ($n = 7$), local ($n = 2$) and subnational-local ($n = 1$) connections were also cited. The nature of the cooperation mainly referred to exchange of data ($n = 93$), joint surveillance ($n = 69$), health policies ($n = 61$), joint intervention ($n = 51$), joint preparedness ($n = 44$), joint training ($n = 41$), shared budget ($n = 9$). As regards the length of the cooperation, it ranged from "the last 5 years"

($n = 23$), to "the last 5-to-10 years" ($n = 30$), "10-to-20 years" ($n = 27$), "20-to-30 years" ($n = 6$) and to "more than 30 years" ($n = 15$). This last answer was given by respondents of the following countries: Italy (five respondents), Malta and Hungary ($n = 2$ each), and Belgium, Bosnia-Herzegovina, Denmark, Latvia, Poland, Romania ($n = 1$ each).

Ninety respondents (52.6%) stated they were aware of OH initiatives being implemented in their countries; 14 respondents (8.2%) answered "no" and the others did not answer. According to the respondents, the number of initiatives being implemented varied from 1 to 5 ($n = 54$), from 6 to 10 ($n = 16$), and more than 10 ($n = 12$). The fields of activities concerning these initiatives were: disease surveillance and monitoring ($n = 80$); disease prevention and control ($n = 74$); research ($n = 70$); participants awareness on the programs ($n = 50$); higher education programs ($n = 41$); NEOH and "Knowledge sharing platforms" were cited by one respondent each.

As regards the categories of professionals involved in these initiatives, the following were cited: veterinarians ($n = 138$); medical doctors ($n = 119$); biologists/entomologists ($n = 82$); environmental/ ecosystem specialists/ecologists ($n = 70$); chemists ($n = 23$); sociology/anthropology/gender specialists ($n = 15$); pediatricians ($n = 15$); family doctors ($n = 13$). Other professionals, entered by respondents, were: public health officers ($n = 3$); microbiologists, epidemiologists ($n = 2$ each). Food safety specialists, earth scientists, economists, psychologists, pharmacologists, civil servants/scientific experts, policy risk managers were also quoted.

Questionnaire Section 3—Zoonotic Diseases, Environmental Health and AMR: Examples of "Burning" OH Issues/Initiatives

Ninety-six people (82.1% of the 117 that answered this question) stated that, in their countries, there is an existing and active cooperation between the Ministry of Health and the Ministry responsible for Animal Health, when dealing with zoonoses. They also stated that there is an obligation to guarantee a reciprocal flux of information or data between Public Health and Veterinary Services. Interviewees were asked to select which zoonotic diseases are controlled and monitored by the Ministry of Health (MoH) and/or Agriculture (MoA). Results are illustrated in **Table 1**.

A couple of questions referred to environmental toxicants. When interviewees were asked about the "level of awareness by the public on zoonoses caused by exposure to environmental toxicants," scoring from 1 (poor) to five (excellent), the median score attributed by 136 respondents was 2 (Q1–Q3: 2–3). Fifty-nine persons stated they were not competent in the field. The median score given to the "quality of national plans for the prevention and monitoring of toxicant zoonoses" was 3 (Q1–Q3: 2–4). In this case, 85 respondents answered the question, while 88 people stated they were not competent in the field.

According to 83 respondents (48.5%), their respective countries contribute to the AMR surveillance in Europe, with specific monitoring and research programs. Conversely, 85 people answered "no answer/I don't know." Conflicting answers within the same country were registered, with eight respondents stating that their respective countries did not contribute to the EU AMR monitoring, although other respondents from the same countries stated they do contribute (**Figure 5**).

TABLE 1 | Zoonotic diseases controlled and monitored by the Ministry of Health (MoH) and/or Agriculture (MoA), according to respondents.

Zoonosis	MoA (*n*; %)	MoH (*n*; %)	MoH + MoA (*n*; %)
Anthrax	31 (26.5%)	33 (28.2%)	53 (45.3%)
Avian influenza	40 (31.0%)	27 (20.9%)	62 (48.0%)
Brucellosis	40 (32.2%)	22 (17.7%)	62 (50.0%)
Campylobacteriosis	22 (19.4%)	39 (34.5%)	52 (46.0%)
Cysticercosis/taeniasis	39 (39.0%)	26 (26.0%)	35 (35.0%)
Ebola	0 (0%)	84 (82.3%)	18 (17.6%)
Leptospirosis	22 (20.7%)	35 (33.0%)	49 (46.2%)
Plague	6 (7.3%)	49 (59.7%)	27 (32.9%)
Q Fever	28 (26.6%)	26 (24.7%)	51 (48.5%)
Rabies	31 (25.6%)	27 (22.3%)	63 (52.0%)
RVF	19 (25.6%)	26 (35.1%)	29 (39.1%)
Ringworm	17 (25.3%)	26 (38.8%)	24 (35.8%)
Salmonellosis	11 (8.6%)	35 (27.5%)	81 (63.7%)
Toxoplasmosis	15 (14.7%)	38 (37.2%)	49 (48.0%)
Trichinellosis	35 (29.6%)	26 (22.0%)	57 (48.3%)
Tularemia	19 (19.5%)	28 (28.8%)	50 (51.5%)

Questionnaire Section 4—Aspects Limiting Interdisciplinarity/Intersectorality in OH

A "siloed approach" of disciplines was considered a limit for interdisciplinarity and intersectorality by 18.1% of respondents ($n = 31$) working in OH, followed by "lack of resources" (15.8% of respondents, $n = 27$), institutional (10.5%, $n = 18$) and "education limits" (8.2%, $n = 14$). Some people mentioned more than one limit. Two respondents stated that there are no limiting factors (1.2%).

Table 2 describes the level(s) and the opportunities for OH collaborations, according to the interviewees, within professional boards, University Departments, institutions involved in veterinary surveillance and food security, and institutions involved in emergencies management.

Questionnaire Section 5—*Conclusions*

Respondents were asked to rate how well the OH approach is implemented by the professionals employed/engaged in Veterinary, Public and Environmental Health sectors in their country, scoring from 1 (poor) to 5 (excellent). The median score attributed by 130 respondents was three (Q1–Q3: 2–3). Details of the answers aggregated by countries are illustrated in **Figure 6**.

The existence of recent formal initiatives to establish and/or to strengthen intersectoral collaboration, aimed at global advocacy of OH approach, was confirmed by 49 respondents (29.8%). Seventeen (10.3%) answered "no" and the other interviewed selected "no answer/I don't know."

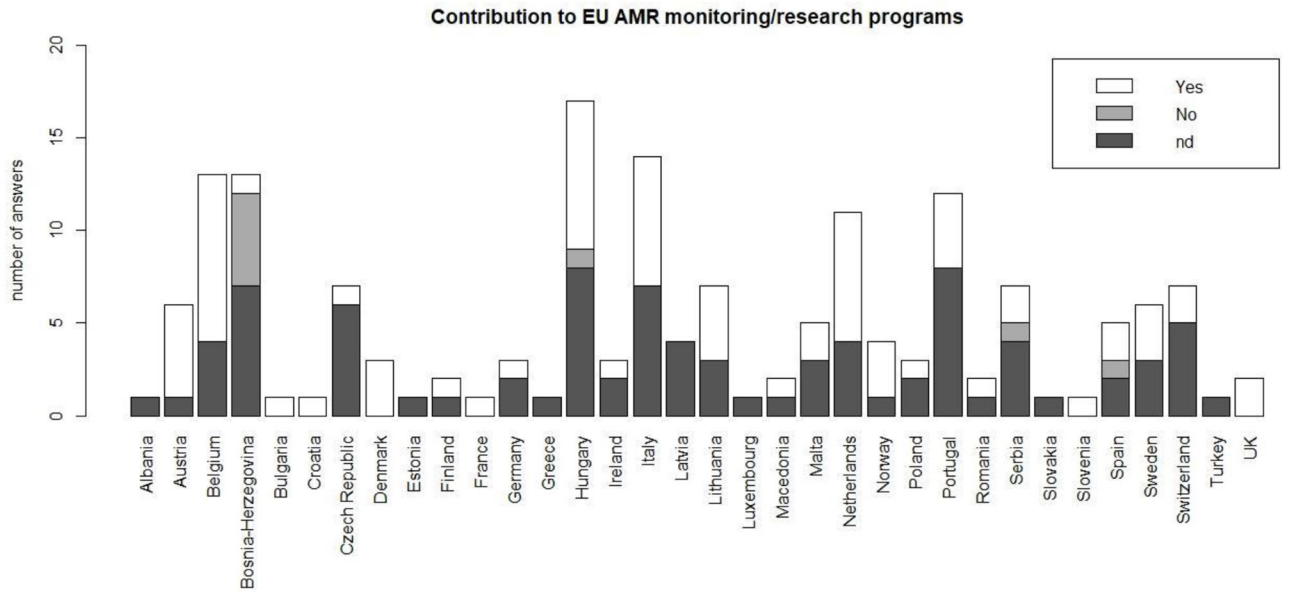


FIGURE 5 | Contribution of respondents' countries to European programs for the monitoring of AMR; nd = not determined/answer not known.

TABLE 2 | Level and opportunities for OH collaboration at different institutional and/or professional levels.

Level and opportunities for OH collaboration within	Poor (%)	Fair (%)	Good (%)	Excellent (%)	n/a (%)
Professional boards	40 (26.1%)	35 (22.9%)	54 (35.3%)	8 (5.2%)	16 (10.5%)
University Departments	37 (24.3%)	47 (30.9%)	47 (30.9%)	10 (6.6%)	11 (7.2%)
Institutions involved in vet surveillance and food security	18 (11.9%)	46 (30.5%)	64 (42.4%)	13 (8.6%)	10 (11.9%)
Institutions involved in emergencies management	22 (14.5%)	43 (28.3%)	64 (42.1%)	11 (7.2%)	12 (7.9%)
Total	117	171	229	42	49

When asked to cite the top three environmental, animal and human health issues in their country over the past 5 years, most respondents cited AMR ($n = 44$ respondents; 25.7%), avian influenza ($n = 32$; 18.7%) and environmental pollution ($n = 27$; 15.8%). A Sankey diagram shows all answers by regional areas (**Figure 7**). When considering answers by group of countries in the same geographical region, we observed differences in the top three issues (**Figure 8**): AMR was cited in all regions except from Balkan countries, avian influenza in all regions except from Balkan and Scandinavian/Baltic countries, and all except Eastern European countries cited environmental pollution.

Strictly related to section 4, respondents were asked to answer where and what are the gaps in OH schemes. Answers mostly referred to the approach of institutions ($n = 24$), followed by problems of funding ($n = 12$) and communication ($n = 11$), the siloed approach of disciplines ($n = 11$), and scarce education ($n = 10$) and awareness ($n = 8$).

According to respondents, the level of awareness/perception of OH amongst citizens/consumers their country is not high. Indeed, they could score from one (poor) to four (excellent), and the median score was 2.0 (Q1–Q3: 1.75–3.0). Details of the answers aggregated by countries are illustrated in **Figure 9**.

Questionnaire Section 6—*End of questionnaire*, Including Comments/Remarks/Suggestions

Only some respondents contributed to this last section, by adding a few comments, remarks and suggestions: four participants suggested that the questionnaire should have been less lengthy and more essential, with less detailed and clearer questions; three signaled that some questions and/or definition were not very clear (i.e., environmental toxicants and toxicant zoonoses); other three suggested that all questions should have the option "don't

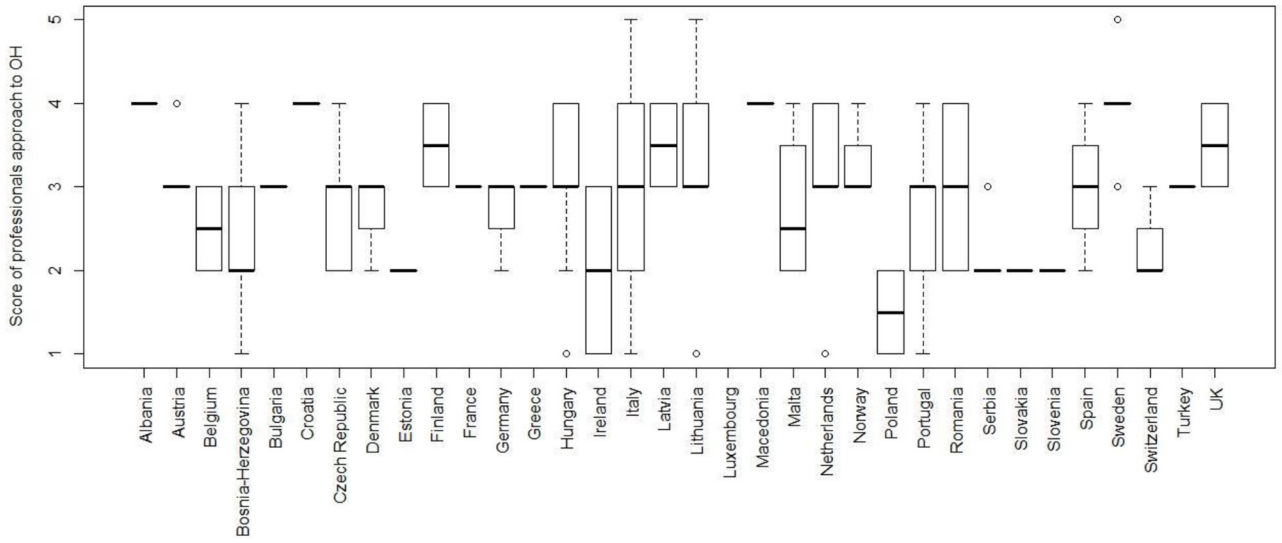


FIGURE 6 | Boxplot of the scores attributed by respondents on the implementation of the OH approach by professionals in their respective countries; scoring from one (poor) to five (excellent).

know/not sure about" (actually "don't know" was always available whenever applicable); a couple of respondents suggested that the text should have been revised by a English native speaker; two stated that the questionnaire was OK and no remarks/comments were needed; one reported that the questionnaire could not be saved in the process of filling in.

A few respondents included a set of comments/suggestions which deserve to be reported here […"*In view of the siloed mentality prevailing in the country, it is difficult to ascertain that the knowledge expressed in this questionnaire captures all the activities happening in other Ministries..*", …. "*the actions in favor of OH will have to continue their creative work in the Universities, both at undergraduate and graduate levels*", …"*OH issues have to be emphasized at Academic level in each of the 3 OH disciplines/components* (i.e., *Animal/Human-Public/Environmental Health)", … "include requirements for OH in health sector legislation, including specific budgeting of resources..*", …"*Having projects managed by people having knowledge of more than one discipline and who are open to listen to all collaborators..*"] and to be recalled/quoted in the discussion and conclusions.

DISCUSSION

Our survey aimed to provide an overview of the existence and the implementation of OH actions/initiatives in Europe and neighboring areas, of the type of institutions and disciplines involved in such initiatives, and on current limits to OH implementation according to professionals working in relevant fields (e.g., education, research, government).

Overall, the response rate (51.3%) of our questionnaire survey falls within the range of the response rates of similar online questionnaires (22). In a study on response rate in organizational research, (23) reported an average response rate of 52.7% for studies that utilized data collected from individuals, while the average response rate for studies that utilized data collected from organizations was 35.7%. However, few countries reached or exceeded the expected minimum number of questionnaires answered (nine per country).

The questionnaire design and distribution were managed such to reach an equal number of respondents from each of the three OH pillars/components, that is, animal health, human-public health and environmental health, evenly across countries, types of institutions and disciplines. However, there was a larger proportion of respondents from animal health, thereby skewing answers toward human and animal health with less consideration of ecosystem health and on collaborative and system aspects of OH. This may be explained by the fact that the OH approach and the OH movement have been promoted strongly by animal health and public health, as documented in some of the most accredited and comprehensive reviews on the origin and development of OH (7, 8). In addition, the larger number of respondents with a professional background in animal health/animal sciences, as well as the larger number of academics/researchers, seem to reflect the composition of NEOH and EurNegVec networks, who implemented the survey. As COST Actions are often research/academic networks, MC members and MC substitutes likely were better connected to academic and research colleagues than officials at Ministries/Directorates. The underrepresentation of nature/environment-related human health benefits and ecosystem health could be a limitation of this study and at the same time a reflection of the origins of OH and the networks of the participants of the two COST Actions. Potentially, more respondents from ecosystem fields could have been engaged with stronger wording around Ecohealth.

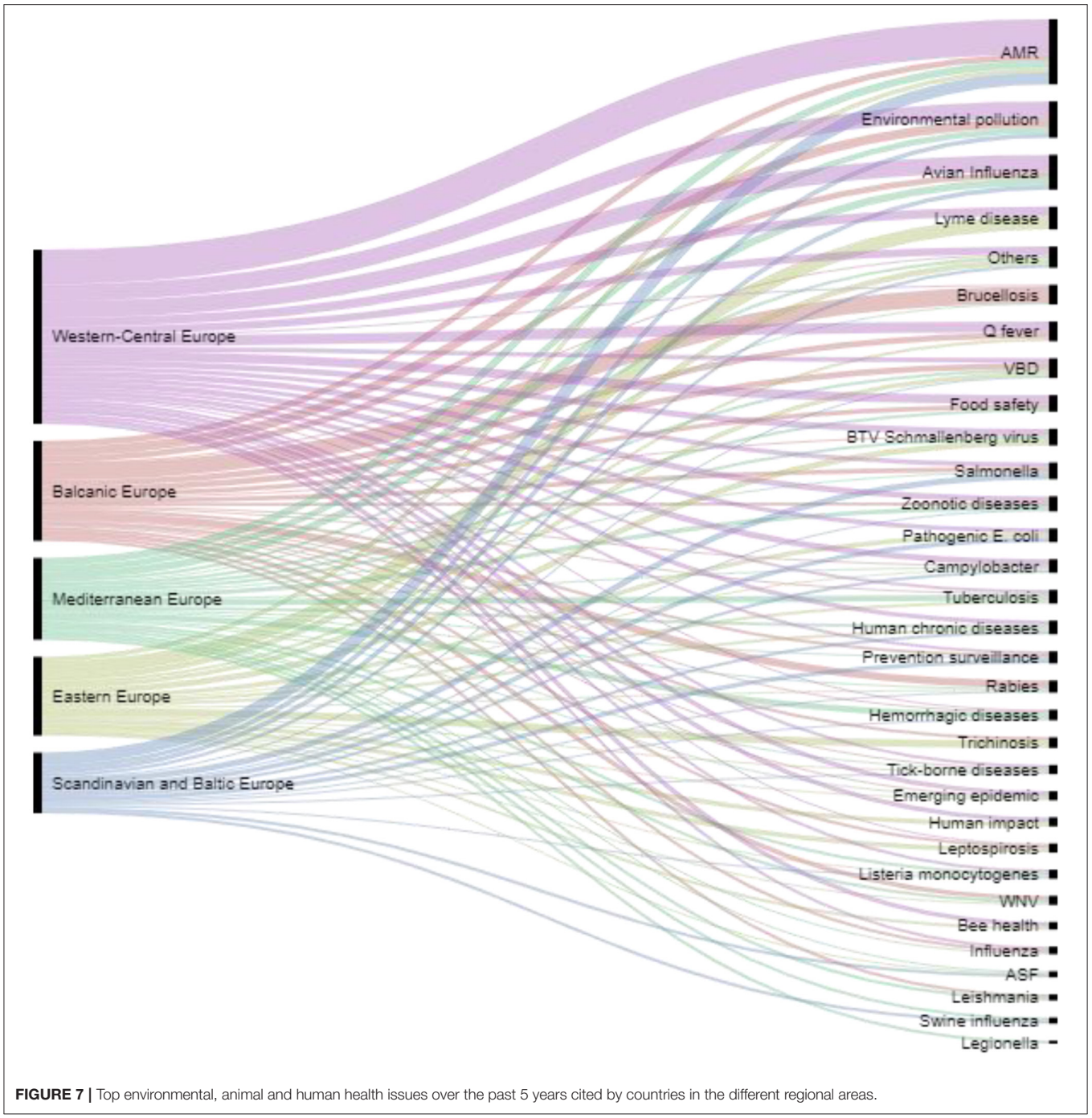


FIGURE 7 | Top environmental, animal and human health issues over the past 5 years cited by countries in the different regional areas.

Another limitation of our study is that data were collected in 2016–7 and therefore may not represent today's OH landscape in the countries surveyed. Nonetheless, it provides a baseline against which future studies of this type can be compared thereby contributing to documentation of how OH evolves in Europe and neighboring areas.

Although One Health was a familiar concept for the majority of respondents, only few were able to provide comprehensive definitions. Their answers demonstrated a traditional understanding of OH evolving around the linkages between "human" and "animal" health. The environmental health component was mentioned less frequently, which suggests that the three pillars/components of OH are overall not perceived as having equal importance. Similar differences amongst the three OH components seem to emerge from other questions, for example most of the respondents, who declared to be presently involved in OH initiatives, had a background in "Animal Sciences." Indeed, we registered

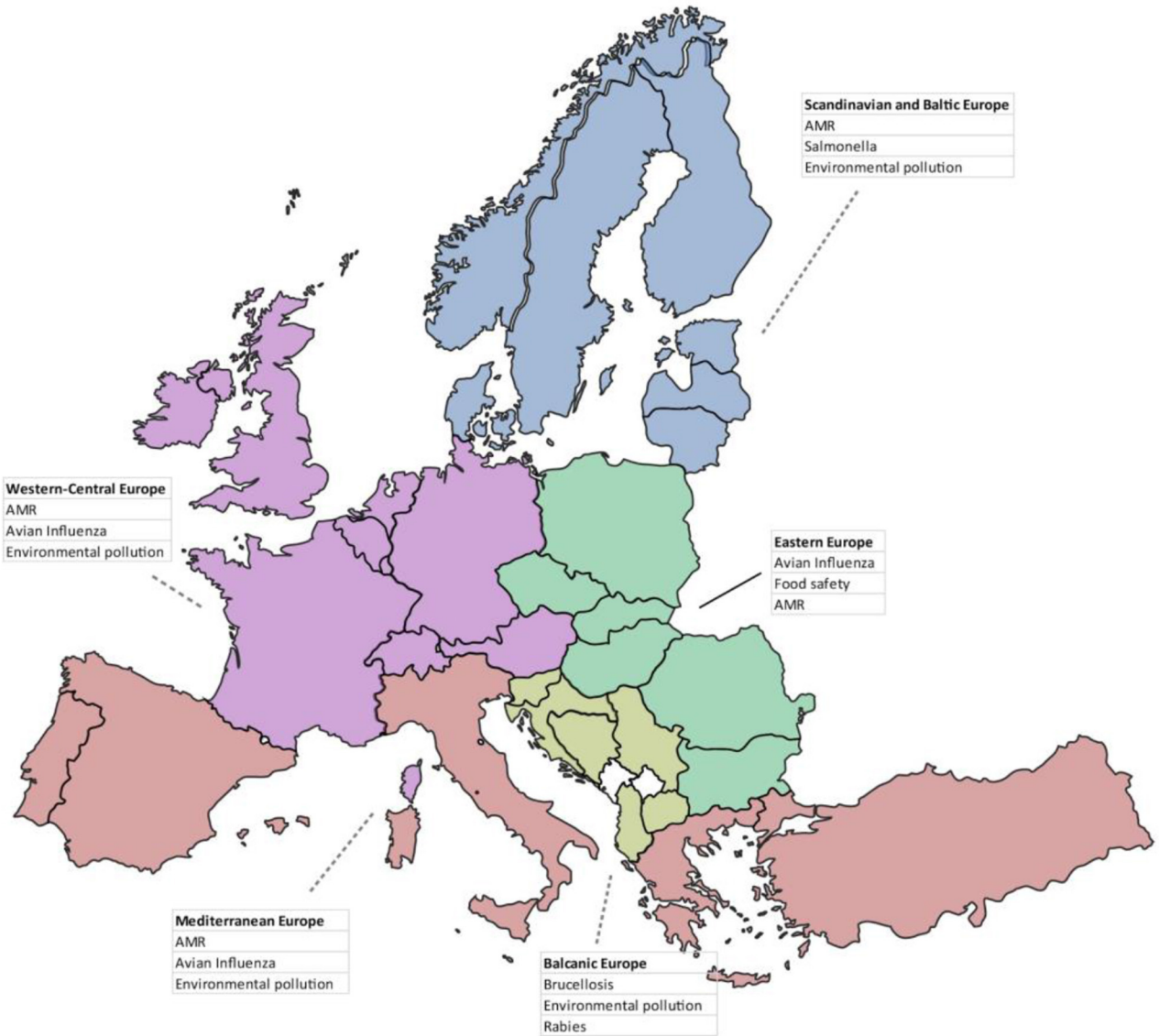


FIGURE 8 | Top three environmental, animal and human health issues over the past 5 years cited by respondents, divided by geographical regions.

a greater involvement in OH initiatives among Animal Sciences professionals, with 76.1% of respondents in this category being involved, vs. around half of respondents in "Public Health" and "Human Health" categories, and 37.5% of "Environmental Sciences."

Only slightly more than half of the respondents involved in OH initiatives seemed to be personally engaged in OH. Although adopting a OH approach for many is still a matter of a personal attitude and less of institutionalization, it seems that some steps toward official endorsement of OH are being taken, and this may constitute a move toward institutionalization of OH—at least in the human and animal health fields. Another challenge emerging from our results is the low public awareness on OH. This could be addressed through extension and information campaigns to give the general public access to OH; and actually, such activities are being started. Existing OH initiatives mentioned by respondents related mainly to "classic zoonoses" (prevention, control, surveillance). This is probably because the majority of respondents belonged to institutions working in the animal and public health disciplines, and these disciplines were those that mainly endorse OH. Other disciplinary sectors were less represented in our sample, so environmental problems, such as climate change, pollution, toxicants, socio-environmental aspects, were less mentioned.

In addition, we hypothesize that "chronic" environmental issues (i.e., contaminated agriculture soil and/or fallow land) are less visible and receive less attention both from the general

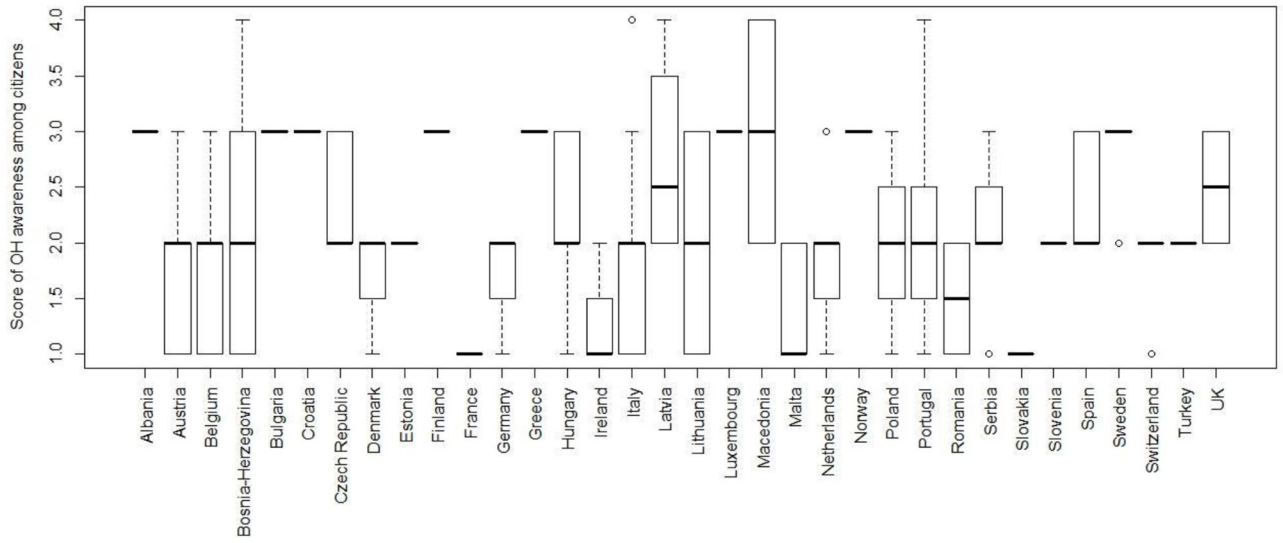


FIGURE 9 | Boxplot of the scores attributed by respondents to the level of awareness on OH in citizens in their respective countries; scoring from one (poor) to four (excellent).

public and health authorities/policy makers. Moreover, such environmental problems are usually more difficult to control and prevent.

The OH approach was adopted for zoonoses (surveillance and control), health education, AMR and food hygiene. Coincidentally, these are also common areas of the field of Veterinary Public Health and this brings up the question whether respondents differentiated between the two. Veterinary Public Health (i.e., the contribution of veterinary medicine to public health) has indeed gradually evolved in OH and in "ecosystem health"—that includes the whole ecosystem, and that considers health and ecosystems and their relevance for global health development (7).

According to the respondents, the most important advantages of OH are preventative measures such as early detection/rapid response, and effective disease control and/or biosecurity measures which actually put "prevention" at the highest rank. Lower scores were attributed to health improvement, knowledge/skills improvements, ecosystem and personal/social benefits, thus confirming a more "traditional" approach oriented toward disease surveillance and response, also suggesting a poor understanding of the environmental health component and still an apparent existing dichotomy between OH and Ecohealth. The fact that two thirds of respondents reported formal connections between veterinary and public health administrations (governmental institutions or services) is noteworthy. Remarkably, the highest "yes" frequency was registered among those respondents involved in Food Safety, Animal and Public/Human Health, while "No" answers prevailed amongst Environmental and Life Sciences persons, suggesting that respondents involved in the former disciplines seem to be more aware of such formal connections. Other respondents may be more aware of Ecohealth connections.

As pointed out by some authors (24–27), the two approaches, despite their apparent dichotomy, have a common ground and unifiying attributes. In fact, according to Zinsstag (7) both Ecohealth and One Health movements emphasize a holistic understanding of health beyond the purely biomedical and champion system thinking as a way of achieving a greater understanding of health problems; both approaches espouse inter- and trans-disciplinary research and collaborative participation. Literature in the field shows that the concepts continue to evolve and be discussed. For example, Lackey (28) promoted a challenging discussion on the values of ecosystem health, Antoine-Mussiaux et al. (29) provided an analysis on framing "nature" or the environment within the scientific communities involved, Harrison et al. (30) addressed the calls for convergence between OH and Ecohealth. Some areas already well-developed in Ecohealth (e.g., relationships between health and ecosystems or between health and sustainable development) have been growing in importance within the One Health movement. Each approach has its own strengths and -by working together- a greater impact in global health and sustainability may be achieved (25). In line with this view, NEOH has therefore established a new Network for Ecohealth and OH as a chapter of the Ecohealth International organization (https://www.ecohealthinternational.org/regional-chapters/europe/).

Section 3, regarding zoonotic diseases, environmental health and AMR, provided interesting insights. More than 80% of the respondents reported an active cooperation in their countries between the Ministry of Health and the Ministry responsible for animal health, when dealing with zoonoses, also stating that there is an obligation to guarantee a reciprocal flux of information between Public Health and Veterinary Services. When respondents were asked to select which zoonotic diseases (from a list taken from Public Health England website) are

or should be monitored and controlled by MoH and/or MoA, there was a convergence –with a few exceptions, that is, Ebola, ringworms, cysticercosis/taeniasis- in attributing the responsibilities to both Ministries. This could be related to the different organization of the Health System and Veterinary Services in the target countries.

Two questions were asked about environmental toxicants and it was requested to score the level of awareness by the public on "toxicant zoonoses" (zoonoses caused by exposure to environmental toxicants) and the quality of national plans for their prevention/monitoring. The percentage of respondents to these questions was not satisfactory; in fact, more than half of them stated that they were not competent in the field, thus suggesting that "non-traditional zoonoses" are generally less known or less taken into consideration.

While nearly half of the interviewees stated that their respective countries contribute to EU AMR surveillance with specific monitoring and research programs, there were some conflicting answers amongst respondents, that is, within the same country, some respondents stated that their country contribute to the EU AMR monitoring and others stated the contrary. However, the European surveillance systems/networks [e.g., EARS-Net (31)] and the international guidelines (16) are likely helping the full implementation of the National Action Plans (NAPs) to fight AMR.

In the section regarding the aspects limiting interdisciplinarity and intersectorality in OH (section 4), the "siloed approach" of disciplines was the most commonly mentioned limiting factor. Lack of resources, institutional and education limits were also cited. All these factors have long been recognized as barriers to moving toward OH (32).

When asked to score the level and opportunities for OH collaboration at different institutional and/or professional levels, the higher proportion of "good" and "excellent" scores were attributed to institutions involved in animal health surveillance/food security, and institutions involved in emergencies management. "Poor" scores prevailed as regards professional boards and university departments, but were attributed by a maximum of 26% of respondents, suggesting that in COST countries there is an overall positive perception about level and the opportunities for OH collaboration.

When asked to rate (one being "poor," and five "excellent") how well the OH approach is implemented by the professionals employed/engaged in Veterinary, Public and Environmental Health sectors, respondents gave a median score of 3 (Q1–3: 2–3). Although the great difference in the number of respondents per country makes it difficult to compare and comment the results, the authors consider such overall score (3) not much "encouraging." Professionals still need to do more efforts for implementing the OH approach in their respective countries. Alike, the answers on the existence of initiatives to establish/strengthen intersectoral collaboration, aimed at global advocacy of OH approach, yielded a not much promising picture: in fact, only 30% of the respondents are aware of such initiatives.

When asked to cite the top three environmental, animal and human health issues in their country over the past 5 years, most respondents cited AMR, avian influenza and environmental pollution. Such results seem consistent with the epidemiological situation at the time the questionnaire was circulated (2016–17). Indeed, in the period under review, AMR was –and actually still it is- capturing most attention by the international scientific community. Zoonotic avian flu was quoted as the second most important health topic as, since 2013, thousands of human cases and many deaths have been reported worldwide. Environmental pollution is considered by the respondents a "chronic" problem, quite often difficult to remediate and to solve, which induce several acute and long-term effects on human health and ecosystems.

The authors believe that if the questionnaire were to be administered nowadays, the top health issue would have certainly been the recent (and ongoing) COVID-19 pandemic.

Regional differences could also be observed, in particular between countries belonging to Balkan Europe and the other groups of countries: this is the only group where AMR was not included among the first three OH issues, while brucellosis and rabies were at the first and third position respectively. This reflects the endemic situation and the challenge posed to public health by these diseases in the Balkan countries (33–36). It is noteworthy that *Salmonella* falls in the top three issues in the Scandinavian and Baltic Europe: this foodborne pathogen, which has been the object of a strong and successful surveillance and control programme in these countries (37), is nonetheless considered as a top priority when public health is involved.

In this section, another important question/issue was about the level of awareness/perception of OH amongst citizens/consumers: the median score attributed by the respondents in their respective countries was only 2, and such overall data is not much "encouraging." This result not only highlights that respondents know that great work still needs to be done to raise public awareness about OH, but also that we all, as members of research and academic institutions, have failed to engage citizens sufficiently. Though there were differences in the number of respondents per country, thus making it difficult to comment on the results, it is certainly crucial that academic and research Institutions, ministries, professional boards have to improve on dissemination, information and education activities, through public engagement and promotion activities on OH for general public and stakeholders.

The gaps on OH schemes cited were strictly related to the question posed in section 4 about factors limiting OH based on the respondents' personal experience. Although many professionals seem highly motivated to endorse the OH approach, barriers exist especially at the institutional level. In fact, interviewees underlined the lack of OH approach in institutions. The "siloed approach" of disciplines, scarce funding and education/awareness limits are other limits to intersectorality, resulting in poor networking, differing priorities and a lack of understanding between sectors.

Respondents from different sectors preferentially selected (prioritized) their own directorates/ministries when looking at the control and monitoring of zoonotic diseases, while actually in most countries, both MoH and MoA are engaged. In Italy, where Veterinary Services are under the Ministry of Health, such differences tend to be less evident.

Despite the limitations described, this study provides an overview of perception and experiences in OH and OH initiatives in Europe, putting into evidence major gaps and challenges as well as opportunities to better apply OH approach. Identifying how initiatives are currently working and knowing their promoting and hindering factors has allowed insights into how improved education and incentives for those working in different areas of the field could change efficiency/effectiveness of OH implementation in years to come. As regards education, academia can play an important role to develop and implement a common OH curriculum to be used by the different European Universities to teach OH approach, strategies, and methods. Health and Environment Institutions/Ministries –together with the Academia, the professional boards, and NGOs- can promote awareness campaigns on the importance of OH approach with stakeholders and the general public at large. Scientists should make efforts to better communicate and share their research results on OH issues to the public and to politicians and policy-makers: such process of sharing information and scientific-based opinions/recommendation would likely make scientists more listened to. The present COVID-19 pandemic –with its enormous toll of victims and socio-economic consequences- has probably greatly contributed to a better awareness of the importance of OH, and -even more- Planetary Health.

Stakeholders, professional boards, the research world and academia, together with citizens must capitalize the momentum gained and use it as a trigger with politicians and decision makers –nationally and internationally to advance OH and related approaches.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

An informed consent form was provided at the beginning of the questionnaire where the participants were advised that the questionnaire was anonymous and that, by completing and submitting it, they voluntarily agreed to participate. Ethical approval was sought and granted by the Clinical Research and Ethical Review Board at the Royal Veterinary College, grant holder of COST Action TD1404 NEOH (ref. prot. n. URN 2016 1554).

AUTHOR CONTRIBUTIONS

FC: conceptualization and design of the questionnaire survey, data cleaning and managing questionnaire answers, creation of figures and tables, drafting and editing manuscript. LT: data cleaning and managing questionnaire answers, data management and analysis, creation of figures and tables, drafting and editing manuscript. SS: conceptualization and design of the questionnaire survey, collaboration in the survey distribution, drafting and editing manuscript. AB: data cleaning and managing questionnaire answers, collaboration in data analysis, collaboration in drafting manuscript. AM: general contribution in the study design, general supervision as EURNEGVEC chair, collaboration in the survey distribution. DM: general contribution in the study design, collaboration in the survey distribution. BH: conceptualization and design of the questionnaire survey, general supervision as NEOH chair, drafting and editing manuscript. DDM: conceptualization and design of the questionnaire survey, general coordination and supervision of the questionnaire distribution, managing questionnaire answers, drafting and editing manuscript. All authors: reviewing the final version of the manuscript.

FUNDING

This study was supported by the COST Actions TD1404 Network for Evaluation for One Health-NEOH and TD1303 European Network for Neglected Vectors and Vector-Borne Infections-EURNEGVEC, and by Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR) under the programme *Dipartimenti di Eccellenza ex L.232/2016* to the Department of Veterinary Science, University of Turin.

ACKNOWLEDGMENTS

The authors would like to thank the MCs members and MC substitutes of NEOH and EURNEGVEC COST Actions for identifying, contacting the target respondents in their respective countries. The valuable contribution of all respondents who kindly answered the online questionnaire is highly acknowledged here: without their keen participation, this survey would not have been possible. Florence Morin, former EU FVO officer, is acknowledged for her suggestions and comments to the early version of the questionnaire, and Rebecca Morris, vet student at the RVC, for redacting a preliminary report on the initial answers to the questionnaire survey. Finally we thank Natalia Cediel, lecturer and researcher at Universidad de La Salle, Bogotà (Colombia) for her useful comments to the manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.609949/full#supplementary-material

REFERENCES

1. Rüegg SR, Nielsen LR, Buttigieg SC, Santa M, Aragrande M, Canali M, et al. A systems approach to evaluate OH initiatives. *Front Vet Sci*. (2018) 5:23. doi: 10.3389/fvets.2018.00023
2. Rüegg SR, Häsler B, Zinsstag J, editors. *Integrated Approaches to Health—A Handbook for the Evaluation of OH*. Wageningen: Academic Publishers (2018). p. 256.
3. Yamada A, Kahn LH, Kaplan B, Monath TP, Woodall J, Conti L, editors. *Confronting Emerging Zoonoses: The OH Paradigm*. Cham: Springer (2014).

4. Frazzoli C, Mantovani A. Toxicants exposures as novel zoonoses: reflections on sustainable development, food safety and veterinary public health. *Zoonoses Public Health.* (2010) 57:e136–42. doi: 10.1111/j.1863-2378.2009.01309.x
5. Patz JA, Hahn MB. Climate change and human health: a OH approach. *Curr Top Microbiol Immunol.* (2013) 366:141–71 141 doi: 10.1007/82_2012_274
6. Paternoster G, Tomassone L, Marchino M. WNV surveillance working groups of Emilia-Romagna, Lombardy, Piedmont regions, Vogler B, Balduzzi G, Favretto AR. Knowledge integration to evaluate OH- Process evaluation of West Nile virus integrated surveillance in northern Italy. *NEOH Final Conference*. Bologna, Italy (2018).
7. Zinsstag J, Schelling E, Waltner-Toews D, Tanner M. From "one medicine" to "one health" and systemic approaches to health and well-being. *Prev Vet Med.* (2011) 101:148–56. doi: 10.1016/j.prevetmed.2010.07.003
8. Zinsstag J, Schelling E, Waltner-Toews D, Whittaker M, Tanner M. *One Health: The Theory and Practice of Integrated Health Approaches*. Wallingford; Boston: CABI (2015).
9. Haxton E, Šinigoj Š, Rivière-Cinnamond A. The network for evaluation of one health: evidence-based added value of one health. *Infect Ecol Epidemiology.* (2015) 5:28164. doi: 10.3402/iee.v5.28164
10. Rüegg SR, McMahon BJ, Häsler B, Esposito R, Nielsen LR, Ifejika Speranza C, et al. A blueprint to evaluate One Health. *Front Public Health.* (2017) 5:20. doi: 10.3389/fpubh.2017.00020
11. Paternoster G, Tomassone L, Tamba M, Chiari M, Lavazza A, Piazzi M, et al. The degree of OH implementation in the West Nile virus integrated surveillance in northern Italy, 2016. *Front Public Health.* (2017) 5:236. doi: 10.3389/fpubh.2017.00236
12. Baum SE, Machalaba C, Daszak P, Salerno RH, Karesh WB. Evaluating One health: are we demonstrating effectiveness? *One Health.* (2017) 3:5–10. doi: 10.1016/j.onehlt.2016.10.004
13. Machalaba CC, Salerno RH, Barton Behravesh C, Benigno S, Berthe FC, Chungong S, et al. Institutionalizing One Health: from assessment to action. *Health Security.* (2018) 16:S—37. doi: 10.1089/hs.2018.0064
14. Stephen C, Karesh WB. Is OH delivering results? Introduction. *Rev Sci Tech.* (2014) 33:375–92. doi: 10.20506/rst.33.2.2301
15. World Bank. *One Health: Operational Framework for Strengthening, Human, Animal, and Environmental Public Health Systems at Their Interface*. 1st ed. Washington, DC: World Bank (2018).
16. WHO/FAO/OIE. *Antimicrobial Resistance—A Manual for Developing National Action Plans*. Geneva; Paris; Rome: WHO/FAO/OIE Publishers. p. 32.
17. Khan MS, Rothman-Ostrow P, Spencer J, Hasan N, Sabirovic M, Rahman-Shepherd A, et al. The growth and strategic functioning of OH networks: a systematic analysis. *Lancet Planet Health.* (2018) 2:e264–73. doi: 10.1016/S2542-5196(18)30084-6
18. Saleh A, Bista K. Examining factors impacting online survey response rates in educational research: perceptions of graduate students. *J Multidiscip Evaluation.* (2017) 13:63–73.
19. R Core Team. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing, (2019).
20. Destoumieux-Garzón D, Mavingui P, Boëtsch G, Boissier J, Darriet F, Duboz P, et al. The OH concept: 10 years old and a long road ahead. *Front Vet Sci.* (2018) 5:14. doi: 10.3389/fvets.2018.00014
21. Häsler B, Cornelsen L, Bennani H, Rushton J. A review of the metrics for OH benefits. *Rev Sci Tech.* (2014) 33:453–64. doi: 10.20506/rst.33.2.2294
22. Millar MM, Dillman DA. Improving response to web and mixed-mode surveys. *Public Opinion Quarterly.* (2011) 75:249–69. doi: 10.1093/poq/nfr003
23. Baruch Y., Holtom B. C. (2008). Survey response rate levels and trends in organizational research. *Human relations.* 61:1139–1160. doi: 10.1177/0018726708094863
24. Mi E, Mi E, Jeggo M. Where to now for OH and eco-health? *EcoHealth.* (2016) 13:12–7. doi: 10.1007/s10393-016-1112-1
25. Zinsstag J. Convergence of eco-health and one health. *EcoHealth.* (2012) 9:371–3. doi: 10.1007/s10393-013-0812-z
26. Zinsstag J. OH EcoHealth 2016: welcome from the president of theInternational Association for Ecology and Health. *EcoHealth.* (2016) 13:613–4. doi: 10.1007/s10393-016-1180-2
27. Lerner H, Berg C. A comparison of three holistic approaches to health: one health, ecohealth, and planetary health. *Front Vet Sci.* (2017) 4:163. doi: 10.3389/fvets.2017.00163
28. Lackey RT. Values, policy, and ecosystem health. *BioScience.* (2001) 51:437–4. doi: 10.1641/0006-3568(2001)051(0437:VPAEH)2.0.CO;2
29. Antoine-Moussiaux N, Janssens de Bisthoven L, Leyens S, Assmuth T, Keune H, Zinsstag, J, et al. The good, the bad and the ugly: framing debates on nature in a One Health community. *Sustain Sci.* (2019) 14:1729–38. doi: 10.1007/s11625-019-00674-z
30. Harrison S, Kivuti-Bitok L, Macmillan A, Priest P. EcoHealth and One Health: a theory-focused review in response to calls for convergence. *Environ Int.* (2019) 132:105058. doi: 10.1016/j.envint.2019.105058
31. European Antimicrobial Resistance Surveillance Network (EARS-Net). Available online at: https://www.ecdc.europa.eu/en/about-us/partnerships-and-networks/disease-and-laboratory-networks/ears-net
32. World Bank Group. People, Pathogens, and our Planet—Volume One: Towards a OH Approach for Controlling Zoonotic Diseases. Washington, DC: World Bank Group (2010).
33. Rossetti CA, Arenas-Gamboa AM, Maurizio E. Caprine brucellosis: a historically neglected disease with significant impact on public health. *PLoS Negl Trop Dis.* (2017) 11:e0005692. doi: 10.1371/journal.pntd.0005692
34. Bosilkovski M, Stojanov A, Stevanovic M, Karadzovski Z, Krstevski K. Impact of measures to control brucellosis on disease characteristics in humans: experience from an endemic region in the Balkans. *Infect Dis.* (2018) 50:340–5. doi: 10.1080/23744235.2017.1407037
35. Buttigieg SC, Savic S, Cauchi D, Lautier E, Canali M, Aragrande M. Brucellosis control in Malta and Serbia: a OH evaluation. *Front Vet Sci.* (2018) 5:147. doi: 10.3389/fvets.2018.00147
36. Henning J, Giorgi E, Magalhães RS, Tizzani P, Viviani P, Pejovic N, et al. Factors influencing the success of aerial rabies vaccination of foxes. *Scientific Rep.* (2017) 7:1–9. doi: 10.1038/s41598-017-14615-2
37. Houe H, Nielsen SS, Nielsen LR, Ethelberg S, Mølbak K. Opportunities for improved disease surveillance and control by use of integrated data on animal and human health. *Front Vet Sci.* (2019) 6:301. doi: 10.3389/fvets.2019.00301

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 01 April 2021
doi: 10.3389/fpubh.2021.628748

Evaluation of the Implementation of a 25-Year Outdoor School Ground Smoking Ban: A Qualitative Interview Study With Implications for Prevention Practise

Pia Kvillemo, Kristin Feltmann, Tobias H. Elgán and Johanna Gripenberg*

Stockholm Prevents Alcohol and Drug Problems, Centre for Psychiatry Research, Department of Clinical Neuroscience, Karolinska Institutet, Stockholm Health Care Services, Region Stockholm, Stockholm, Sweden

OPEN ACCESS

Edited by:
Salma El Tayeb El Amin, University of Tampere, Finland

Reviewed by:
Paolo D'Argenio, Associazione Italiana di Epidemiologia, Italy
Gianluigi Ferrante, Piedmont Reference Center for Epidemiology and Cancer Prevention, Italy

***Correspondence:**
Pia Kvillemo
pia.kvillemo@ki.se

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

Received: *12 November 2020*
Accepted: *03 March 2021*
Published: *01 April 2021*

Citation:
Kvillemo P, Feltmann K, Elgán TH and Gripenberg J (2021) Evaluation of the Implementation of a 25-Year Outdoor School Ground Smoking Ban: A Qualitative Interview Study With Implications for Prevention Practise. Front. Public Health 9:628748. doi: 10.3389/fpubh.2021.628748

Introduction: Tobacco use, often initiated in younger ages, is a serious health challenge worldwide. In Sweden, smoking has been prohibited on school grounds since 1994. Municipal environmental and health inspectors control the compliance of the ban. Nevertheless, the enforcement and maintenance of the ban are inadequate. The aim of the current study was to identify facilitators, barriers, and the potential for improved implementation of a 25-year outdoor school ground smoking ban in upper secondary schools.

Materials and Methods: A process evaluation was conducted using semi-structured interviews with principals in upper secondary schools, local environmental and health inspectors, and local politicians ($n = 30$) in Stockholm County, with purposive sampling for informant recruitment. A qualitative content analysis of the transcribed interviews was performed.

Results: Three main categories and 10 subcategories were generated from the interviews, revealing facilitators, barriers, and the potential for improvement of the implementation of the ban. A prominent facilitator of the ban was informed and engaged principals and inspectors. Prominent barriers were conflicting goals governing the schools, which reduce staffs' motivation to maintain the ban, unclear school ground boundaries, and lack of resources. Potential for improvement was found in a new tobacco act with an extended ban on smoking at school entrances, extended support for schools and staff to strictly enforce the ban, and a continued denormalisation of smoking in society.

Conclusion: To achieve effective implementation of outdoor school ground smoking bans in upper secondary schools, authorities need to address conflicts between different

goals governing the schools and give necessary support to the staff to strictly enforce the ban. Policies on smoke-free working hours in the municipalities along with tobacco restrictive policies in the surrounding society may increase the possibility to maintain the smoking ban in upper secondary school grounds.

Keywords: tobacco, outdoor school ground smoking ban, qualitative content analysis, policy, students, public health, Sweden

INTRODUCTION

Tobacco use is a serious public health challenge in the world. According to the World Health Organisation, one in ten deaths is caused by tobacco use (1). Smoking is associated with several diseases, such as chronic obstructive pulmonary disease, cardiovascular disease, lung cancer, and other cancers (2–4). Therefore, most countries, including Sweden, have adopted restrictive policies on tobacco sales and tobacco use (5–8). Smoking at an early age when the brain is under development is particularly harmful and associated with being an adult smoker (9–13). European data from 2015 on students aged 15–16 years revealed that 21% were smokers (range between countries 6 and 37%) (14). In line with these data, a Swedish, school survey from 2018 showed that 23% of the students aged around 17 were smokers (in upper secondary school) (15), calling for action. Since young people spend a lot of mandatory time in school, the implementation of smoking bans in school settings has been regarded as a promising policy intervention to prevent smoking among children and young adults. Thus, many countries have in the last decades implemented smoking bans in school settings (5, 16–20). Studies on the direct effect of such bans have, however, shown inconclusive results with regard to students' smoking behaviour (20–25). Thus, there is a need for more research on how the bans function in relation to the level of enforcement, national setting, and possible indirect effects (17, 18).

In the growing field of implementation research, some general knowledge on effective implementation strategies has emerged. In a comprehensive synthesis of the literature, Fixsen et al. (26) argue that implementation activities are influenced by components connected to the implementation process (e.g., training and coaching of staff), the organisation in which an intervention is implemented (e.g., prioritisation, attitudes and norms among staff), and external circumstances (e.g., societal norms, politics, and economy). Moreover, they claim that an implementation process, in general, takes between 2 and 4 years and contains the following six stages: (1) exploration/adoption, (2) installation, (3) initial implementation, (4) full implementation, (5) innovation, and (6) sustainability. Similarly, Scaccia et al. (27) emphasise the importance of innovation-specific capacities, motivation to implement an innovation in an organisation, and general capacities of the organisation in which it is implemented. Referring to Aarons et al. (28), Scaccia, et al. (27) also highlight the need to ensure quality implementation throughout the entirety of the innovation's lifespan.

Outdoor school ground smoking bans are internationally less common than corresponding indoor smoking bans, especially those regulated by law at a national level (16, 18, 24). Thus, less is known about the facilitators and barriers influencing the implementation of these bans. The few studies that we found on facilitators and barriers affecting the implementation of outdoor school ground smoking bans specifically were from the Netherlands (16, 29) and Canada (30, 31). While studying the sustainability of an outdoor school ground smoking ban in the Netherlands, Rozema et al. (29) found that perceived barriers and facilitators for sustainability could be sorted into the following three categories: smoking ban implementation factors, school factors, and community environment factors. The authors concluded that the involvement of all staff is important for sustainability, as they function as role models, have an interrelationship with students, and share responsibility for enforcement. In a process evaluation of the implementation of an outdoor school ground smoking ban in 24 Dutch secondary schools, Rozema et al. (16) consolidated the findings on facilitators and barriers (1–3) outlined above, suggesting that directors should deal with violators by strictly enforcing the ban, initiating a dialogue with them, and/or using counselling as methods to help offenders stop smoking. In a Canadian study on the enforcement of a ban on smoking on school properties, Ashley et al. (30) found that schools and tobacco enforcement officers experienced a lack of resources and an increased workload in schools, as a result of the enforcement task given to them. The authors also cited the need for increased education on tobacco for students as well as complementary measures such as price increases and enforcement of the ban on sales to minors. Finally, in another Canadian study of a smoking ban in schools, Pickett et al. (31) suggested that attention should be given to informing teachers and gaining their support when implementing a ban, as well as having strategies for dealing with potential safety risks to students who leave the school property to smoke.

In Sweden, a national ban on smoking on school grounds was established by law in 1994 (32). The responsibility for ensuring compliance with the ban is divided between authorities at the national, regional, and local levels (33). The Public Health Agency has central supervisory responsibility at the national level, while the County Administrative Boards have a regional responsibility, and the municipality authorities have a local supervisory responsibility. The County Administrative Board shall follow the municipalities' activities and assist them with information and advice, and promote cooperation between relevant organisations and actors. The municipality's

environmental and health inspectors conduct supervision of compliance with the tobacco legislation at the municipal's schools. The inspectors can instruct the school to ensure that smoking at the school ground ceases and request an action program. The inspectors can also suggest changes in the physical environment, e.g., removal of ashtrays, and initiate injunctions or prohibitions, sometimes combined with an economic penalty (33, 34). Injunctions and prohibitions must be approved by local politicians, who have responsibility for smoking policy in their municipality, which is often carried out by a department handling social and health-related issues. The municipality is responsible for the supervision of several environments in the community and can charge fees for supervision connected to that. However, they cannot charge a fee for the supervision regarding the outdoor school ground smoking ban. The primary responsibility for maintaining a smoke-free school ground lies with the school's principal (34). Tobacco prevention activities, like information to staff, students and parents at schools, can be assisted by actors in the local community, including staff employed by the municipality, e.g., prevention coordinators. In 2016 (34), prevention coordinators were found in almost all of the 26 municipalities in Stockholm County, as well as in the city districts of Stockholm.

Despite efforts to ensure that the smoking ban on school grounds, launched in 1994, is properly implemented, the enforcement of the ban was still found inadequate in 2016–2018 (34–36). Surveys among school staff in Stockholm in 2016 and 2017 suggested that smoking occurs on several of the county's school grounds, not least in upper secondary schools, suggesting the need for effective actions to improve the implementation of the ban (34, 37).

Previous studies on facilitators and barriers influencing the implementation of smoking bans in school settings, including those focusing on outdoor school ground smoking bans, have investigated the implementation process primarily from a school perspective. One exception is a recent study by Hoffmann et al. (18), assessing barriers to the implementation of school tobacco policies (indoor and outdoor) in seven European cities by interviewing local stakeholders outside the schools. In the current study, we build on previous research by combining three perspectives on the implementation of an outdoor school ground smoking ban, namely the perspective of key stake holders, i.e., secondary school principals, local politicians, and municipality inspector officials. The aim of the current study was to identify facilitators, barriers, and the potential for improved implementation of a 25-year outdoor school ground smoking ban in upper secondary schools in Stockholm County. The study will add to a multi-perspective knowledge base of the implementation processes related to outdoor school ground smoking bans and highlight necessary measures to improve the implementation and maintenance of such bans.

MATERIALS AND METHODS

A process evaluation study was conducted using qualitative data from semi-structured interviews with local stakeholders in Stockholm County.

Participants and Procedures

Purposive sampling was used to include relevant informants for the interviews, based on the organisation of tobacco restriction control in Sweden. Three vocational groups were selected: principals in upper secondary schools (hereafter named principals), local environmental and health inspectors (hereafter named inspectors) and local politicians, elected and currently active (hereafter named politicians). The County Administrative Board in Stockholm provided the research team with a list of contact details to 30 local persons from each vocational group, i.e., 90 names from different municipalities and schools, including assisting principals. Persons were chosen from a variety of schools and municipalities to allow for varying sociodemographic profiles and efforts to implement the outdoor school ground smoking ban. To achieve reasonable saturation (38), the aim was to interview 10 persons from each category ($n = 30$). At the beginning of 2019, the research team chose the names of the first 10 principals, inspectors, and politicians on the list, asking them *via* e-mail to participate in the study. They were informed that participation was voluntary; that data would only be reported in aggregate form; and that audio and text files were to be stored safely (i.e., at encrypted servers) in coded form to preserve confidentiality. Informed consent was obtained by asking the receiver to reply, and if giving a positive answer, agreeing to participate in the study. If participants refrained from participation, additional persons were contacted, i.e., the next person on the list, until the intended number of participants was reached. About one-third to one-half of those contacted refrained from participation, mainly due to time constraints.

At inclusion of the participants, a code key was established with an individual code for every informant, consisting of a number between 1 and 10 connected to the current category, e.g., Principal 3, Inspector 7. The Regional Ethical Review Board in Stockholm was contacted and informed about the study but regarded it as unnecessary to review for approval (dnr. 2019-00719).

Semi-Structured Interviews

Semi-structured interview guides for each category of informants were elaborated by the research team in collaboration with officials at the County Administrative Board. The interview guides included 10–12 questions, along with supplementary questions. The interviews started by asking the informants about how long they had held their current position, which was on average 3 years for inspectors, 6.5 years for principals, and 1.5 years for politicians. The main interview questions reflected issues concerning facilitators, barriers, and the potential for improvement of the implementation processes. Example questions were: *Initially, do you want to say something about the municipality's work with smoke-free schoolyards? In what way does the school inform students about the smoking ban? Are smoking and the health risks something that is integrated into teaching? What else would be required to remove smoking on the school grounds?* Three of the authors (KF, THE, PK) conducted the interviews by phone. The interviews, on average 20 min long, were recorded and transcribed verbatim into 272 pages of text.

Content Analysis

Qualitative content analysis with a team-based approach was used to analyse the interview data (39–41) and the software NVivo 12 was utilised for structuring the data. The four researchers in the team have extensive knowledge in social sciences, public health, drug prevention, and implementation theories, which facilitated the analysis. Initially, one researcher (PK), who has a PhD in medical science, a master's degree in political science, and extensive experience in qualitative analysis, started the analysis process by repeatedly reading 8 of the 30 interviews. The analysis was to some extent deductive since the interview questions initially directed the analysis (40). During the reading, meaningful units were identified and grouped into categories (**Supplementary Table 1**). A preliminary coding scheme with the key concepts of facilitators, barriers and potential areas for improvement, along with main categories, inspired by Rozema et al. (29), and sub-categories with definitions (codebook) (41) were developed and presented for the other three researchers in the team (KF, TE, JG). The team discussed the definitions of certain codes and agreed to a slightly refined codebook, but with the same number of codes. After the discussion, PK, continued the coding of the remaining interviews, while defining the various codes more clearly, excluding one of them because of irrelevance, and dividing one sub-category of codes into two. To assess the reliability of the coding, an independent recoding of three of the interviews (one from each occupational group) was carried out by a second coder from the research team (KF) (42). A high degree of agreement between coders was obtained with a few disagreements resolved through discussion.

RESULTS

The Informants

The final group of informants represented 17 of the 26 municipalities in Stockholm County, including municipalities with various sizes and socioeconomic characteristics (43, 44) (**Supplementary Table 2**). The capital of Sweden (Municipality "A") is by far the largest municipality with the most schools within its borders, both public and independent. With the exclusion of this municipality, the mean size of all municipalities in the county is 52,056 (Standard Deviation (SD): 28,131.51) inhabitants and the mean number of upper secondary schools 4.2 (SD: 3.84) of which 1.64 (SD: 1.38) are public schools and 2.68 (SD: 3.03) are independent schools. The corresponding numbers for the municipalities included in the study, excluding the municipality of Stockholm, are 62 413 (SD: 28,807.92) inhabitants, 5.56 (SD: 4.15) upper secondary schools, 2.12 (SD: 1.49) public schools, and 3.24 (SD: 3.56) independent schools. Thus, the municipalities included in the study are on average somewhat larger than those not included. In terms of education, the proportion of inhabitants aged 25–64 years with at least 3 years of university education is 31% in the entire county, and in the municipalities included in the study 32%. Eight principals, two representatives of principals, i.e., one administrative manager and one official, appointed by the principal, 10 inspectors, and 10 politicians, constituted the final group of informants.

TABLE 1 | Main categories and sub-categories.

Main categories	Sub-categories
Smoking-ban implementation factors	Regulation of outdoor school ground smoking ban by The Tobacco Act
	Enforcement actors
	Municipality-based control of compliance with outdoor school ground smoking ban
	School leadership
	School-based implementation and enforcement
School factors	School culture
	School ground
Community environment factors	Other actors or activities in the society
	Social environment
	Laws and regulations apart from the smoking ban on school grounds

Analytical Categories

The key concepts, facilitators, barriers, and potential factors were categorised into three main categories, corresponding to those previously outlined by Rozema et al. (29), i.e., smoking-ban implementation factors, school factors, and community environment factors. Smoking-ban implementation factors are factors related to (1) the actual implementation of the ban, including how it is expressed in the Tobacco Act, (2) enforcement actors at different organisational levels, and (3) the enforcements' actor's performance and ability to implement the ban. School factors are factors connected to the schools *per se*, regardless of the smoking ban. Community environment factors are circumstances which surround the actual implementation organisation, influencing the implementation of the ban without being directly connected to the implementation process. Along with the main categories, 10 sub-categories were defined, as outlined in **Table 1**.

Additionally, 29 codes were generated from the material (**Supplementary Table 3**). Facilitators, barriers and potential for improvement were found in all the sub-categories, except for "Laws and regulations apart from the smoking ban on school grounds," were no facilitators were revealed. In the following, the results are presented under headings corresponding to the main categories and sub-categories.

Smoking-Ban Implementation Factors

Regulation of Outdoor School Ground Smoking Ban by the Tobacco Act

Although a smoke-free school ground is regulated by law, only one informant emphasised that a ban facilitates the maintenance of non-smoking in upper secondary school grounds. Several other informants found it difficult to implement the ban and the view that the law is meaningless because of a lack of tools to maintain compliance with it was also expressed.

It doesn't help us, because nothing happens, and our students know that if they smoke in the school ground, "it is certainly forbidden by law, but I don't suffer the consequences." So, that it is forbidden by law, will not be a tool for us. Possibly signal policy, but at least our young people are not receptive to that type of signal policy, so I don't think the law helps me at all. (Principal 3)

At the time of the interview (January–March 2019), several informants looked forward to a revised version of the Swedish Tobacco Act that was due to be implemented in July 2019. The new act encompasses a smoking ban in certain public spaces, including the entrances to school buildings, which several informants said will make it easier to enforce the ban, especially at schools without a well-defined school ground.

Enforcement Actors

A facilitating factor related to enforcement actors concerned support given to the municipalities by the County Administrative Board. Meetings organised by the Board are perceived as rich opportunities to learn about the interpretation of the Tobacco Act and how to write injunctions and prohibition documents regarding deficiencies in compliance with the school ground smoking ban. The inspectors further expressed appreciation for the opportunity to meet colleagues and exchange experiences at the meetings.

I think we've got a lot of information. We've had a lot of fun. We have received manuals, manuals on policy, handbooks on action plans. We have checklists. We had a network meeting last autumn at the County Administrative Board. (Inspector 10)

Most of the inspectors expressed engagement and motivation for their work and suggested that managers were also engaged in the tobacco prevention work. Although the work was perceived as meaningful, two of the inspectors doubted whether they would succeed in abolishing smoking at the school grounds.

I think it feels meaningful […]. But there are cases when it may not really work. Thus, upper secondary school students get so much input from so many other "realities." Both from social media and television and the mass media. (Inspector 8)

Enforcement actors expressed that barriers mostly seemed to concern local politicians, expressed by a local inspector in the following way:

The politicians in our local committee, they are interested in issues on building law and beach protection. But in tobacco, I can say, they are not interested at all! (Inspectors 8)

Some politicians described smoke-free school grounds not to be a prioritised issue in the municipality, while a majority said that smoking among young people is important to address, although smoke-free school grounds cannot be prioritised over other required municipality tasks. In line with this, only a few municipalities have implemented smoke-free working hours for municipality employed staff. One politician saw an opportunity to educate local politicians about tobacco and related problems in order to facilitate well-informed decisions on the issue.

Municipality-Based Control of Compliance With Outdoor School Ground Smoking Ban

The frequency of supervisory visits at schools varies between municipalities, with some schools being visited every year or every second year and others less frequent. The absence of a specific fee for supervision is considered to contribute to sparse visits. However, half of the inspectors considered the existing frequency of supervision to be sufficient. Additionally, two inspectors considered injunctions to be a useful tool for supervision.

It gives more weight […] than if it becomes a report that may end up in someone's junk mail or the like. […] We have that opportunity and I think we should use it. (Inspectors 8)

The view on injunctions among principals was overall neutral or negative. Several inspectors expressed reasons why these instruments are not used more often.

We find it very difficult to submit injunctions about smoking to a school. This is just about a school ground, what is a school ground? Then you can always ask for routines, but they often have them. (Inspectors 6)

The possibility of adding a charge to injunctions and prohibitions was regarded as problematic by some politicians and inspectors, partly because it would seem strange to demand payment from an actor financed by public funds.

No, I don't believe it. […] Even if you were to charge a private school, it's tax money that the school is running with. It doesn't feel reasonable. (Politician 2)

Some inspectors indicated that supervision of schools through more frequent visits would improve the schools if there were more resources assigned for the visits. However, there were also inspectors claiming that that with more resources they would prefer to focus on preventive supervision than on supervisory control visits. Smoke-free working time in all public workplaces in the community, including schools, was also suggested as more effective than making more supervisory visits to schools.

School Leadership

All principals seemed well-informed about the outdoor school ground smoking ban and could also express reasons why the ban exists, such as smoking being a health hazard and non-smoking students and staff should not be exposed to or inhale tobacco smoke. A majority of the principals argued that a smoke-free school ground is prioritised even if it is not the highest priority on the agenda.

Yes, it's quite a priority. Obviously, there are degrees in everything. It may not be the primary mission, but it's a priority. It's something we work with daily. (Principal 1)

Both principals and inspectors stated the schools generally comply with observations on the shortcomings and requirements of inspectors. Activities linked to tobacco prevention in the schools include teachers and other staff who see students smoking on the school ground and tell them to stop. Although most principals seemed motivated to carry out the implementation of a smoke-free school ground, there was also a critical stance on the school's responsibility for maintaining the tobacco law's smoking ban.

> *To put all the responsibility on the school by having a law that says it's forbidden to smoke on the school ground, without adding any resources at all. [...] It doesn't work! I have been working at a lot of different upper secondary schools and it has never worked. [. . .] Young people do dangerous things and it doesn't help with a ban. Period.* (Principal 3)

When trying to stop students from smoking on the school ground, staff sometimes experience problems, such as rude responses from students and a lack of time to stop and argue. Two principals expressed the problem as follows:

> *That's easier said than done [...] The one who stops may not know who the student is that stands and smokes. It's not always certain that he or she will agree to leave the area. Sometimes they choose to remain, or even perceive a kind of provocation, acting rude.* (Principal 1)

> *We have no chance whatsoever of having systematic control, or hiring someone who walks around as a smoke guard at the school. [. . .] We don't have the capacity within the school budget, to stick with employees who have this as an assignment.* (Principal 2)

Two of the principals thought that they were required to work harder to raise the staff's sense of responsibility to act when observing smoking students. Simultaneously, they highlighted the insufficient sanctions they can employ if smoking students are discovered. The principal and staff can tell students to stop and inform the parents that their child is smoking if the student is under 18 years of age, but otherwise, the student has to approve the contact with parents. The school can send one or more warnings to parents or students themselves if they are of legal age, but then several principals feel that it is impossible to do more. However, several principals said that suspension due to smoking is not possible within the framework of the Education Act and the curriculum.

> *What do we do if we catch a student who smokes in the school ground? [. . .] At the individual level, we cannot suspend students because they smoked on the school ground.* (Principal 4)

Further, some principals believed that prohibition is not the right way to achieve smoking cessation on the school grounds and conflicts between staff and students due to the students' refusal to stop may inhibit learning and completion of students' education.

> *My assignment is that the students should be in school and learn things, and then it feels very unreasonably to expel a student. [. . .] It will be like a kind of punishment that may somehow affect the student's studies and study results.* (Principal 6)

Regardless of the possibility of suspension, some principals believed that conflicts between staff and students over smoking habits are not worth the problems that they create. One principal, however, held a strict position regarding the smoking ban, stating that it is clearly a school's task to ensure that no smoking occurs on the school ground and that schools should take action and stand behind the law. Claiming the potential for schools to effectively address a violation of the ban, the principal expressed the following:

> *The school must own this issue and regard it as important. We, the school, stand behind this law, and that's a thing that one should work for.* (Principal 9)

This principal claimed that there was no, or almost no, smoking occurring on the school ground currently, in contrast to the remaining principals who clearly stated that smoking occurs at their schools.

School-Based Implementation and Enforcement

Principals indicated that all schools have a policy on tobacco and smoking. Moreover, smoking prohibition is communicated *via* signs on school grounds. The tobacco policies include information, e.g., that smoking is prohibited in the school's area, the harmful effects of smoking, what measures the school should take if students violate the smoking ban and other measures to be implemented against smoking. The prevention efforts at schools include, e.g., integrating teaching on tobacco and related consequences into the schedule, smoking cessation support, and various campaigns and programs. Information about policy and any action plan or rules of procedure regarding smoking is preferably given when the students are introduced to the school, often accompanied by information to their parents. Education about smoking and related issues is further often integrated into the curriculum. One of the principals said that parental contact, in case students violate the smoking ban, can have the intended effect on students' smoking. However, since the parents often already know that their child smokes, the contact often does not improve the situation but is rather perceived as a time-consuming process.

> *But just to take this to the next step and try to register the incident in some way. And then send home a warning to parents of minor students, or to the student, if they are of age, I think is an extremely difficult procedure.* (Principal 1)

Other principals expressed a pragmatic view of the problem, saying that it is good that staff continue to tell students that smoking on the school ground is forbidden even if no additional measures are taken when students are caught smoking. Conversely, one principal, the same principal who had obtained a smoke-free school ground, said that it is extremely important to maintain a restrictive line against smoking and expressed potential for intensifying implementation efforts as follows:

You have to inform with clarity in writing! Both orally and written [. . .]. The students know that it will be a consequence. They know that many adults care. They know that adults are caring. They know that if they are under the age of 18, we call home. (Principal 9)

School Factors

School Culture

Several principals expressed an awareness that staff are role models for students in smoking prevention. Some schools had made efforts to support the staff with smoking cessation and promote a smoke-free school. Despite the awareness of staffs' importance as role models for the students, some informants had observed staff smoking on the school ground, e.g., school canteen staff and teachers. Additionally, students can often see other adults smoking near the school ground, or even in the school ground, as many schools share the area closest to the school with other organisations with no smoking ban. Moreover, students can see smoking peers, either on the school ground, at entrances, or next to the school ground, inhibiting a supportive school culture. The social aspect of smoking and the influence of peer behaviour on students' was also highlighted.

I would say that it's very much a social phenomenon. It's not often I see a student standing and smoking alone, rather going out together. (Principal 2)

In order to prevent students from smoking, some schools supply other social activities, such as sports equipment and games.

School Ground

The presence of a school ground is central for the possibility of enforcing the school ground smoking ban. Several schools have no school ground at all and those that do often have an unclearly defined ground, which was expressed as problematic.

There has always been a dilemma. What is a school ground and what is not a school ground? It's very difficult in some places. (Inspector 8)

Due to supervision from the inspectors, several schools have removed smoking shelters and ashtrays from the school ground to prevent smoking. Nevertheless, the issue of having ashtrays or not is disputed. Some informants argued that it is better for smoking students to put butts in ashtrays than on the ground, to prevent an unpleasant environment. Some inspectors had, despite guidance to avoid objects or circumstances that invite smoking, observed the presence of smoke shelters or hidden places in some school grounds. A conflict between a school's sometimes more permissive attitude to smoking and the inspectors' more restrictive perspective was expressed by one of the principals as follows:

We talked before about having ashtrays outside the school's area, so that we can really clearly mark that "if you should smoke you will smoke there." But we didn't get permission for that from the municipality environment and health unit. And due to that, a lot of butts end up on the ground, unfortunately. (Principal 5)

One of the principals suggested that making the school ground outside smoke shelters more pleasant and beautiful would encourage students not to smoke but stay in the nice areas of the school ground.

Community Environment Factors

Other Actors or Activities in the Society

In addition to the school and the municipality's supervisory organisation, the informants see the surrounding community as an important factor in achieving smoke-free school grounds. This includes the municipality's other activities, e.g., leisure activities, crime prevention, and drug prevention. The collaboration with prevention coordinators and the role of social services were cited as a resource in tobacco prevention at the schools.

Working within the school on different levels and with outside support to prevent smoking was highlighted by one inspector, who gave observations of what an ideal prevention effort might look like.

When you go to such good schools with colleagues that work on it on many levels, they may have had tobacco-free school time. And there has been contact with parents, counsellors and it has been possible to offer cessation weaning talks. And so, you have people who can help and support. (Inspector 1)

Several informants emphasised that the school needs additional external support from decision-makers and authorities.

The school obviously needs guidance, an idea bank, something to stand on. [. . .] that they feel that they have a support. In part from the decision-makers, but above all, from government agencies that can produce information material. (Politician 2)

Social Environment

Despite an increasingly more tobacco-restrictive norm in the society, several informants referred to social norms at both group and societal levels as an explanation for adolescents' and adults' smoking. To change the attitude of young people to a more tobacco-restrictive orientation, the idea of a collaboration between school and parents to convey preferable values was advanced. The influence of peers as an important factor for whether students start smoking was also highlighted.

Students starting in one year, and returning in the second year, suddenly have started smoking. And it's very much about group affiliation and identity and who you want to keep up with. (Principal 4)

Several of the informants said that changed norms throughout society are necessary to make young people abstain from smoking.

Laws and Regulations Apart From the Smoking Ban on School Grounds

Several principals indicated there are insufficient sanction opportunities connected to the school ground smoking ban, and the combination of the requirements of the Tobacco Act and the Education Act along with the school curriculum is also a

problem. One principal expressing frustration suggested a change in the Education Act or the Tobacco Act.

> *I would like it to be included in the School Act or the Tobacco Act, anywhere. I would like some clearer powers to actually take any kind of disciplinary action. Because I think it's terrible to go on forever [telling smoking students to stop].* (Principal 1)

Several of the informants mentioned that sharper tobacco legislation in general, which includes areas outside the school, is needed to eliminate smoking in society and thereby in schools. One reasoned about a total ban in society as follows:

> *So, to get rid of smoking, because that is what you really should work with, you simply have to criminalise tobacco possession and use. And the state should simply cease with this double standard that we have the smoking as a tax source for our welfare system, while also saying that we should stop smoking.* (Principal 1)

DISCUSSION

The aim of the current study was to identify facilitators, barriers, and the potential for improved implementation of a 25-year outdoor school ground smoking ban in upper secondary schools. The most salient finding in our study is the conflicting goals governing the schools, which seem to lower staffs' motivation to maintain the ban. Moreover, in upper secondary schools in Stockholm County, the lack of school grounds or unclear school ground boundaries impede the implementation of the ban.

Several factors promote the implementation of the outdoor upper secondary school ground smoking ban in Stockholm County. Consistent with previous research, facilitators are good support from the County administrative board; collaboration between local community actors; tobacco prevention strategies in schools; education and other prevention activities for students; well-informed principals engaged in the prevention of smoking on the school ground (26, 27), although to a somewhat varying degree; and generally motivated inspectors with access to sharp sanction tools (26, 27), although they are not always used. However, smoking on upper secondary school grounds in Stockholm County is a persistent problem, and the work to achieve smoke-free school-grounds is hampered by several barriers.

Firstly, there is a lack of fit between existing values and policies governing the school (45), vs. the outdoor school ground smoking ban in the Tobacco Act (32), which is an implementation barrier highlighted in previous research (26, 27, 46, 47), but not specifically in studies on the implementation of outdoor school ground smoking bans (16, 22, 29–31). Staffs' positive attitude to the implementation is hindered by an obvious conflict between the goal of strict enforcement of the ban, connected to sometimes troublesome discussions with students and time-consuming routines to report violations of the ban, and the schools' overarching objective of students' learning and completion of their exams (45, 48). Hesitation to start conflicts with students and the lack of effective sanctions to use for violators (45), especially students of legal age, reduces the motivation to pay attention to and report smoking students to the school administration. Lack of motivation among school staff, although not explicitly linked to conflicting goals governing the schools, has previously been highlighted in research on the implementation of outdoor school ground smoking bans in Canada and the Netherlands (16, 29, 31, 47), and implementation research in general (26, 27). Teachers' goal of avoiding conflicts with students is generally positive, since good relations between students and staff can promote the implementation of outdoor school ground smoking bans (21, 22, 29, 47). However, this motivation seemed to cause a less strict implementation of the ban in the current study. Moreover, if more effective sanctions were introduced, such as suspension from school, it may adversely affect the students' studies, thereby lowering the staffs' and principals' motivation to use it. Nevertheless, it is important for stakeholders, including schools' principals and staff, to discuss the conflicts and find reasonable solutions to solve them.

Secondly, a conflict may exist between the goals of reducing smoking among young people in general (5), and achieving smoke-free upper secondary school grounds. If smoking students are forced to leave the school ground, they escape the influence of non-smoking peers and staff who express a non-smoking attitude and can also encounter people and situations that can be harmful (31). Therefore, forcing smokers to leave the school ground may be a less desirable solution to the problem of smoking students on the school ground.

Thirdly, despite seemingly clear and comprehensible legislation, some complexity (26, 27) arises in the Swedish outdoor school ground smoking ban due to unclear boundaries of upper secondary school grounds and even a lack of such school grounds, which is a barrier that, to our knowledge, has not been presented in previous studies (16, 22, 29–31). At schools where this issue exists, the principal and staff cannot point out the school ground boundaries for students, and inspectors visiting these schools cannot carry out proper control of compliance with the ban, which, of course, inhibits the enforcement of the ban. Some informants in the current study mentioned the possibility of combating school ground smoking in a more general manner, through the introduction of smoke-free working hours at public workplaces in all municipalities (21, 29, 49). This strategy has been successfully tried in some Irish, German and Finnish schools (50).

Fourthly, in line with previous implementation research in general (26, 27) and studies on the implementation of smoking bans in particular (16, 30), the lack of resources is perceived as an implementation barrier among principals and inspectors. Several informants expressed that the implementation of the outdoor school ground smoking ban is less of a priority compared to many other issues that must be handled within existing resources and working hours.

Despite several barriers, there seems to be the potential for improvement of the implementation of the Swedish outdoor upper secondary school ground smoking ban. A new tobacco act, implemented in Sweden in 2019, can likely prevent students from smoking at school entrances, regardless of whether or not there is a school ground, which decreases the importance of

clear school ground boundaries. This policy change may also support the denormalisation of smoking, thereby facilitating the prevention of smoking among students (21, 29, 49). Sustaining a clearly restrictive non-smoking norm, supported by the new tobacco act, seems important and also possible, preferably in combination with the continuation of the existing education on smoking in the curriculum (24, 29, 51, 52). However, previous studies have also indicated that a high level of conflict between staff and students regarding the enforcement of smoking bans in school settings may have a reversal effect for some individuals (22, 52), especially for alienated students with a high risk of substance use and school drop-out (22). Rozema et al. (16) suggested that one way to lower the level of conflicts with smoking students is by training staff on effective ways of dealing with violators of the ban. Such training could be part of the solution in Swedish upper secondary schools. Also, other vocational categories could be employed or provided from the municipality to support the staff in the maintenance of the ban, e.g., prevention coordinators.

Collaboration between the municipality's committees and administrations and extra resources for tobacco prevention activities (26, 27) may also facilitate the work of achieving non-smoking school grounds. Education of politicians could facilitate an awareness of the importance of obtaining smoke-free school grounds, thereby facilitating a higher priority of current prevention efforts in the municipalities (26). Finally, the surrounding community and actions at the societal level can facilitate smoking prevention among students in several ways. Extending the smoking ban to areas near the schools might facilitate implementation, as highlighted in previous research (21). Tobacco restrictive norms among parents, and the prohibition of smoking at restaurants and public places can further contribute to the denormalisation of smoking and the reduction of teenage smoking (49, 53, 54). Moreover, compliance with the age limit for tobacco sales can make it more difficult for people below 18 years of age to obtain cigarettes, thereby preventing smoking both in schools and elsewhere (23, 55). A more drastic measure is a total ban on tobacco in the society, which would certainly lower the prevalence of smoking among students if the black market was effectively counteracted (21, 23).

Strengths and Limitations

The current study has several strengths. Firstly, the inclusion of three vocational groups with the power to influence the implementation of the outdoor upper secondary school ground smoking ban provided rich material that deepens our understanding of the implementation, highlighting conflicting interests and different views connected to different professional roles. Secondly, the inclusion of informants from larger and smaller municipalities with different average education levels among inhabitants, which has been previously shown to influence smoking habits (56), reduced the risk of receiving a limited view of the implementation due to the exclusion of factors related to inhabitants' smoking habits, e.g., socioeconomic background (57), and municipalities' economic resources. Thirdly, the selection of municipalities and upper secondary schools with varying motivations to implement the smoking ban, as evaluated by the County council, may have influenced stakeholders to have a nuanced view of the implementation. In addition, the team-based analytical process, involving all the authors and applying independent coding, should strengthen the credibility of the results (58). However, there are also some limitations. Because less engaged persons in the implementation of the ban might be more likely to abstain from participation in the current study than more engaged persons, there is a risk of selection bias due to personal interest, resulting in a more positive view of the implementation of the ban than is actually the case. Future studies could include longitudinal statistics on progress, e.g., number of non-smoking policies in schools, and number of smoking students. Finally, the current vocational categories of informants may have given a too limited view on the problem with implementation of the outdoor school ground smoking ban. Future studies could include additional vocational categories, e.g., teachers and also students, to give an even more elaborated view on the implementation, e.g., concrete strategies to support the teachers and ways to approach smoking students.

Conclusion

To achieve effective implementation of outdoor school ground smoking bans in upper secondary schools, authorities need to address conflicts between different goals governing the schools and give necessary support to the staff to strictly enforce the ban. Policies on smoke-free working hours in the municipalities along with tobacco restrictive (58) policies in the surrounding society may increase the possibility of maintaining the smoking ban in upper secondary school grounds. Future studies could include additional informants connected to the schools, such as teachers and students, and longitudinal data on smoking in upper secondary school grounds where smoking bans are implemented.

DATA AVAILABILITY STATEMENT

Collected data will be available from the Centre for Psychiatry Research, a collaboration between the Karolinska Institute and Region Stockholm, but restrictions apply to their availability, as they were used under ethical permission for the current study, and so are not publicly available. However, data are available from the authors upon reasonable request and with permission from the Centre for Psychiatry Research.

ETHICS STATEMENT

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

PK: conceptualization, methodology, investigation, data curation, formal analysis, project administration, writing—original draft, and writing—review and editing. KF: conceptualization, methodology, investigation, data curation,

formal analysis, validation, and writing—review and editing. TE: conceptualization, methodology, investigation, formal analysis, and writing—review and editing. JG: conceptualization, methodology, formal analysis, supervision, funding acquisition, and writing—review and editing.

FUNDING

This work was supported by the County Administrative Board of Stockholm funded the study, dnr.no: 705-49314-2018.

ACKNOWLEDGMENTS

We would also like to thank all the participants for making this study possible and for describing their work in a generous way.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.628748/full#supplementary-material

REFERENCES

1. WHO. WHO report on the global tobacco epidemic 2017. Available online at: http://apps.who.int/iris/bitstream/handle/10665/255874/9789241512824-eng.pdf;jsessionid=B01C6C0E1E6C69539E40B4BCBB606ADC?sequence=1 (accessed October 12, 2020).
2. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. *J Am Coll Cardiol*. (2004) 43:1731–7. doi: 10.1016/j.jacc.2003.12.047
3. National Board of Health and Welfare. *Registeruppgifter om Tobaksrökningens Skadeverkningar (Register Data on Smoke Related Harm)*. Stockholm: National Board of Health and Welfare (2014). (In Swedish).
4. Sasco AJ, Secretan MB, Straif K. Tobacco smoking and cancer: a brief review of recent epidemiological evidence. *Lung Cancer*. (2004) 45(Suppl. 2):S3–9. doi: 10.1016/j.lungcan.2004.07.998
5. Gifford H, Thomson G. Smoke free environments for children-the relationship between schools and wider smoke free environments. In: O'dea JA, editor. *Current Issues and Controversies in School and Commun Health, Sport and Physical Education*. New York, NY: Nova Science Publishers (2012).
6. Lyvers M, Tobias-Webb J. Effects of acute alcohol consumption on executive cognitive functioning in naturalistic settings. *Addict Behav*. (2010) 35:1021–8. doi: 10.1016/j.addbeh.2010.06.022
7. Act on tobacco and similar products. *SFS 2018:2088. Lag om tobak och liknande produkter (Act on Tobacco and Similar Products)*. Stockholm: Ministry of Health and Social Affairs (2018). (In Swedish)
8. Ranabhat CL, Kim C-B, Park MB, Jakovljevic M. Situation, impacts, and future challenges of tobacco control policies for youth: an explorative systematic policy review. *Front Pharmacol*. (2019) 10:981. doi: 10.3389/fphar.2019.00981
9. Swendsen J, Le Moal M. Individual vulnerability to addiction. *Ann N Y Acad Sci*. (2011) 1216:73–85. doi: 10.1111/j.1749-6632.2010.05894.x
10. Barron S, White A, Swartzwelder HS, Bell RL, Rodd ZA, Slawecki CJ, et al. Adolescent vulnerabilities to chronic alcohol or nicotine exposure: findings from rodent models. *Alcohol Clin Exp Res*. (2005) 29:1720–5. doi: 10.1097/01.alc.0000179220.79356.e5
11. Chambers RA, Taylor JR, Potenza MN. Developmental neurocircuitry of motivation in adolescence: a critical period of addiction vulnerability. *Am J Psychiatry*. (2003) 160:1041–52. doi: 10.1176/appi.ajp.160.6.1041
12. Chen J, Millar WJ. Age of smoking initiation: implications for quitting. *Health Rep*. (1998) 9:39–46.
13. D'Avanzo B, La Vecchia C, Negri E. Age at starting smoking and number of cigarettes smoked. *Ann Epidemiol*. (1994) 4:455–9. doi: 10.1016/1047-2797(94)90005-1
14. The ESPAD Group. ESPAD Report 2015. *Results from the European School Survey Project on Alcohol and Other Drugs*. Luxembourg: European Monitoring Centre on Drugs and Drug Addiction (2016).
15. Zetterqvist ME. *Skolelevers Drogvanor 2018*. Stockholm: Centralförbundet för alkohol- och narkotikaupplysning (CAN) (2018).
16. Rozema AD, Mathijssen JJP, van Oers HAM, Jansen MWJ. Evaluation of the Process of Implementing an Outdoor School Ground Smoking Ban at Secondary Schools. *J SchHealth*. (2018) 88:859–67. doi: 10.1111/josh.12692
17. Linnansaari A, Schreuders M, Kunst AE, Rimpelä A, Lindfors P. Understanding school staff members' enforcement of school tobacco policies to achieve tobacco-free school: a realist review. *Syst Rev*. (2019) 8:177–10. doi: 10.1186/s13643-019-1086-5
18. Hoffmann L, Mlinarić M, Mélard N, Leão T, Grard A, Lindfors P, et al. '[…] the situation in the schools still remains the Achilles heel.' Barriers to the implementation of school tobacco policies-a qualitative study from local stakeholder's perspective in seven European cities. *Health Educ Res*. (2020) 35:32–43. doi: 10.1093/her/cyz037
19. Schreuders M, Klompmaker L, van den Putte B, Kunst AE. Adolescent smoking in secondary schools that have implemented smoke-free policies: in-depth exploration of shared smoking patterns. *Int J Environ Res Public Health*. (2019) 16: 2100. doi: 10.3390/ijerph16122100
20. El Amin SET. School smoking policies and health science students' use of cigarettes, Shisha, and Dipping Tombak in Sudan. *Front Public Health*. (2019) 7:290. doi: 10.3389/fpubh.2019.00290
21. Rozema AD, Hiemstra M, Mathijssen JJP, Jansen MWJ, van Oers H. Impact of an Outdoor Smoking Ban at Secondary Schools on Cigarettes, E-Cigarettes and Water Pipe Use among Adolescents: An 18-Month Follow-Up. *Int J Environ Res Public Health*. (2018) 15:205. doi: 10.3390/ijerph15020205
22. Poulin CC. School smoking bans: do they help/do they harm? *Drug Alcohol Rev*. (2007) 26:615–24. doi: 10.1080/09595230701613619
23. Feigl A, Salomon J, Danaei G, Ding E, Calvo E. Teenage smoking behaviour following a high-school smoking ban in Chile: interrupted time-series analysis. *Bull World Health Organ*. (2015) 93:468–75. doi: 10.2471/BLT.14.146092
24. Galán I, Díez-Gañán L, Gandarillas A, Mata N, Cantero JL, Durbán M. Effect of a smoking ban and school-based prevention and control policies on adolescent smoking in spain: a multilevel analysis. *Prevent Sci*. (2012) 13:574–83. doi: 10.1007/s11121-012-0283-4
25. Moore L, Roberts C, Tudor-Smith C. School smoking policies and smoking prevalence among adolescents: multilevel analysis of cross-sectional data from Wales. *Tob Control*. (2001) 10:117. doi: 10.1136/tc.10.2.117
26. Fixsen DL, Naoom SF, Blase KA, Friedman RM. *Implementation Research: A Synthesis of the Literature*. Tampa, FL: Universitu of South Florida (2005).
27. Scaccia JP, Cook BS, Lamont A, Wandersman A, Castellow J, Katz J, et al. A practical implementation science heuristic for organizational readiness: R = MC(2). *J Commun Psychol*. (2015) 43:484–501. doi: 10.1002/jcop.21698
28. Aaron GA, Hurlburt M, Horwitz SM. Advancing a conceptual model of evidence-based practice implementation in public service sectors. *Adm Policy Ment Health*. (2011) 38:4–23. doi: 10.1007/s10488-010-0327-7
29. Rozema AD, Mathijssen JJP, Jansen MWJ, van Oers HAM. Sustainability of outdoor school ground smoking bans at secondary schools: a mixed-method study. *Eur J Public Health*. (2018) 28:43–9. doi: 10.1093/eurpub/ckx099
30. Ashley MJ, Northrup DA, Ferrence R. The Ontario ban on smoking on school property: issues and challenges in enforcement. *Can J Public Health*. (1998) 89:229–32. doi: 10.1007/BF03403923
31. Pickett W, Northrup DA, Ashley MJ. Factors influencing implementation of the legislated smoking ban on school property in Ontario. *Prevent Med*. (1999) 29:157–64. doi: 10.1006/pmed.1999.0533
32. Tobacco Act. SFS 1993:581. *Tobakslag (Tobacco Act)*. (1993). (In Swedish).
33. The Public Health Agency of Sweden. Regler om tobaksvaror (Rules on tobacco products) (2017). (In Swedish). Available online at: https://www.folkhalsomyndigheten.se/livsvillkor-levnadsvanor/alkohol-narkotika-

dopning-tobak-och-spel-andts/tobak/tobaksreglering/regler/ (accessed December 17, 2019).
34. County Administrative Board *Stockholm. Ett steg närmare rökfri skola - förslag till fortsatt lokalt arbete (One Step Further to Smoke-Free School—Suggestion for Continued Local Work)*. (2016). (In Swedish).
35. County Administrative Board Västra Götaland. *Rökfria skolgårdar - ett steg närmare ett rökfritt Sverige 2025 (Smoke-Free School Grounds - One Tep Further to a Smoke-Free Sweden 2025*. (2018). (In Swedish).
36. County Administrative Board Örebro. *Rökfria skolgårdar. Kartläggning av rökning på skolgårdar i Örebro län (Smoke-Free Schoolgrounds. Mapping of Smoking on School Grouns in the County of Örebro* (In Swedish) (2018).
37. The municipality of Stockholm. *Projekt rökfria skolgårdar (Project Smoke-Free School Grounds)*. Stockholms stad (2018). (In Swedish).
38. Weller SC, Vickers B, Bernard HR, Blackburn AM, Borgatti S, Gravlee CC, et al. Open-ended interview questions and saturation. *PLoS ONE*. (2018) 13:e0198606. doi: 10.1371/journal.pone.0198606
39. Graneheim U, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today*. (2004) 24:105–12. doi: 10.1016/j.nedt.2003.10.001
40. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. (2005) 15:1277–88. doi: 10.1177/1049732305276687
41. MacQueen KM, McLellan E, Kay K, Milstein B. Codebook development for team-based qualitative analysis. *CAM J*. (1998) 10:31–6. doi: 10.1177/1525822X980100020301
42. Kvale S. *Interviews: An introduction to Qualitative Research Interviews*. London: SAGE Publications (1996).
43. Gymnasieguiden.se. *Gymnasieguiden (The guide on Upper Secondary Schools)*. (2020). (In Swedish). Available online at: https://www.gymnasieguiden.se/ (accessed August 5, 2020).
44. Statistics Sweden. *Utbildning, jobb och dina pengar (Education, Job And Your Money)*. (2020) (In Swedish). Available online at: https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/befolkningens-utbildning/befolkningens-utbildning/#_Tabellerochdiagram (accessed August 5, 2020).
45. The Education Act. SFS 2010:800. *Skollag (Education Act)*. (2010). (In Swedish).
46. Fleuren M, Wiefferink K, Paulussen T. Determinants of innovation within health care organizations: literature review and Delphi study. *Int J Qual Health Care*. (2004) 16:107–23. doi: 10.1093/intqhc/mzh030
47. Schreuders M, van den Putte B, Kunst AE. Why secondary schools do not implement far-reaching smoke-free policies: exploring deep core, policy core, and secondary beliefs of school staff in the Netherlands. *Int J Behav Med*. (2019) 26:608–18. doi: 10.1007/s12529-019-09818-y
48. The Swedish National Agency for Education. *Läroplan för gymnasieskolan 2011 (Curriculum for the High School 2011)*. (2011). (In Swedish).
49. Stanwick R. E-cigarettes: are we renormalizing public smoking? Reversing five decades of tobacco control and revitalizing nicotine dependency in children and youth in Canada. *Paediatr Child Health*. (2015) 20:101–5. doi: 10.1093/pch/20.2.101
50. Schreuders M, van den Putte B, Kunst AE. Smoke-free school policies in Europe: challenges for the future. *Prevent Med*. (2020) 138:106130. doi: 10.1016/j.ypmed.2020.106130
51. Adelman HS, Taylor L. On sustainability of project innovations as systemic change. *J Educ Psychol Consult*. (2003) 14:1–25. doi: 10.1207/S1532768XJEPC1401_01
52. Harris KJ, Stearns JN, Kovach RG, Harrar SW. Enforcing an outdoor smoking ban on a college campus: effects of a multicomponent approach. *J Am Coll Health*. (2009) 58:121–6. doi: 10.1080/07448480903221285
53. Wakefield MA, Chaloupka FJ, Kaufman NJ, Orleans CT, Barker DC, Ruel EE. Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: cross sectional study. *BMJ*. (2000) 321:333–7. doi: 10.1136/bmj.321.7257.333
54. Lindqvist A-K, Kostenius C, Gard G. "Peers, parents and phones"-Swedish adolescents and health promotion. *Int J Qual Stud Health Well-being*. (2012) 7:17726. doi: 10.3402/qhw.v7i0.17726
55. Grucza RA, Plunk AD, Hipp PR, Cavazos-Rehg P, Krauss MJ, Brownson RC, et al. Long-term effects of laws governing youth access to tobacco. *Am J Public Health*. (2013) 103:1493–9. doi: 10.2105/AJPH.2012.301123
56. Jarvis MJ, Wardle J. Social patterning of individual health behaviours: the case of cigarette smoking. In: Marmot MWR, editor. *Social Determinants of Health*. New York, NY: Oxford University Press (2006).
57. Harwood GA, Salsberry P, Ferketich AK, Wewers ME. Cigarette smoking, socioeconomic status, and psychosocial factors: examining a conceptual framework. *Public Health Nurs*. (2007) 24:361–71. doi: 10.1111/j.1525-1446.2007.00645.x
58. Golafshani N. Understanding reliability and validity in qualitative research. *Qual Rep*. (2003) 8:597. doi: 10.46743/2160-3715/2003.1870

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.

frontiers in Public Health

PERSPECTIVE
published: 12 April 2021
doi: 10.3389/fpubh.2021.651089

COVID-19 Research: Challenges to Interpret Numbers and Propose Solutions

Marc J. Struelens[1]* *and Paolo Vineis*[2]

[1] Faculty of Medicine, Universite Libre de Bruxelles, Brussels, Belgium, [2] School of Public Health, Imperial College, London, United Kingdom

The response of the scientific community to the COVID-19 pandemic has been unprecedented in size, speed and discovery output. Within months of virus emergence, the SARS-CoV-2 genomics, replication, evolution and dissemination dynamics as well as natural history, infection risk and prognostic factors and biology of the disease have been gradually deciphered. More than 250 articles on COVID-19 published in Frontiers in Public Health have contributed to these insights. We discuss here some of the key research themes and challenges that have been addressed. We provide our perspective on current research issues with surveillance data quality and limitations of epidemiological methods. We warn against the potential misuse or misleading interpretation of public data of variable quality and the use of inadequate study designs for the evaluation of effect of non-pharmaceutical interventions. We conclude by interrogating possible public health strategies for pandemic control as well as discuss the ethical responsibilities and democratic accountability of researchers in their role as experts and policy advisors.

Keywords: COVID-19, epidemiologic methods, transmission models, surveillance, open science, pandemic control, evidence-based policy, researcher responsibility

OPEN ACCESS

Edited by:
Stefania Salmaso, Independent Researcher, Rome, Italy

Reviewed by:
Caterina Rizzo, Bambino Gesù Children Hospital (IRCCS), Italy
Arnold Bosman, Transmissible Public Health Support, Netherlands

***Correspondence:**
Marc J. Struelens
mj.struelens@gmail.com

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

Received: *08 January 2021*
Accepted: *15 March 2021*
Published: *12 April 2021*

Citation:
Struelens MJ and Vineis P (2021) COVID-19 Research: Challenges to Interpret Numbers and Propose Solutions. Front. Public Health 9:651089. doi: 10.3389/fpubh.2021.651089

THE OUTSTANDING RESEARCH RESPONSE TO THE PANDEMIC

The COVID-19 pandemic has inflicted immense health and societal damage across the world in 2020, with over 1.9 million deaths, massive economic recession and life disruption related to drastic social distancing and other control measures. In comparison to any other infectious disease, the response of the scientific community has been unprecedented in size, speed and discovery output. Within months of COVID-19 emergence, the SARS-CoV-2 genomics, replication, evolution and dissemination dynamics as well as natural history, infection risk and prognostic factors, biology and pathogenesis of the disease have been gradually deciphered. Novel diagnostic approaches and assays have been developed, while an array of antiviral and immunomodulating agents were tested in multicentre trials. COVID-19 vaccines have been developed at record speed with several safe and effective products authorized and launched for mass immunization in December 2020.

To make sense of emerging information on this pandemic, one should acknowledge how these extraordinary research efforts have generated an explosion of scientific papers. Bibliometric surveys indicate that more than 180,000 peer-reviewed articles and 30,000 preprints on COVID-19 were published this year (1). This surge has required substantial time and resource investment from authors, editors and publishers. From the outset of the pandemic, *Frontiers* has facilitated the timely peer-review and open-access publication to date of 2,000 scientific papers in 168 COVID-19 dedicated Research Topics across its journals (2). In *Frontiers in Public Health,* manuscript submissions on infectious diseases have increased 5-fold this year as compared with last year, 80%

of which report on COVID-19 research. We wish to thank our authors, editors and reviewers for their time and commitment to deliver over 250 articles advancing our understanding of COVID-19-related issues. We discuss here some of the key research themes that have been addressed in 2020 in *Frontiers in Public Health,* with selected examples of salient contributions from this Journal.

MARKED GEOGRAPHICAL HETEROGENEITY IN COVID-19 BURDEN

One of the striking public health features is that countries around the world are facing such dramatically different impact of the pandemic both on morbidity and mortality. Though different health burden indicators have different meanings, time dependencies and pitfalls, they consistently indicate that some countries fare much worse than others. As of 21 December 2020, the continuously increasing cumulative COVID-19 incidence ranged by country worldwide from 3.26 to 98,388 total confirmed cases per million population (3) while COVID-19 related mortality ranged by country worldwide from 0.03 to 163 death per 100,000 population (4). As indicator of lethality, the crude case-fatality (CF) among notified COVID-19 cases ranged at latest report from 0 to 29%, with many high-income countries falling in the higher range (4). Likewise, modeled estimates of SARS-CoV-2 infection fatality (IF) inferred from population sero-surveys in 11 selected countries and cities range from 0.14 to 0.42% in low-income countries to 0.78–1.79% in high income countries, with the differences in those ranges related to the older population of high-income countries (5). Another mortality indicator, the number of excess deaths from all causes above historical baseline that are temporally associated with COVID-19 incidence peaks, does not depend on diagnostic testing nor disease reporting capacity. Data from countries that monitor this more robust indicator confirm their contrasting mortality burden and reveal further geographical heterogeneity within the larger ones (6, 7). These data also highlight striking variation in the degree of national underreporting of COVID-19-related deaths (7). Many published data illustrate the heterogeneity of COVID-19 epidemiologic indicators, that complicates our understanding of the heterogeneity of the burden across countries.

USE AND MISUSE OF EPIDEMIOLOGIC SURVEILLANCE DATA

Extensive epidemiologic and multidisciplinary research has explored possible determinants to these major variations in the pandemic burden between countries and regions. These studies have taken advantage of notification of COVID-19 surveillance data by national authorities and of open data compilation and trends monitoring by academic centers (3, 4) and supranational agencies like the WHO and ECDC. However, the first step that is often overlooked by researchers in international comparative studies is appraisal of the accuracy and comparability of national surveillance statistics. Unfortunately, national COVID-19 surveillance methods are not standardized and their implementation further depends on local clinical and laboratory capabilities and practice. Differences and changes over time in national surveillance protocols, case definitions and reporting delays in the European Union are monitored by ECDC (8). Inter-country variation affects the following steps of surveillance data reporting: 1. case definition criteria, such as for the attributed cause of death (laboratory confirmed COVID-19 case only or also probable case, time delay of death after positive COVID-19 test, type of test - PCR, antigen test, serology, place of death - in hospital or also community deaths); 2. case ascertainment (SARS-CoV-2 testing policy, testing rate, testing method quality); 3. case notification delays and corrections. There is a certain degree of confusion around commonly used metrics, and clarifications are needed. A good introduction to the methodological issues and main types of biases behind apparent inter-country differences in pandemic health outcomes is discussed by Backhaus (9). Specific warnings against misinterpretation of COVID-19 surveillance data and their derived indicators are provided in public health and academic resources (3, 8). To enhance preparedness and support response to this and future pandemics, national infectious diseases surveillance systems should further standardize and improve the collation and timely reporting of complete, disaggregated and comparable epidemiologic data.

Ecological studies on potential determinants of COVID-19 outcomes across countries have used open data on environmental conditions, population demographics, economic resources, health systems, and public health policies. Some of these health determinants are conveniently summarized in composite indices such as those provided by the Oxford COVID-19 Government Response Tracker initiative, aimed at comparing the stringency of government responses to COVID-19 across countries and over time (10). Attempting to use such indices to address the effectiveness of epidemic containment policies and interventions raises a number of methodological caveats (3, 10, 11). Articles, including from this Journal, are open to questioning as to the study design, quality of data and interpretation. One example is the report by De Larochelambert et al. (12), that explored five domains (demography, public health, economy, policy, environment) and their potential associations with COVID-19 mortality during the first 8 months of 2020, through a Principal Component Analysis and Pearson correlation tests. Although it raises interesting points about the background weaknesses of the countries that were more affected by the early phase of the pandemic, most of these features are correlated with an aging population. The pitfalls with the study include a lack of age-standardization of death rates, and a lack of consideration of the timing of and compliance with public health interventions. First, COVID-19 CF and IF steeply increase with age above 50 years (3–5). Comparing the COVID-19 related risk of death in populations with different age structures by age- standardized mortality as attempted by Villani et al. (13), shows very different ranking of countries than by using crude mortality data. Second, the analysis of public health interventions through national scores of the Oxford University Containment and health index and Stringency index, as predictors of COVID-19 mortality in this study is in our opinion inadequate as neither the degree

of policy implementation, nor the timing of interventions in their epidemiological context were taken into account. Indeed, the Oxford University government index designers warn that "these indices should not be interpreted as a measure of the appropriateness or effectiveness of a government's response" (10). Time series and temporally weighted regression analysis of these indices indicate that high stringency control policies may be associated with divergent trends in national mortality depending on whether it was initiated early or late after the start of the epidemic (10, 11). Therefore, the conclusions by De Larochelambert et al. (12) that the "stringency of the measures settled to fight pandemia (sic), including lockdown, did not appear to be linked with death rate" and that "this (mortality) burden was not alleviated by more stringent public decisions" are simply meaningless. Unfortunately, this publication has been cited by conspiracy theorists on social media as supporting claims that "Lockdowns do not control the coronavirus: The evidence" (12).

This is only an example of the caution that needs to be exerted before drawing inferences from open data that are of variable quality and sometimes wrongly interpreted. On the other hand, epidemiologic studies reported in this journal have progressed our understanding of the risk factors associated with SARS-CoV-2 transmission and COVID-19 fatal outcomes (13–19). Likewise, modeling studies have shed light on effective control measures and likely trajectory of the pandemic in various settings (20–23).

On risk factors, an early case series by Jin et al. on the role of gender in morbidity and mortality in patients with COVID-19 showed that men are at higher risk for severe disease and death, independent of age (14). Li et al. analyzed the COVID-19 incidence and mortality risk in China using a maximum likelihood approach that indicated a steeply increasing mortality risk in older adults (15). In an ecological study, Khan et al. used a negative binomial regression model and Principal Component Analysis to assess the association between national healthcare capacity index (number of physicians, nurse and hospital beds per population) and crude COVID-19 CF data available on 30 April 2020 from 86 countries, adjusting for other covariates (demographic, health expenditure, population density, and prior burden of non-communicable disease as well as civil society openness index) (16). While acknowledging the data limitations and possible biases, their analysis confirmed that greater healthcare capacity was related to lower COVID-19 CF (16). This has been experienced very acutely in countries confronted with insufficient intensive care capacities for managing a surge of patients with respiratory failure during epidemic peaks (6, 8, 13, 16).

More detailed epidemiologic investigations revealed important determinants of epidemic spread at the local level by using diverse statistical models (17, 18). De Ridder et al. used a spatiotemporal cluster detection algorithm to monitor SARS-CoV-2 transmission dynamics in neighborhoods of Geneva until 30 April 2020 (17). By using survival analysis and Cox model adjusted for population density, they found a dose-response relationship between level of socio-economic deprivation and prolonged duration of virus transmission within local clusters, highlighting the need for inequality mitigation measures as part of COVID-19 risk mitigation strategies. Castaneda and Saygili examined the county-level proportion of residents staying at home as measured by mobile device location data and COVID-19 daily case increase rates in Texas during February-May 2020 (18). They found that the growth rate of COVID-19 cases decreased when a larger proportion of the local population stayed at home. Interestingly, county emergency policies coincided more closely with the increase of people at home than the later State-wide order to "shelter in place," suggesting that to reach out with an alert to the local population may be a more effective communication strategy in that setting (18). Bönisch et al. assessed the effect of confinement in Germany by using an Interrupted Time-Series analysis linking actively collected population mobility data and weekly estimates of COVID-19 reproduction number before, during and after the lockdown from January to May 2020 (19). They measured a significant mobility decrease by more than half across all age groups and regions during lockdown and to a lesser degree thereafter. This mobility reduction was followed after a few weeks by a sustained reduction in COVID-19 transmission as indicated by an effective reproduction number falling from a value of ∼3 to below 1 (19).

Mathematical modeling has been extensively applied during this pandemic to nowcast and forecast its national trajectory and impact on healthcare resources and to inform decisions about control interventions (20, 21). It is important to remember that all models are a simplified hypothetical representation of reality. In a helpful commentary for the non-mathematician, Mac et al. clearly explain the main types of epidemic models used for analyzing and projecting SARS-CoV-2 transmission and discuss their respective strengths and limitations (21). The authors underline the advantages of defining the modeling questions, appraising the input data quality and model assumptions in partnership with stakeholders who work in the field and may use the results for making practical decisions (21).

A range of mechanistic models formalize the transition of groups or individuals in a population from the susceptible to infected to recovered (SIR) states, with model variation by inclusion of further states such as death (SIRD) or susceptible again (SIRS) (21). In Frontiers in Medicine, Roques et al. applied an elaborate analytical framework combining a SIRD transmission model, a probabilistic observation model and Bayesian inference procedure to measure the effect of the nationwide lockdown in France in March 2020 (22). They estimated that the lockdown effectively reduced the transmission of the COVID-19 by a factor 7, based on an effective reproduction number $R_e = 0.47$ during lockdown compared to the basic reproduction number $R_0 = 3.2$ in the early stage of the epidemic (22). With yet another approach, Wang et al. developed a survival convolution model to fit the dynamics of national epidemics and estimated the effect of nationwide control interventions in selected countries through a natural quasi-experimental design (23). Their forecasting results predicted better COVID-19 transmission control in China and Korea than in Italy and the USA after relaxing restriction measures in the spring 2020 (23).

Overall, as illustrated above, idiosyncrasies abound in COVID-19 reported data, and competing analytical approaches

do not allow easy interpretations of observations across settings. Therefore, one should consider their limited external validity to infer actions, especially when attempting to generalize effectiveness beyond the local or national context. We acknowledge that relying only on studies published in *Frontiers* is a limitation of the wider perspective that could come from reviewing publications in other Journals on COVID-19 epidemiology and control.

PROSPECTS FOR THE FUTURE

Frankly, and as consequence of the above warnings and limitations of the assessed evidence, it is not clear what the optimal strategy for the future control of the COVID-19 pandemic is beyond mass vaccination. There are great expectations toward the vaccines, several of which have been recently authorized for emergency use or approved by regulators after demonstrating high levels of efficacy and safety in trials. Their administration has started in many countries in December 2020. The first real-world estimates of very high levels of short-term protective effectiveness against infection and disease from national vaccination campaigns are extremely encouraging (24). However, uncertainties remain about the duration of vaccine-induced protection against asymptomatic infection and against disease in vaccinated individuals, especially in the event of emergence and spread of viral antigen-variants that escape vaccine-induced immunity. The ultimate goal of reaching herd immunity across populations will require extensive immunization campaigns and wide population coverage, and will likely occur later than 2021.

Therefore, a multipronged strategy of testing, tracing and isolating infectious cases and their contacts, in combination with sustainable levels of social distancing and use of personal protection such as face masks, remains the best option beyond vaccination to reduce viral transmission to minimum levels (25). In many countries, experience has shown that molecular testing for SARS-CoV-2 RNA has limited capacity related to the laboratory resources available and the delays in obtaining results. On this basis, decentralized rapid antigen detection tests have acquired considerable popularity. Their optimal use has been outlined in a clear way by the ECDC (26) and OECD (27), i.e., the test can be useful for testing recent contacts of cases or screening particular categories of subjects, such as elderly people living in closed communities and health sector workers. In spite of these guidelines, people in several countries may access the rapid test e.g., through pharmacies, and test themselves with no consultation with GPs or coordination with preventive services. This approach has several drawbacks. In particular, the antigen tests have limited sensitivity, around 70% but ranging from 20 to 95%, while specificity is higher (26, 27). False positives can be ruled out by confirming positive antigen test results with a nucleic acid test. Even though the best antigen tests would detect a majority of infected people with a high viral load who are likely to be the most infectious, a negative result on a given day does not predict non-infectiousness thereafter. In a period of sustained community-wide transmission of SARS-CoV-2, there is a risk of false security if people perform the rapid antigen test to allow themselves participation in group gatherings and festive activities, loosening their observance of preventive measures and thereby acquiring and spreading the virus further.

An experiment of population-wide screening for SARS-CoV-2 infection with rapid antigen tests has been performed in Slovakia but the evaluation of its impact is complicated by combination with lockdown measures (28). A one-off cross-sectional screening campaign is likely not enough to isolate all the infected individuals and quench the epidemic. It is not clear what follows after such a complex and expensive testing experiment. Further research to assess the cost-effectiveness of this approach is to be encouraged. In addition, extensive genomic surveillance and structure-function molecular studies are essential to monitor the possibility of emergence of diagnostic or vaccine escape viral variants with mutations in the antigen-encoding genes (29).

Biomedical and public health experts are playing a prominent and essential role around the world in providing evidence-based advice to the public and government on measures to suppress or slow down COVID-19 spread, with varying degree of decision-making responsibility. At the same time, increasingly large parts of the public have been expressing distrust of expert knowledge and reclaiming their autonomy of decision from technocratic policies, as illustrated in the anti-vaccination movement (30). In this Journal, Lavazza and Farina opine that expert recommendations on risk management such as priority access to testing or intensive care, or digital tracing of personal contacts, are not neutral and carry axiomatic content that goes beyond the epistemic authority of scientific experts (30). We support their view that decisions which are not only technical but also normative must be justified as such and subject to wider participatory democratic decision-making. In the line of the above discussion about the limited robustness of available epidemiologic data, transparency about uncertainty in scientific inference based on the analysis of these data is a moral imperative. As underlined by Provenzi and Barello, building trust between lay citizens and researchers on identifying COVID-19 solutions also requires a renewed partnership that includes public education on the scientific method as well as the active participation of "citizen scientists" in biomedical investigations and health intervention trials (31).

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/s.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

REFERENCES

1. Else H. COVID in papers: a torrent of science. *Nature.* (2020) 588:553. doi: 10.1038/d41586-020-03564-y
2. *Frontiers Editors' Summit - December 2020*. Frontiers Science News (2020). Available online at: https://blog.frontiersin.org/2020/12/10/frontiers-editors-summit-december-2020/ (accessed January 7, 2020).
3. Roser M, Ritchie H, Ortiz-Ospina E, Hasell J. *Coronavirus Pandemic (COVID-19)*. (2020). Available online at: https://ourworldindata.org/grapher/covid-daily-vs-total-cases-per-million?tab=table&time=2020-01-22.latest (accessed January 7, 2020).
4. Johns Hopkins University of Medicine. *Coronavirus Resource Center-Mortality Analyses*. (2020). Available online at: https://coronavirus.jhu.edu/data/mortality (accessed January 7, 2020).
5. Brazeau NF, Verity R, Jenks S, et al. *COVID-19 Infection Fatality Ratio: Estimates from Seroprevalence*. Imperial College London (2020). Available online at: https://doi.org/10.25561/83545. https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/report-34-IFR/ (Accessed January 7, 2020).
6. Vestergaard LS, Mølbak K. Timely monitoring of total mortality associated with COVID-19: informing public health and the public. *Euro Surveill.* (2020) 25:2001591. doi: 10.2807/1560-7917.ES.2020.25.34.2001591
7. The Economist - COVID-19 Data. *Tracking Covid-19 Excess Deaths Across Countries*. (2020). Available online at: https://www.economist.com/graphic-detail/2020/07/15/tracking-covid-19-excess-deaths-across-countries (accessed January 7, 2020).
8. European Centre for Disease Prevention and Control (ECDC). *Situation Updates on COVID-19*. (2020). Available online at: https://www.ecdc.europa.eu/en/covid-19/situation-updates (accessed January 7, 2020).
9. Backhaus A. Common pitfalls in the interpretation of COVID-19 data and statistics. *Intereconomics.* (2020) 3:162–6. doi: 10.1007/s10272-020-0893-1
10. Hale T, Boby T, Angrist N, Cameron-Blake E, Hallas L, Kira B, et al. *Variation in Government Responses to COVID-19*. Blavatnik School of Government Working Paper Version 9.0 (2020). Available online at: https://www.bsg.ox.ac.uk/covidtracker (accessed January 7, 2020).
11. Arsalan M, Mubin O, Alnajjar F, Alsinglawi B, Zaki N. Global and temporal COVID-19 risk evaluation. *Front Public Health.* (2020) 8:440. doi: 10.3389/fpubh.2020.00440
12. De Larochelambert Q, Marc A, Antero J, Le Bourg E, Toussaint JF. Covid-19 mortality: a matter of vulnerability among nations facing limited margins of adaptation. *Front Public Health.* (2020) 8:604339. doi: 10.3389/fpubh.2020.604339
13. Villani L, McKee M, Cascini F, Ricciardi W, Boccia S. Comparison of deaths rates for COVID-19 across Europe during the first wave of the COVID-19 pandemic. *Front Public Health.* (2020) 8:620416. doi: 10.3389/fpubh.2020.620416
14. Jin J-M, Bai P, He W, Wu F, Liu X-F, Han D-M, et al. Gender differences in patients with COVID-19: focus on severity and mortality. *Front Public Health.* (2020) 8:152. doi: 10.3389/fpubh.2020.00152
15. Li H, Wang S, Zhong F, Bao W, Li Y, Liu L, et al. Age-dependent risks of incidence and mortality of COVID-19 in Hubei Province and other parts of China. *Front Med.* (2020) 7:190. doi: 10.3389/fmed.2020.00190
16. Khan JR, Awan N, Islam MM, Muurlink O. Healthcare capacity, health expenditure, and civil society as predictors of COVID-19 case fatalities: a global analysis. *Front Public Health.* (2020) 8:347. doi: 10.3389/fpubh.2020.00347
17. De Ridder D, Sandoval J, Vuilleumier N, Azman A, Stringhini S, Kaiser L, et al. Socioeconomically disadvantaged neighborhoods face increased persistence of SARS-CoV-2 clusters. *Front Public Health.* (2020) 8:626090. doi: 10.3389/fpubh.2020.626090
18. Castaneda MA, Saygili M. The effect of shelter-in-place orders on social distancing and the spread of the COVID-19 pandemic: a study of Texas. *Front Public Health.* (2020) 8:596607. doi: 10.3389/fpubh.2020.596607
19. Bönisch S, Wegscheider K, Krause L, Sehner S, Wiegel S, Zapf A, et al. Effects of coronavirus disease (COVID-19) related contact restrictions in Germany, march to may 2020, on the mobility and relation to infection patterns. *Front Public Health.* (2020) 8:568287. doi: 10.3389/fpubh.2020.568287
20. Flaxman S, Mishra S, Gandy A, Unwin H, Mellan T, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. *Nature.* (2020) 584:257–61. doi: 10.1038/s41586-020-2405-7
21. Mac S, Mishra S, Ximenes R, Barrett K, Khan YA, Naimark D, et al. Modeling the COVID-19 pandemic: a comprehensive guide of infectious disease and decision-analytic models. *J Clin Epidemiol.* (2021) 132:133–41. doi: 10.1016/j.jclinepi.2020.12.002
22. Roques L, Klein EK, Papaïx J, Sar A, Soubeyrand S. Impact of lockdown on the epidemic dynamics of COVID-19 in France. *Front Med.* (2020) 7:274. doi: 10.3389/fmed.2020.00274
23. Wang Q, Xie S, Wang Y, Zeng D. Survival-convolution models for predicting COVID-19 cases and assessing effects of mitigation strategies. *Front Public Health.* (2020) 8:325. doi: 10.3389/fpubh.2020.00325
24. Dagan N, Barda N, Kepten E, Miron O, Perchik S, Katz M, et al. BNT162b2 mRNA Covid-19 vaccine in a nationwide mass vaccination setting. *N Engl J Med*. (2021). doi: 10.1056/NEJMoa2101765. [Epub ahead of print].
25. World Health Organization (WHO). *Contact Tracing in the Context of COVID-19: Interim Guidance*. Available online at: https://www.who.int/publications/i/item/contact-tracing-in-the-context-of-covid-19 (accessed January 7, 2020).
26. European Centre for Disease Prevention and Control (ECDC). *Options for the Use of Rapid Antigen Tests for COVID-19 in the EU/EEA and the UK*. (2020). Available online at: https://www.ecdc.europa.eu/sites/default/files/documents/Options-use-of-rapid-antigen-tests-for-COVID-19_0.pdf (accessed January 7, 2020).
27. Organisation for Economic Co-operation and Development (OECD). *Testing for COVID-19: How to Best Use the Various Tests?*. Technical report (2020). Available online at: http://www.oecd.org/coronavirus/policy-responses/testing-for-covid-19-how-to-best-use-the-various-tests-c76df201/ (accessed January 7, 2020).
28. Mahase E. Covid-19: mass testing in Slovakia may have helped cut infections. *BMJ.* (2020) 371:m4761. doi: 10.1136/bmj.m476
29. European Centre for Disease Prevention and Control (ECDC). *Risk Related to Spread of New SARS-CoV-2 Variants of Concern in the EU/EEA*. (2020). Available online at: https://www.ecdc.europa.eu/en/publications-data/covid-19-risk-assessment-spread-new-sars-cov-2-variants-eueea (accessed January 7, 2020).
30. Lavazza A, Farina M. The role of experts in the Covid-19 pandemic and the limits of their epistemic authority in democracy. *Front Public Health.* (2020) 8:356. doi: 10.3389/fpubh.2020.00356
31. Provenzi L, Barello S. The science of the future: establishing a citizen-scientist collaborative agenda after Covid-19. *Front Public Health.* (2020) 8:282. doi: 10.3389/fpubh.2020.00282

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 13 December 2021
doi: 10.3389/fpubh.2021.780390

Examining the Economic Perspective of Treatable Mortality: The Role of Health Care Financing and the Importance for Economic Prosperity

Viera Ivankova, Beata Gavurova, Samer Khouri and Gabriel Szabo*

Institute of Earth Resources, Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Košice, Košice, Slovakia

OPEN ACCESS

Edited by:
Stefania Salmaso, Independent Researcher, Rome, Italy

Reviewed by:
Marek Vochozka, Institute of Technology and Business, Czechia
Aleksandr Ključnikov, College of Information Management and Business Administration, Czechia
Manuela Tvaronaviciene, Vilnius Gediminas Technical University, Lithuania

***Correspondence:**
Beata Gavurova
beata.gavurova@tuke.sk

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

Received: *21 September 2021*
Accepted: *19 November 2021*
Published: *13 December 2021*

Citation:
Ivankova V, Gavurova B, Khouri S and Szabo G (2021) Examining the Economic Perspective of Treatable Mortality: The Role of Health Care Financing and the Importance for Economic Prosperity. Front. Public Health 9:780390. doi: 10.3389/fpubh.2021.780390

Health is an essential element of economic life and is therefore considered a source of comparative economic development of countries. The aim of the study was to examine the associations between health care financing, specific treatable mortality of males and females of working age, and economic prosperity, taking into account to the classification of health systems applied in the countries of the Organization for Economic Co-operation and Development (OECD). An insurance-based health system and a tax-based health system were identified in these countries, and data were collected for the period 1994–2016. Descriptive analysis, panel regression analysis and cluster analysis were used to achieve the aim. The analytical process included economic indicators [health expenditure, gross domestic product (GDP)] and health indicators (treatable mortality from circulatory system diseases and endocrine, nutritional and metabolic diseases). The results revealed significant negative associations of health care financing with treatable mortality from circulatory system diseases and endocrine, nutritional, and metabolic diseases in both health systems and both gender categories. There were also negative associations between treatable mortality in both diagnosis groups and economic prosperity. These results have shown that health care financing is linked to economic prosperity also through health variability in the working age population. In terms of assessing economic and health outcomes, less positive and more positive countries were identified using cluster analysis. Countries such as Latvia with a tax-based health system and Hungary, Lithuania, Estonia with an insurance-based health system were characterized by great potential for improvements. Although reducing treatable mortality is a great motivation for public health leaders to increase health care financing, the importance for economic prosperity may be a more compelling argument. Effective interventions should be considered in the light of their regional, social and economic contexts.

Keywords: economic productivity, health systems, expenditure, treatable mortality, gross domestic product, gender classification, OECD countries, working age population

INTRODUCTION

The current global situation underlines the need to focus on public health in order to eliminate unnecessary deaths and ensure economic growth. The economic impact of health is well-known, and therefore measures leading to better population health contribute to the creation of richer economies (1). In this context, health care can be considered as one of the important factors in the economic development of countries (2). It is also true that the provision of health care depends to a large extent on its financing, and therefore if countries strive to have a healthy productive population, they must also focus on the financing of health care (3). These facts suggest that health care financing, health and economic prosperity are important and interconnected elements of any country's life and should be at the center of both professional and political attention.

In line with the above-mentioned facts, the main aim of the study was to examine the associations between health care financing, specific treatable mortality of males and females of working age, and economic prosperity, taking into account to the classification of health systems applied in OECD countries. The main idea of the research was based on the assumption that the way and level of health care financing could be reflected in specific health outcomes, which can also affect the economic prosperity of OECD countries. If health systems are well-designed, they should achieve comparable results. The importance of the issue is unquestionable due to the ongoing pandemic, which has caused health and economic losses around the world, but the need for attention has also been before it. The continuing need for research into treatable mortality is underlined by the importance of this indicator, which is poorly investigated in the economic dimension. The results of the presented study are important for understanding the extent to which health and economic elements are interconnected, in a diverse classification according to the applied health system and gender characteristics of the working age population. Knowledge of these results makes it possible to design optimal forms of health policies at the national and international levels in order to eliminate health inequalities not only within individual countries but also between countries. Along with health improvements, leaders can expect economic benefits.

THEORETICAL BACKGROUND

It is well-known that health is a value in itself, it is also a prerequisite for economic prosperity. Population health is linked to economic performance in terms of productivity, labor supply, human capital, and public expenditure. In this context, individuals in good health represent the driving force of the economy, but individuals in poor health spend public resources and represent a potential burden in times of disease and death. Therefore, the issue of health and economic life requires an increased attention of researchers, professionals and policy makers in order to improve the health of the population. One of the many ways to improve it is adequate financing. Health expenditure can ensure the good health of individuals which can increase the volume and productivity of their work and bring benefits to the economy (4). In this context, the findings of Murphy and Topel (5) need to be emphasized, which have clearly shown that improving the health of the population in terms of increasing life expectancy and reducing mortality translates into increased economic value of health capital, bringing significant economic gains. Based on all these findings, it is true that health is essential for economic prosperity and represents economic development (6).

The relationship between health care financing and public health has received considerable attention in recent decades, and the authors of several international studies support the idea that health outcomes are influenced, among other factors, by the level of health care financing (7–9). Novignon et al. (10) revealed that higher health expenditure has a significant effect on population health, especially in terms of higher life expectancy and lower mortality. On this basis, it can be stated that an adequate level of financing in health care plays an important role in improving health outcomes in a country (3, 11, 12). On the other hand, there are findings that indicate that health expenditure is not the only determinant of health (13). This underlines the ambiguity and complexity of the relationship between health expenditure and health outcomes, which creates problems in international comparison (14).

Although health care financing varies from country to country, it should be based on pillars such as solidarity and equity, in order to provide accessible and quality health care. That is the core of modern health systems applied in countries based on tax or insurance principles. At the macroeconomic level, the overall effectiveness of health systems is assessed in terms of improving health, while health outcomes are often confronted with health expenditure (15). Van der Zee and Kroneman (16) compared the effectiveness of an insurance-based health system and a tax-based health system with a focus on health care financing, health outcomes and patient satisfaction. In their results, the authors revealed that the system based on health insurance acquired a more favorable assessment in terms of overall mortality, life expectancy, as well as patient satisfaction. On this basis, differences in health outcomes can be expected between countries with different health systems, and this aspect should be taken into account when examining the link between health and economic outcomes.

The issue under investigation provides many health indicators as appropriate measures. One of the most commonly used indicators of population health is mortality, and the results of many studies support the claim that reducing population mortality improves aspects of economic life in countries such as economic development and prosperity (17–19). On the other hand, treatable mortality is considered a key indicator demonstrating the extent of the contribution of health care to the health status of the population (20, 21). Treatable mortality is part of the concept of avoidable mortality that is based on the idea that, with current medical knowledge and technology, certain deaths could be averted, in particular through effective interventions in health systems (prevention and treatment). This means that overall mortality would not reach such a level if effective prevention and adequate health care were provided (22). It follows that treatable mortality, as part of avoidable

mortality, is linked to the financing of health care. This fact was proved by Heijink et al. (23), who confirmed a statistically significant negative association between avoidable mortality and health expenditure using fixed-estimate regression models. The authors emphasized that most countries with above-average growth in health expenditure reported above-average decline in avoidable mortality. Reduction of treatable mortality is desirable, as treatable mortality represents an economic burden. According to Alkire et al. (24), the unfoundedness of these deaths brings economic losses in the form of a decline in countries' GDP.

The above-mentioned facts underline the importance of examining the associations between treatable mortality and economic outcomes. As could be seen, the link between health and economic life has been often examined in one dimension, while this study applies multilevel research, first the association between health care financing and treatable mortality, and then the association between treatable mortality and economic prosperity. Health policy makers should know how health care financing can be reflected in economic prosperity through population health represented by treatable mortality. The novelty of the presented study also lies in the international comparison of OECD countries classified according to their applied health system. In addition to the classification according to health systems, the study respects gender differentiation in treatable mortality from circulatory system diseases and endocrine, nutritional and metabolic diseases. This allows a deeper insight into the issue.

METHODOLOGY

Research Aim and Questions

The main aim of the study was to examine the associations between health care financing, specific treatable mortality of males and females of working age, and economic prosperity, taking into account to the classification of health systems applied in OECD countries. Based on this aim, the following research questions were formulated:

RQ1: Are there significant associations between health care financing and selected diseases as a cause of treatable mortality for males and females of working age in OECD countries that apply a tax-based health system?

RQ2: Are there significant associations between health care financing and selected diseases as a cause of treatable mortality for males and females of working age in OECD countries that apply an insurance-based health system?

RQ3: Are there significant associations between selected diseases as a cause of treatable for males and females of working age and economic prosperity in OECD countries that apply a tax-based health system?

RQ4: Are there significant associations between selected diseases as a cause of treatable mortality for males and females of working age and economic prosperity in OECD countries that apply an insurance-based health system?

Research Data

For the purposes of this research, data were collected from available OECD (25, 26) and World Health Organization (WHO) (27) databases. These data were collected for all available years, with the oldest data from 1994 and the most recent data from 2016. In this sense, it is possible to define the analyzed period from 1994 to 2016. The variables analyzed in this research can be divided into two groups according to their nature:

- Economic variables – health care financing, economic prosperity of countries represented by their GDP,
- Health variables – treatable mortality of males and females with a closer look at diseases of the circulatory system and endocrine, nutritional and metabolic diseases.

The financing of health care represented total health expenditure as a percentage of countries' GDP. Health expenditure expressed the final consumption of health products and services, including personal health care (medical care, rehabilitation care, long-term care, ancillary services, and medical goods/materials) and collective services (prevention, public health services, health administration) (26).

Economic prosperity covered the GDP of countries, which is a standard measure of the added value generated in a country. GDP is considered to be one of the most important outcome indicators that capture countries' economic activity. This indicator was based on GDP expressed in dollars and converted per capita (in current PPP prices) (25).

Health variables included mortality from treatable diseases in males and females, specifically circulatory system diseases and endocrine, nutritional and metabolic diseases. These diagnosis groups were selected on the basis that they mainly include non-communicable diseases, which tend to be long-lasting. Treatable mortality is mortality from causes that can be avoided in particular by early and effective interventions in health care, including secondary prevention and treatment (after the onset of diseases to reduce mortality from treatable causes) (28). The calculation of the treatable mortality rate was based on the sum of standardized mortality for specific causes and data were collected from the WHO database (27). As indicated above, the research covered two diagnosis groups of treatable diseases with regard to the OECD and Eurostat list (28). Each group consisted of specific treatable diseases identified by the 10th version of the International Classification of Diseases (ICD-10):

- Circulatory system diseases: I01–I26, I60–I71, I73, I80, I82,
- Endocrine, nutritional and metabolic diseases: E00–E14, E24–E25, E27, E74.

Numbers of deaths from these treatable causes were collected across countries for all available years for which countries reported a value (including zero). Data were available for various age categories separately for males and females. The data collected on treatable deaths were recalculated per 100,000 inhabitants of a given country in a specific gender and age category (i.e., per 100,000 males aged 25–64 years in a given country and per 100,000 females aged 25–64 years in a given country). This step was preceded by the collection of population data in this specific gender and age category for each country and each analyzed year, when individual treatable deaths were reported. Population data were provided from the United

Nations database as part of their report "World Urbanization Prospects" (29).

From a macroeconomic point of view, productivity is the connecting element of all analyzed variables and the associations between them. The selected indicators present the level of health care financing in countries as a percentage of their productivity (GDP), the treatable mortality of the working age population and the level of economic productivity (GDP) as such. The age category was selected on the basis of several studies examining the age and productivity of the population (30–32), but it is also generally assumed that people enter the labor market from the moment of graduation and leave it at retirement age. At the same time, the age of 25 is a period of life in which individuals are likely to have found a targeted job or have already established themselves in the labor market, even if they have not graduated from university.

Research Subjects

The research sample consisted of countries that have developed a health system for the provision of primary and specialized (secondary and tertiary) health care. Thus, 37 OECD countries were included in the analytical process. The classification of OECD countries in terms of applied health system was performed on the basis of data from surveys of health systems characteristics in OECD countries (33, 34), on the basis of data from country health profiles (35, 36), as well as on the basis of data provided on the websites of the Ministry of Health of each country included in the research. It should also be noted that Latvia replaced the principle of health care financing from an insurance-based system to a tax-based system in 2011 and therefore only the most recent data were taken into account. The classification of countries was as follows:

- Tax-based health system: Australia (AU), Canada (CA), Denmark (DK), Finland (FI), Iceland (IS), Ireland (IE), Italy (IT), Latvia (LV), Norway (NO), New Zealand (NZ), Portugal (PT), Spain (ES), Sweden (SE), the United Kingdom (GB);
- Insurance-based health system: Austria (AT), Belgium (BE), Chile (CL), Colombia (CO), the Czech Republic (CZ), Estonia (EE), France (FR), Germany (DE), Greece (GR), Hungary (HU), Israel (IL), Japan (JP), Korea (KR), Lithuania (LT), Luxembourg (LU), Mexico (MX), the Netherlands (NL), Poland (PL), Slovakia (SK), Slovenia (SI), Switzerland (CH), Turkey (TR), the United States (US).

Based on this classification of countries, it can be seen that a tax-based health system was applied by a total of 14 countries and an insurance-based health system was applied by 23 countries.

Statistical Analysis

The assessment of the collected data was performed in the first step of the statistical processing through a descriptive analysis, which provided a closer look at the economic and health outcomes in OECD countries. In this context, central tendency measures (arithmetic mean, median), variability measure (standard deviation), quartiles, minimum and maximum, as well as position measures (skewness and kurtosis) were used in this analysis. It was the position measures in most of the cases that indicated a possible disruption of the normal distribution of data. Hair et al. (37) declare that values of skewness and kurtosis in the range of -1 to $+1$ are indicators of normal distribution, but most cases in this study exceeded this range. The structure of the data indicated a disruption of the normal distribution as well as the presence of outliers.

Regression analysis was used to evaluate the significance of the associations between health care financing, treatable mortality in selected diagnosis groups, and the economic prosperity of countries. Robust methods were used to estimate the coefficients, specifically models with random or fixed effects in one-way (individual) or two-ways variants. The regression analysis was preceded by panel diagnostics to select appropriate regression models using the F test for the presence of individual effects (or time effects) and the Hausman test. The one-way variant was supported if a statistically significant effect was demonstrated only within countries or only within years, then the effect was taken into account in the corresponding model. As pointed out in the following section, if there was only one significant effect in the data structure, it was the country structure, not the time structure. Thus, the one-way variant of the models always took into account the effects identified in the country structure. On the contrary, the two-ways variant was supported if a statistically significant effect was demonstrated both within countries and within years (time effect), and these effects were taken into account in the relevant models. Subsequent decision-making processes led to a preference for a model with random or fixed effects, and Hausman's test statistics helped with this choice. If the result of the Hausman test confirmed the significance at the level $\alpha < 0.05$, the preference was in favor of choosing a model with fixed effects (the null hypothesis was rejected). Otherwise ($\alpha > 0.05$), the choice was focused on a model with random effects (the null hypothesis was not rejected).

The HC3 estimator was used to estimate the regression coefficients, with respect to the data showing outliers and heteroscedasticity. The Arellano estimation method (38) for fixed effect models and the White 2 estimation method for random effects models were used to assess the significance of the coefficients. Finally, the associations were examined in four variants of regression models with a preference for one of them (based on the above panel assumptions): "One-way (individual) effect Fixed effect model" (Arellano), "One-way (individual) effect Random effect model" (White 2), "Two-ways effects Within (fixed) effect model" (Arellano), "Two-ways effects Random effect model" (White 2).

In the last third step of the statistical processing, a cluster analysis of the links between economic outcomes and treatable mortality outcomes was performed in the specification of gender and health systems. The number of clusters was supported by the result of the silhouette method (39), while the Partitioning Around Medoids (PAM) method based on the Manhattan distance was used to determine the clusters (40). The output of this analysis offered a classification of countries.

The analytical processing was performed in the programming language R v 4.1.1 (RStudio, Inc., Boston, MA, USA).

TABLE 1 | Descriptive statistic of economic and health variables classified by health systems and gender (1994–2016).

	N	Miss	Mean	Median	St Dev	Skew	Kurt	Min	Max	1st Q	3rd Q
Tax-based health system											
HF	216	0	8.68	8.69	1.07	−0.25	0.55	5.4	10.98	8.02	9.32
GDP	216	0	35,565.1	34,198.6	9,402.5	0.8	0.78	19,887.8	66,956.3	28,704.9	41,523.5
CRC–M	216	0	74.44	65.73	37.99	3.38	14.77	27.25	289.23	53.53	81.91
CRC–F	216	0	25.32	22.9	12.04	3.21	14.87	3.67	99.1	18.17	29.40
END–M	216	0	6.59	6.3	3.02	0.44	−0.33	<0.01	14.79	4.08	8.84
END–F	216	0	3.38	3.22	1.65	0.46	−0.20	<0.01	7.66	2.24	4.35
Insurance-based health system											
HF	389	17	7.82	7.15	2.45	1.16	1.76	3.35	16.71	6.08	9.55
GDP	406	0	28,591.4	26,585.6	16,312.2	1.51	3.63	6,554.6	103,788	16,451.5	35,896.2
CRC–M	406	0	110.53	71.74	79.8	1.37	0.78	29.26	386.57	60.34	149.84
CRC–F	406	0	41.35	33.51	26.97	1.3	1.17	7.69	141.41	21.77	50.66
END–M	406	0	10.61	7.77	11.49	3.96	15.84	1.55	71.31	5.72	10.8
END–F	406	0	7.12	4.33	10.33	3.96	15.18	0.66	56.4	2.77	7.44

HF, Health care financing in % of GDP; GDP, Gross domestic product per capita; F, Females; M, Males, CRC, Treatable mortality from circulatory system diseases per 100,000 males/females aged 25–64 years; END, Treatable mortality from endocrine, nutritional and metabolic diseases per 100,000 males/females aged 25–64 years; N, number of observations, Miss, Missing values; St Dev, Standard deviation; Skew, Skewness; Kurt, Kurtosis; Min, Minimum; Max, Maximum; 1st Q, First quartile; 3rd Q, Third quartile.

RESULTS

Descriptive Statistic—Univariate View

This section focuses on the statistical description of variables to provide a closer look at economic and health outcomes across OECD countries.

Based on the results in **Table 1**, the economic variables can be interpreted as follows. In countries with a tax-based health system, health care financing averaged 8.68% of GDP during the analyzed period, with a minimum of 5.4% (Latvia in 2013) and a maximum of 10.98% (Sweden in 2014). Health care financing in countries with an insurance-based health system averaged 7.82% of GDP, with a minimum of 3.35% of GDP (Korea in 1995) and a maximum of 16.71% of GDP (the United States in 2015). Thus, it is clear that countries with an insurance-based health system financed health care at a lower level than countries with a tax-based health system. Countries with an insurance-based health system also showed lower economic prosperity, as evidenced by a mean of 28,591.4 USD per capita compared to a mean of 35,565.1 USD per capita in countries with a tax-based health system.

With a focus on health variables, the results revealed the following facts. In both types of health system, males of working age were characterized by considerably higher rates of treatable mortality from circulatory system diseases, as well as endocrine, nutritional and metabolic diseases. Treatable mortality from circulatory system diseases dominated over mortality from endocrine, nutritional and metabolic diseases. Regarding circulatory system diseases, in countries with a tax-based health system, the results indicated that males annually achieved an average of 49.12 more deaths (per 100,000 males of working age) than females (per 100,000 females of the same age category). In countries with an insurance-based health system, this inequality represented an average of 69.18 more deaths at the expense of males. Based on the mean values, it was also clear that countries with an insurance-based health system reported higher mortality rates than countries which applied a tax-based health system.

Assessing the Associations Between Health Care Financing, Treatable Mortality, and Economic Prosperity—Bivariate and Multivariate View

This subsection aims to assess the significance of the examined associations between health care financing, treatable mortality in individual diagnosis groups, and the economic prosperity of countries in gender differentiation of the working age population, as well as in the specification of health systems.

The use of specific panel regression models was preceded by testing the assumptions. The balance statistics of panel regression models in the analyzed cases leaned more toward a balanced model. This was supported by the following values of gamma (γ) and nu (ν), and it is true that the closer their value is to 1, the more the panel appears to be balanced. For countries with a tax-based health system, both diagnosis groups acquired $\gamma = 0.8463299$ and $\nu = 0.9060825$ when examining all the associations. For countries with an insurance-based health system, these were $\gamma = 0.7470208$ and $\nu = 0.9352060$ when examining the associations between health care financing and treatable mortality due to given causes, and $\gamma = 0.7376557$ and $\nu = 0.9380606$ when examining the associations between treatable mortality and economic prosperity. The presented coefficients of determination (R^2) provide only an informative value and it is not necessary to consider them in terms of model strength, as the low value is given by a relatively low number of observations due to the classification of the panel data structure, i.e., within diagnosis groups, gender and health system specification.

After regression analysis, a cluster analysis was performed in each diagnosis group in the classification according to gender and health system. In the first place, the data in the individual

TABLE 2 | Testing of assumptions for the selection of regression models in the diagnosis group of circulatory system diseases.

		F Test–countries (*p*)	*F* Test–years (*p*)	Hausman Test (*p*)	Model
Tax-based health system					
Males	HF→ CRC	162.988 (<0.001)	0.678 (0.858)	10.655 (0.001)	One-way fixed
	CRC→ GDP	68.552 (<0.001)	5.474 (<0.001)	81.097 (<0.001)	Two-ways fixed
Females	HF→ CRC	98.413 (<0.001)	0.608 (0.915)	12.705 (<0.001)	One-way fixed
	CRC→ GDP	39.985 (<0.001)	5.192 (<0.001)	56.078 (<0.001)	Two-ways fixed
Insurance-based health system					
Males	HF→ CRC	196.484 (<0.001)	0.532 (0.961)	2.699 (0.100)	One-way random
	CRC→ GDP	92.320 (<0.001)	2.734 (<0.001)	6.931 (0.008)	Two-ways fixed
Females	HF→ CRC	114.004 (<0.001)	1.082 (0.364)	5.085 (0.024)	One-way fixed
	CRC→ GDP	89.978 (<0.001)	1.948 (0.007)	2.562 (0.109)	Two-ways random

HF, Health care financing in % of GDP; CRC, Treatable mortality from circulatory system diseases per 100,000 males/females aged 25–64 years; GDP, Gross domestic product per capita.

diagnosis groups were averaged over the analyzed period in each country separately for males and females. The same step was taken in economic indicators, and thus health care financing and economic prosperity (GDP) were first averaged separately in each country for the analyzed period, but gender differentiation was not applied. In the next step, these health and economic outcomes were standardized in the range of 0–1, with a value of 0 indicating the least positive result and a value of 1 indicating the most positive result. In the case of economic indicators, the data were again averaged to create one economic outcome per country. This process created two variables assessing economic indicators and indicators of treatable mortality in individual countries, which were included in the cluster analysis.

Treatable Mortality From Circulatory System Diseases

This part of the analytical processing is devoted to the evaluation of the investigated associations and their significance in the diagnosis group of circulatory system diseases (CRC). The results of testing the assumptions for the preference of the regression model are shown in **Table 2**.

From the results in **Table 2**, it is clear that a one-way fixed effects model and its results were recommended to be taken into account when assessing the significance of most associations between health care financing and treatable mortality due to circulatory system diseases (HF→CRC). The choice of this model was supported by the results of F tests, which revealed significant effects in the data structure only within the countries that needed to be respected in a one-way variant of the model. At the same time, in these cases, the results of the Hausman test with a $p < 0.05$ testified in favor of a model with fixed effects. An exception was the case in the male population of countries with an insurance-based health system, in which a one-way model was preferred but with random effects, as the result of the Hausman test was not significant. In most cases, a two-ways fixed effects model was recommended to assess the significance of the associations between treatable mortality due to circulatory system diseases and economic prosperity (CRC→GDP). The results of F tests, where appropriate, showed effects in the data structure in terms of countries and years, and the results of the Hausman test favored a model with fixed effects ($p < 0.05$). An exception could be observed in the female population in countries with an insurance-based health system, in which the preference leaned toward a two-ways model with random effects.

Table 3 presents the results of the evaluation of associations in the diagnosis group of circulatory system diseases, based on which it can be concluded that health care financing appeared to be a significant factor in treatable mortality from circulatory system diseases in males and females aged 25–64 years in both systems. The association with statistical significance at the level of $\alpha < 0.001$ was confirmed in all analyzed cases in terms of gender and health systems. Simultaneously, negative values for the β coefficient were identified in all cases, indicating that a higher rate of health care financing was associated with a reduction in treatable mortality due to circulatory system diseases and vice versa. When comparing health systems, more pronounced results can be observed in countries with an insurance-based health system, while in a gender comparison, more pronounced results could be observed in the male population.

With a focus on the associations between treatable mortality from circulatory system diseases and economic prosperity, it is clear that a significance ($\alpha < 0.001$) was revealed in the female population of countries with an insurance-based health system, when the result of the two-ways random effects model was taken into account. It is also evident that no significant associations were observed in the other cases when considering panel two-ways models with fixed effects. The choice of two-ways variants should be considered correct, but there was room to accept the results of a two-ways model with random effects. This model still appeared to be effective, although it may not be consistent as a model with fixed effects. Therefore, the results of this model could be supported with some caution, which also suggested a limitation of the research. On the other hand, the value of the determination coefficients indicated the possibility to lean toward the two-ways model with random effects. From the results of the two-ways random effects model, it was evident that treatable mortality from circulatory system diseases was negatively associated with economic prosperity. In this way, an

TABLE 3 | Regression analysis—associations between health care financing, treatable mortality from circulatory system diseases and economic prosperity.

			One-way random effects model	One-way fixed effects model	Two-ways random effects model	Two-ways fixed effects model
Tax-based health system						
Males	HF→ CRC	R^2	0.544	0.550	0.338	0.044
		α	188.90***		145.05**	
		β	−12.34***	**−12.02*** **	−6.88	−2.15**
	CRC→ GDP	R^2	0.592	0.755	0.213	0.009
		α	63668.55***		46501.71***	
		β	−350.60***	−463.12***	**−163.70*** **	−43.30
Females	HF→ CRC	R^2	0.469	0.459	0.284	0.006
		α	64.73***		49.32***	
		β	−4.27***	**−4.13*** **	−2.36	−0.39
	CRC→ GDP	R^2	0.518	0.642	0.242	0.001
		α	59125.19***		42168.98***	
		β	−873.74***	−1134.75***	**−338.81*** **	12.64
Insurance-based health system						
Males	HF→ CRC	R^2	0.202	0.208	0.099	0.027
		α	208.41***		196.82***	
		β	**−13.10*** **	−13.29***	−11.55***	5.22
	CRC→ GDP	R^2	0.376	0.392	0.208	0.003
		α	47884.35***		31938.93***	
		β	−178.95***	−187.81***	**−43.20*** **	−9.40
Females	HF→ CRC	R^2	0.230	0.241	0.109	0.038
		α	85.60***		80.36***	
		β	−5.97***	**−6.19*** **	−5.26***	2.43*
	CRC→ GDP	R^2	0.434	0.442	0.289	0.001
		α	46299.33***		33180.44***	
		β	−442.63***	−450.02***	**−141.75*** **	−5.03

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$.
The accepted significant results are highlighted in bold.

increase in GDP was associated with a reduction in treatable mortality from circulatory system diseases and vice versa. These inverse associations with a significance at the level of $\alpha < 0.001$ were revealed in both health systems and both gender categories of the population.

The cluster maps shown in **Figures 1**, **2** provided a grouping of countries based on an assessment of treatable mortality from circulatory system diseases and economic outcomes (a variable combining health care financing and the economic prosperity of countries). **Figures 1**, **2** also show that the silhouette method recommended two clusters to form organized groups in both health systems and in both gender categories. With a focus on countries with a tax-based health system (**Figure 1**), cluster 1, which could be considered the most positive in terms of assessment, included all countries except Latvia. This country acquired the least positive assessment of economic and health outcomes in the male and female population, indicating an undesirable position in the lower left margin. Regarding countries with an insurance-based health system (**Figure 2**), the countries in cluster 1 could be considered as the countries with the most positive outcomes. These countries were characterized by lower treatable mortality and higher economic conditions. The positive outcomes were dominated by countries such as Switzerland, Luxembourg and France. On the other hand, countries such as Lithuania, Hungary, Estonia, and Slovakia in cluster 2 could be considered the least positive. These countries reported higher treatable mortality and lower economic outcomes.

Treatable Mortality From Endocrine, Nutritional, and Metabolic Diseases

The evaluation of individual associations and their significance in the diagnosis group of endocrine, nutritional and metabolic diseases (END) is presented in this part of the analytical process. Also in this diagnosis group, a panel diagnostic for model selection was first performed and its results are presented in **Table 4**.

Based on the results in **Table 4**, it is possible to state that a one-way random effects model should be preferred to assess the significance of most associations between health care financing and treatable mortality due to endocrine, nutritional and metabolic diseases (HF→ END). Specifically, this model was recommended in the case of the male population in countries with a tax-based health system, as well as in the case of both

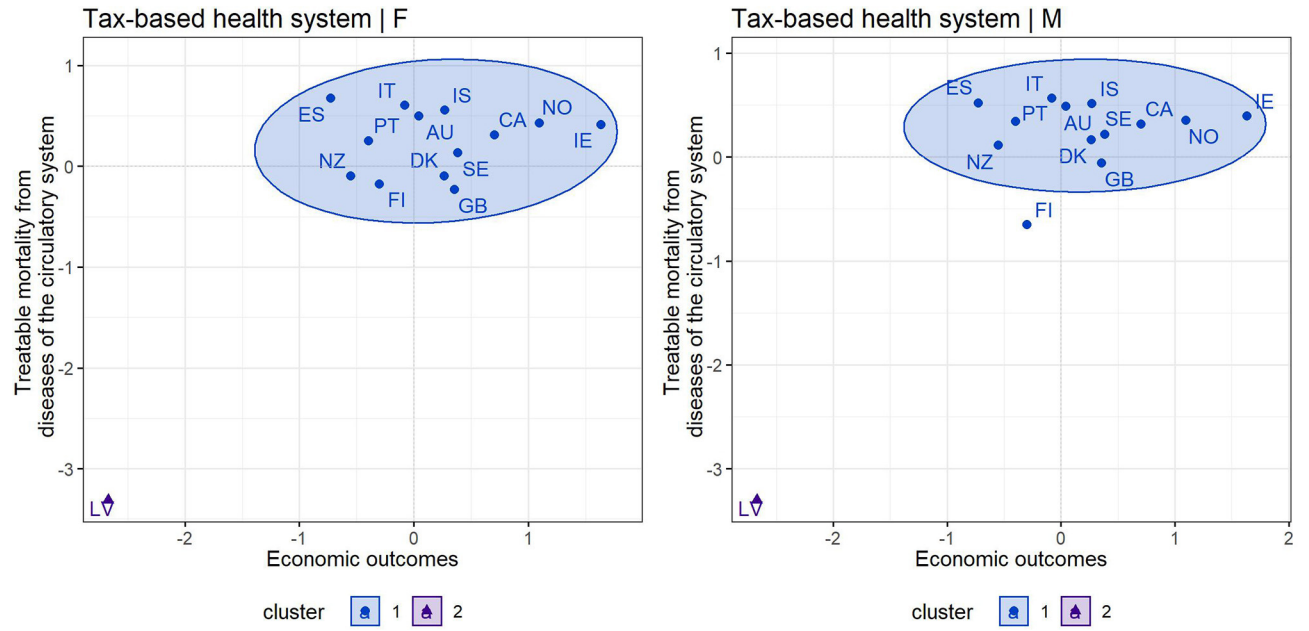


FIGURE 1 | Cluster map—economic outcomes and treatable mortality from circulatory system diseases for countries applying a tax-based health system—females (F) and males (M).

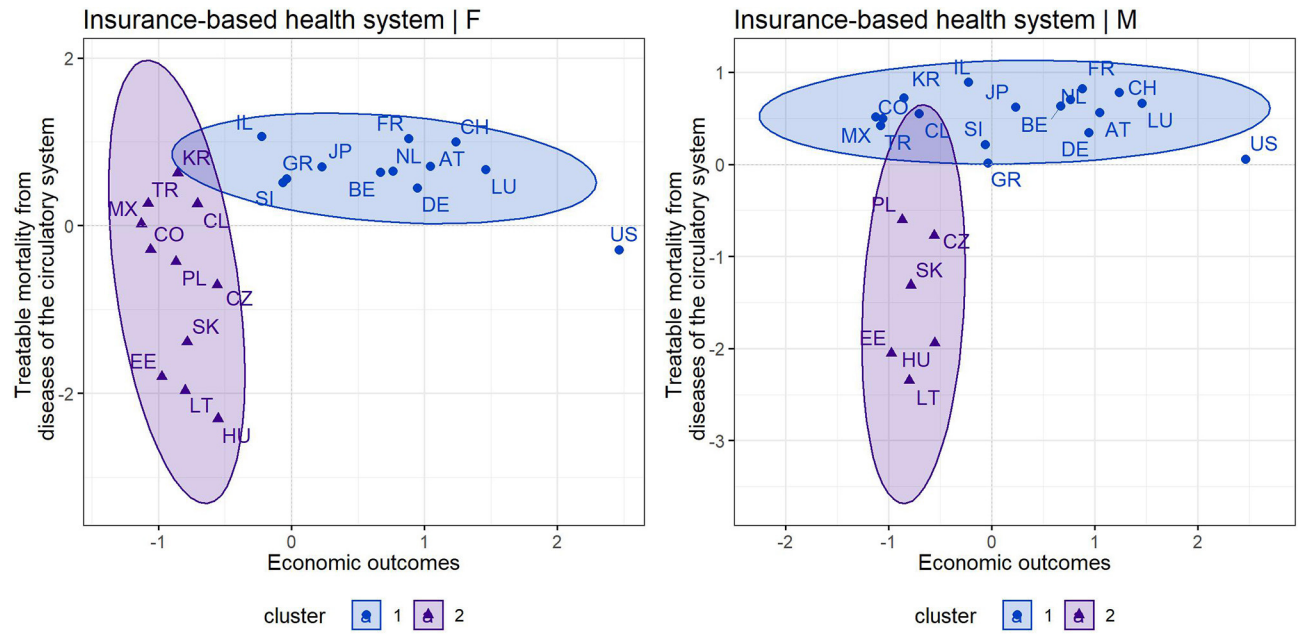


FIGURE 2 | Cluster map—economic outcomes and treatable mortality from circulatory system diseases for countries applying an insurance-based health system—females (F) and males (M).

gender categories in countries with an insurance-based health system. The preference for this variant of the panel regression model was based on the results of F tests indicating significant effects in the data structure only within countries and on the results of the Hausman test with a $p > 0.05$ recommending a model with random effects. Conversely, a one-way model with fixed effects was preferred in the case of the female population of countries with a tax-based health system, as the results of the Hausman test showed a $p < 0.05$. In terms of the associations between treatable mortality due to endocrine, nutritional and

TABLE 4 | Testing of assumptions for the selection of regression models in the diagnosis group of endocrine, nutritional and metabolic diseases.

		F Test–countries (*p*)	*F* Test–years (*p*)	Hausman Test (*p*)	Model
Tax-based health system					
Males	HF→ END	126.372 (<0.001)	0.372 (0.996)	1.638 (0.201)	One-way random
	END→ GDP	9.627 (<0.001)	5.995 (<0.001)	0.459 (0.498)	Two-ways random
Females	HF→ END	92.657 (<0.001)	0.527 (0.961)	4.054 (0.044)	One-way fixed
	END→ GDP	10.486 (<0.001)	5.705 (<0.001)	11.149 (0.001)	Two-ways fixed
Insurance-based health system					
Males	HF→ END	416.679 (<0.001)	0.198 (1.000)	0.073 (0.786)	One-way random
	END→ GDP	61.336 (<0.001)	4.260 (<0.001)	0.016 (0.901)	Two-ways random
Females	HF→ END	1240.726 (<0.001)	0.194 (1.000)	0.011 (0.916)	One-way random
	END→ GDP	74.341 (<0.001)	4.073 (<0.001)	5.949 (0.015)	Two-ways fixed

HF, Health care financing in % of GDP; END, Treatable mortality from endocrine, nutritional and metabolic diseases per 100,000 males/females aged 25–64 years; GDP, Gross domestic product per capita.

TABLE 5 | Regression analysis—associations between health care financing, treatable mortality from endocrine, nutritional and metabolic diseases and economic prosperity.

			One-way random effects model	One-way fixed effects model	Two-ways random effects model	Two-ways fixed effects model
Tax-based health system						
Males	HF→ END	R^2	0.039	0.020	0.002	0.003
		α	8.27***		7.74***	
		β	**−0.18***	−0.17 ×	−0.12	−0.09
	END→ GDP	R^2	0.045	0.023	0.063	0.024
		α	42293.70***		34656.26***	
		β	−1103.40**	−1098.04	**−447.19***	−432.86
Females	HF→ END	R^2	0.146	0.127	0.021	0.001
		α	6.00***		5.35***	
		β	−0.28***	**−0.28*****	−0.21 ×	0.02
	END→ GDP	R^2	0.167	0.160	0.166	0.019
		α	7942.43***		32271.36***	
		β	−3704.73***	−4379.47***	−117.62	573.28
Insurance-based health system						
Males	HF→ END	R^2	0.011	0.010	0.039	0.015
		α	12.83***		12.83***	
		β	**−0.29***	−0.28	−0.29	−0.53
	END→ GDP	R^2	0.017	0.008	0.072	0.022
		α	31839.40***		29072.91***	
		β	−306.32*	−281.49	**−215.14*****	−203.86
Females	HF→ END	R^2	0.106	0.109	0.049	0.001
		α	11.11***		11.11***	
		β	**−0.52*****	−0.51*	−0.52*	−0.02
	END→ GDP	R^2	0.106	0.169	0.095	0.010
		α	39280.76***		29254.50***	
		β	−1499.83***	−2348.16*	**−337.15*****	−265.73

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; × $p < 0.1$.
The accepted significant results are highlighted in bold.

metabolic diseases, and economic prosperity (END→ GDP), a two-ways variant of the model was preferred, as the results of *F* tests revealed significant effects in the data structure across countries and years. The results of the Hausman test with a $p > 0.05$ supported the choice of a model with random effects in the male population in both health systems, and the results with a *p*

< 0.05 were in favor of a model with fixed effects in the female population in both health systems. The main results of the panel regression models are shown in **Table 5**.

The results in **Table 5** point to the fact that even in the diagnosis group of endocrine, nutritional and metabolic diseases, health care financing played an important role in both health systems. Proof of this is the statistical significance of associations in both male and female populations. It can also be noted that in both health systems, a greater strength of associations with significance at the level of $\alpha < 0.001$ was identified in the female population. In terms of the male population, associations with less strength and statistical significance at the level of $\alpha < 0.05$ were found in both health systems. Based on the negative β coefficients, an increase in health care financing was associated with a reduction in treatable mortality in this diagnosis group. When comparing the systems, it can be seen that the financing of health care was a more significant aspect in countries with an insurance-based health system.

Focusing on the associations between treatable mortality from endocrine, nutritional and metabolic diseases and economic prosperity, a significant negative association was found in the male population in both health systems. For this diagnosis group, a reduction in the treatable mortality in males of working age was associated with an increase in GDP. A different situation could be observed in the female population in both health systems, as no significant association was confirmed by the preferred two-ways model with fixed effects. As in the previous diagnosis group, there was a room for cautious acceptance of the results of the two-ways random effects model, which revealed a significant negative association in the female population of countries with an insurance-based model. This could be considered a limitation.

As in the previous diagnosis group, **Figures 3**, **4** show the cluster maps that provide grouping of countries based on an assessment of treatable mortality from endocrine, nutritional and metabolic diseases and economic outcomes (a variable combining health care financing and economic prosperity of countries). The silhouette method recommended two clusters to form organized groups of countries with a tax-based health system in both gender categories, while three clusters were recommended for countries with an insurance-based system and for both gender categories. In countries with a tax-based health system (**Figure 3**), a similar situation could be observed as in the previous diagnosis group. Thus, cluster 1 included all countries except Latvia with the least positive outcomes. However, the countries in cluster 1 were not as homogeneous as in the previous diagnosis group. At this point, it is possible to pay increased attention to countries such as Denmark, New Zealand, Canada and Portugal, which acquired less positive assessment of health outcomes compared with other countries in this cluster, i.e., higher treatable mortality from endocrine and metabolic diseases. Focusing on countries with an insurance-based health system (**Figure 4**), Mexico acquired the least positive assessment of economic and health outcomes in the male and female population, indicating an undesirable position in the lower left margin. This country can be considered as a remote country among other countries due to its high level of treatable mortality recorded in this diagnosis group. Consequently, the countries with less positive outcomes included Colombia and Turkey. Attention can also be drawn to the United States, which showed

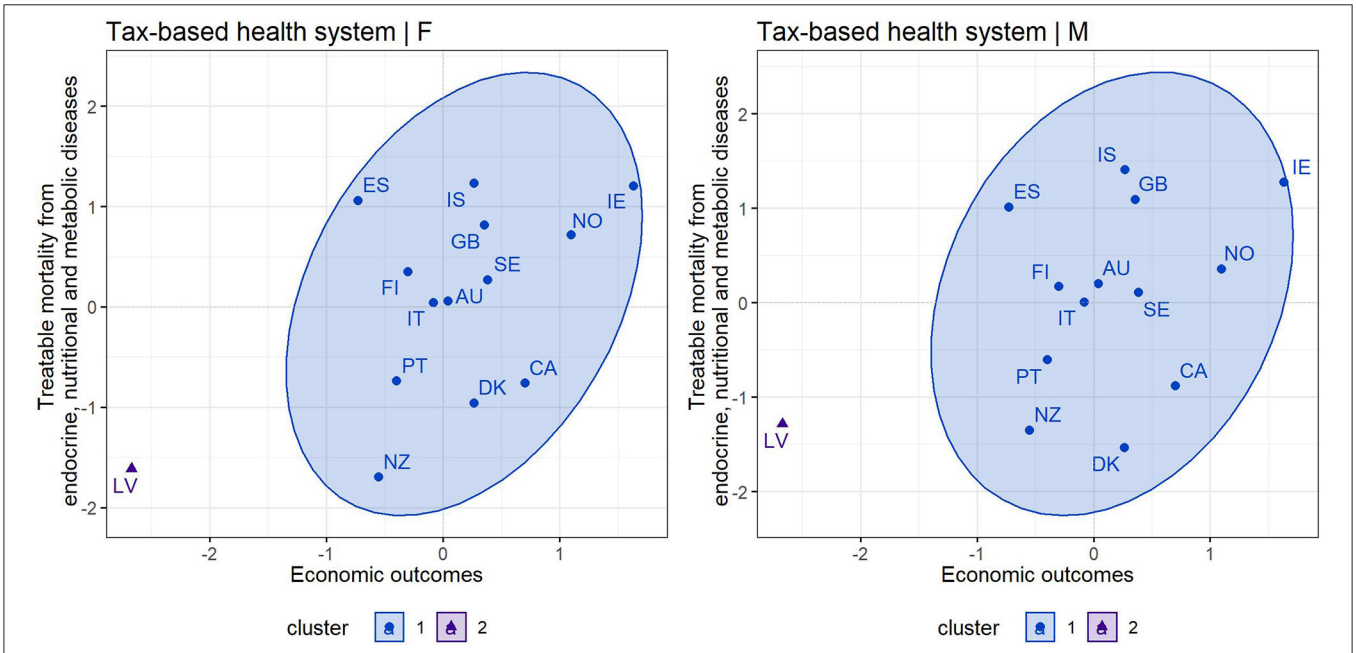


FIGURE 3 | Cluster map—economic outcomes and treatable mortality from endocrine, nutritional and metabolic diseases for countries applying a tax-based health system—females (F) and males (M).

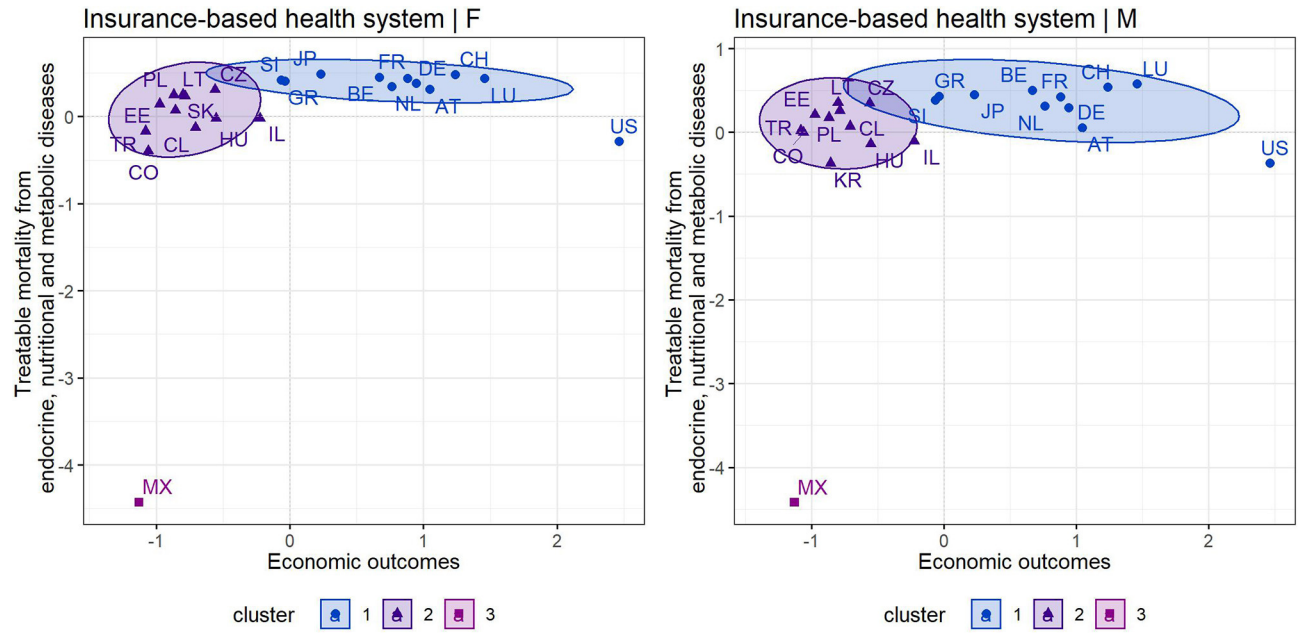


FIGURE 4 | Cluster map—economic outcomes and treatable mortality from endocrine, nutritional and metabolic diseases for countries applying an insurance-based health system—females (F) and males (M).

high economic outcomes, but despite its level, the country recorded a high treatable mortality rate.

DISCUSSION

Insight Into Treatable Mortality in OECD Countries

By comparing the examined diagnosis groups, the presented study and its results showed that diseases of the circulatory system contributed to a greater extent to treatable mortality in OECD countries with a tax-based health system and an insurance-based system. These findings are consistent with the results of Jarčuška et al. (41), as well as the results of the WHO survey (42) on the leading causes of deaths from a global perspective. The survey showed that ischemic heart diseases and strokes, belonging to the diagnosis group of circulatory system diseases, occupy the first ranks in a negative sense. At the same time, Dagenais et al. (43) confirmed that cardiovascular mortality is the largest health burden in low-, middle- and high-income countries. A positive signal is the declining trend in treatable mortality (44–46), while Weber and Clerc (47) attributed this trend mainly to a reduction in mortality from diseases of the circulatory system.

In terms of gender, the results clearly showed that males were characterized by a higher average mortality than females in the examined diagnosis groups of treatable mortality. These findings are consistent with the findings of other studies that confirmed a higher mortality rate for males, reflecting the fact that females live longer (48–50). In this regard, Le et al. (51) revealed that it is the higher male mortality from diseases of the circulatory and respiratory systems that appears to be the main contributing factor to this gender gap. Gender differences in avoidable mortality were also revealed by Westerling (52) and Sundmacher (53), while the results clearly showed that males are higher risk of deaths due to treatable and preventable diseases than females (54, 55). This study on treatable mortality is consistent with previous findings. The problem should take into account biological differences between males and females, while genetic factors, immune system responses, hormonal activity or the course of diseases that can lead to such differences (48). It is also important to realize that males have different patterns of health behavior, which are manifested in a reluctance to seek medical treatment, a reluctance to adhere to treatment, and a lack of reporting of their health problems (48). All of these factors can be critical to treatable deaths and should be taken into account in health care provision and strategy development. This can be an important impetus for leaders of health systems, which strive to improve the health of the population, reduce inequalities and ensure quality health care. According to the results, monitoring the health status of males appears to be justified.

In addition to gender differences, cluster maps also indicated differences between individual OECD countries. Similar findings were revealed by Weber and Clerc (47), who pointed to large differences in treatable mortality between European countries at the international level, but also at their regional level. Focusing on the individual indicators of treatable mortality in both examined systems, it can be concluded that countries applying an insurance-based health system were characterized by less positive health outcomes than countries applying a tax-based health system. These findings differ from those of van der Zee and Kroneman (16), who considered an insurance-based health system to be a more positive system. On the other

hand, these authors took into account overall mortality, life expectancy, and patient satisfaction in their research. In the presented study, countries with an insurance-based health system were characterized by a higher rate of treatable mortality in both diagnosis groups. The results of a descriptive analysis of health care financing pointed to the fact that countries applying an insurance-based health system spend less on health care than countries applying a tax-based health system. Already at this point, it was possible to see a certain link between health care financing and treatable mortality.

The Role of Health Care Financing in Treatable Mortality

In both diagnosis groups, health care financing has been shown to play an important role in the treatable mortality of both males and females in both systems. The regression analysis revealed a significant negative association between health care financing and treatable mortality in each analyzed case, with greater strength of the associations observed in countries with an insurance-based health system. Also, a greater strength of the significant association was identified for diagnosis group of circulatory system diseases. These findings indicated that an increase in health expenditure may be associated with a reduction in treatable mortality of females and males of working age in both diagnosis groups. The results of the regression analysis also indicated that the associations were greater in the male population than in the female population. Despite the findings of several authors suggesting that health care financing is not such an important aspect in population health (13, 14), the findings of this study support the idea that a level of health expenditure is associated with treatable mortality in each of the examined health systems. Under ceteris paribus conditions, a higher level of health expenditure may be reflected in reduced treatable mortality. These findings are consistent with the findings of studies examining commonly used health indicators that involve more or less the strength of other factors (7–9). These were overall mortality, infant mortality, morbidity of the population or life expectancy, which also include social and economic factors affecting the health of the population (3, 10, 11). In terms of overall mortality, many studies confirmed the significant impact of health expenditure (56, 57), but treatable mortality is a specific health indicator separated from overall mortality that is able to capture the contribution of health care. The findings in this study are consistent with the findings of Heijink et al. (23) or Kjellstrand et al. (58), who provided evidence that countries with a higher level of health care expenditure report lower avoidable mortality.

The Role of Treatable Mortality in Economic Prosperity

It should be borne in mind that treatable mortality includes avoidable deaths that are considered unnecessary and dependent on health care interventions and secondary prevention (21). For this reason, there is an assumption that, in the absence of these unnecessary deaths, people would continue to contribute to the economic productivity of countries through their activity. In this context, treatable mortality can represent a significant economic burden. This assumption was also based on a study conducted by Alkire et al. (24), whose findings revealed that the unfoundedness of treatable mortality brings economic losses reflected in a decline in countries' GDP. Based on the regression analysis performed in this study, it can be concluded that a reduction of treatable mortality due to circulatory system diseases and endocrine and metabolic diseases in people of working age is associated with an increase in economic prosperity. At this point, it can be emphasized that these are diagnosis groups that include diseases of civilization, which is a great challenge in many countries, and these findings underline the importance of treating individual diseases. In the diagnosis group of endocrine and metabolic diseases, it has been shown that reducing mortality, especially in males of working age, could be economically beneficial in countries applying a tax-based health system as well as an insurance-based health system. It was also possible to speak cautiously of a significant association in the female population in countries with an insurance-based health system. Regarding diseases of the circulatory system with the greatest health and economic burden (42, 43), the results supported the assumption that reducing mortality in this diagnosis group is associated with increasing economic prosperity of countries. All these findings support the idea that the financing of health care can be reflected in the economic prosperity of countries through the variability of population health. The presented findings are in line with evidence that reducing population mortality improves economic development and prosperity (17–19, 24). Thus, in order to achieve economic benefits, emphasis needs to be placed on reducing mortality and, among other interventions, increased health care financing can help.

Assessment of Individual Countries

The cluster analysis offered the categorization of countries into clusters according to the assessment of treatable mortality outcomes and economic outcomes. In countries with a tax-based health system, almost all countries formed a homogeneous cluster in terms of assessing economic outcomes and treatable mortality from circulatory system diseases. The only exception was Latvia with the least positive outcomes among these countries. In countries with an insurance-based health system, higher treatable mortality from circulatory system diseases and lower economic outcomes were found in Lithuania, Hungary, Estonia, and Slovakia. On the contrary, Switzerland, Luxembourg and France could be considered the most positive countries with an insurance-based health system. With a focus on the endocrine and metabolic treatable causes of deaths, Latvia, as well as Denmark, New Zealand, Canada, and Portugal with a tax-based health system have taken a position indicating higher mortality. Mexico showed the least positive assessment of treatable mortality from endocrine and metabolic diseases and economic outcomes compared to other countries with an insurance-based health system. In addition to this country, Colombia and Turkey also reported less positive outcomes. Special attention should also be paid to the United States, which, despite high levels of health expenditure and GDP, has not acquired such positive results in terms of treatable mortality as other developed Western countries. This could be due to the high

cost of health care in this country. In this comparative manner, the findings in this study are consistent with the findings of authors such as Pritchard et al. (59), who examined this issue in terms of specific mortality, but without taking into account the treatability of diseases. Regarding avoidable mortality, the findings agree with those of Kjellstrand et al. (58). The authors of both studies considered the health system of the United States to be the least efficient (58, 59). With a high level of health expenditure, more positive health outcomes could be expected. The serious situation in the United States is also underlined by the fact that some countries reported lower expenditure but achieved more positive health outcomes. All these findings confirm the fact that health is a source of comparative economic development in countries (2).

At this point, it is possible to highlight the results of the regression analysis, which revealed that the financing of health care represents one of the important tools for improving the health of the population. The findings indicated that if less positively evaluated countries in the cluster analysis increase their level of financing for health care, this could translate into lower treatable mortality and consequently higher economic prosperity. This could improve their position, and therefore it is possible to look at less positively evaluated countries as countries with great potential and opportunities for improvement. At the same time, other countries with a positive assessment can be an inspiration for these countries.

Policy Implications

A look at the problem in this study suggests that health expenditure is one of the important factors in the treatable mortality of both males and females, which supports the need to take this factor into account when developing strategic plans. The financing of health care is highlighted as key aspect in universal health coverage (24). Moreover, health care financing can be reflected in economic prosperity through health variability in the working age population, as treatable mortality is considered an economic burden. Although reducing treatable mortality is a great motivation for public health leaders to increase health care financing, the importance for economic prosperity may be a more compelling argument for government representatives. The considerations and recommendations from this study can be applied both in a tax-based health system and in an insurance-based health system, as each system should be able to be more efficient.

As there were clear differences in treatable mortality across OECD countries (41, 44), policy makers should also address the issue of closing this health gap. Differences in treatable mortality were also evident between population groups within one country, and in order to achieve comparable outcomes with other countries, an internal problem needs to be addressed first (60). It is very difficult to get closer to successful countries if there are obvious health disparities between geographical regions and provinces (61, 62). Each country is specific and this fact should be taken into account when formulating health policies. For instance, poverty is closely linked to treatable mortality (63, 64) and in this context it should be borne in mind that if the health system provides health care to populations with higher poverty and other socio-economic specificities, it may be reflected also in a greater need for financial resources in the system (20). Treatable mortality should be interpreted both as an indicator of health care quality and as a reflection of the unequal distribution of socio-economic resources (65). Both health systems examined in this study should increase efforts to enhance treatable survival. In order to increase the effectiveness of health systems, special emphasis should be placed on the development of rules, standards and regulations with a view to a more integrated and equitable implementation of health policies and financing (66). These efforts can also be economically beneficial, as the rate of associations between treatable mortality and economic prosperity has not been negligible, which has also been shown in the research of Alkire et al. (24). Thus, when creating public policies, it is appropriate to consider all the facts resulting from the presented study. However, it should be emphasized that financing is not the only important factor and other country-specific factors should be taken into account.

In view of the above-mentioned facts, international cooperation is needed to address global challenges in terms of treatable mortality and related economic risks. This cooperation would strengthen the global health system by improving collaboration and coordination across international organizations. This effort can fill gaps in knowledge with respect to treatable causes of death, research and development needs, financing models, and the social and economic impacts of potential threats. Also, this international response would provide high-level, evidence-based recommendations for managing the global risks associated with treatable mortality (67).

Strengths and Limitations

The study clarified the economic perspective of treatable mortality and its strength lies in a multi-level investigation. Thus, the study explained the associations between health care financing and treatable mortality, and, subsequently, the associations between treatable mortality and economic prosperity in a comprehensive data classification, which made it possible to avoid superficial findings. The analyzes respected specific diagnosis groups, gender differentiation and individual health systems and their results provided a deeper insight to the issue. Based on multidimensional research and multilevel classification, it was possible to answer the question of what strength of associations exists in individual health systems, individual diagnosis groups, and gender categories. The study also provided a comparison of countries and contributed to the creation of a valuable platform of evidence at national and international level. The results of this study were able to clarify the comprehensive view of the associations that existed in the scientific community. Last but not least, given the low availability of treatable mortality data in specific diagnosis groups in individual countries, it should be emphasized that the study contains the most up-to-date data on treatable mortality for up to 37 OECD countries.

This research did not avoid the limitations that could be addressed in future research. In this sense, it should be pointed out that the findings concern only OECD countries and cannot be generalized to less developed countries or countries with other

health systems. The unbalanced structure of the panel data is also a weakness of the research, but it should be noted that not every country reported the number of specific treatable deaths each year and the presented research covered the widest possible range of treatable mortality in 37 OECD countries. Limitations also include the fact that the results of a regression model other than the recommended one were taken into account. Nevertheless, a reliable model was chosen. Regarding the limitations of the models, it should be noted that the models used in this study did not examine causality as such, and therefore the results cannot be interpreted as causal relationships. All results can only be seen in terms of associations, while a consideration of causal relationships can be misleading. Last but not least, it must be emphasized that the financing of health care is not the only factor in the health of the population. Thus, the results should not be considered the only right pathway. Factors such as doctors' qualifications, their working conditions, equipment, access to medicines, or hospital management play an important role in treatable mortality. Future research should address them.

CONCLUSION

This study focuses on the associations between health care financing, specific treatable mortality of males and females of working age, and economic prosperity in the classification of health systems applied in OECD countries. The main aim was met by descriptive analysis, panel regression analysis, and cluster analysis. Based on the results, it was possible to answer the research questions in the affirmative. The treatable mortality was represented by two diagnosis groups, namely circulatory system diseases and endocrine, nutritional, and metabolic diseases. In addition to these diagnosis groups, the analyzes respected the specification of gender and health systems, which provided a deeper insight into the main findings. There were significant negative associations between health care financing and treatable mortality, as well as between treatable mortality and economic prosperity in both health systems. The study also provides an international comparison of OECD countries, on the basis of which less positive and more positive countries were identified. The main findings of the study supported the idea that the economic life of countries is linked to the health of the population. Healthy individuals are considered the driving force of the economy, but sick individuals represent a potential burden in times of disease and death. In any case, it should be borne in mind that investing in public health can translate into economic benefits, and therefore the financing of health care requires special attention. This is true, although it is not the only significant factor. Successful management of health systems requires an individualized approach to decision-making that takes into account proven evidence and implements it in procedures aimed at achieving health goals. This study would help policy makers to understand the nature of the problem from the presented perspective and to make the right decisions given the diversity of systems, population groups and other country specificities. The study supports the strengthening of health systems and offers a basis for further research and the creation of international databases of evidence.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. Data on health expenditure can be found in the OECD database: https://data.oecd.org/healthres/health-spending.htm#indicator-chart. Data on GDP can be found in the OECD database: https://data.oecd.org/gdp/gross-domestic-product-gdp.htm. Data on treatable mortality can be found in the WHO database: https://www.who.int/data/data-collection-tools/who-mortality-database?fbclid=IwAR2gVBBqbMEUf6Y1g505FjN_hg77TkINf_VWGO3-efYrTr-J9sC7_Wkpy7Q. Data on population can be found in the United Nations database: https://population.un.org/wup/.

ETHICS STATEMENT

Ethical approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

VI, BG, GS, and SK: conceptualization, investigation, visualization, and writing—review and editing. BG and SK: original draft preparation, supervision, project administration, and funding acquisition. VI: methodology, formal analysis, data curation, and original draft preparation. BG: resources. All authors contributed to manuscript revision, read, and approved the submitted version.

FUNDING

This research was funded by the Scientific Grant Agency of the Ministry of Education, Science, Research, and Sport of the Slovak Republic and the Slovak Academy Sciences and Quantification of Environmental Burden Impacts of the Slovak Regions on Health, Social and Economic System of the Slovak Republic as part of the research project VEGA 1/0797/20.

ACKNOWLEDGMENTS

The authors thank the journal editor and reviewers for their guidance and constructive suggestions.

REFERENCES

1. Boachie MK. Health and economic growth in Ghana: an empirical investigation. *Fudan J Hum Soc Sci.* (2017) 10:253–65. doi: 10.1007/s40647-016-0159-2
2. Gallardo-Albarrán D. Health and economic development since 1900. *Econ Hum Biol.* (2018) 31:228–37. doi: 10.1016/j.ehb.2018.08.009
3. Compah-Keyeke G, Gyimah Sackey FG, Azinim MA. Public expenditure and health status in Ghana. *J Econ Sustain Dev.* (2013) 4:88–99.
4. European Commission. *Commission Staff Working Document – Investing in Health*. (2013). Available online at: https://ec.europa.eu/health/sites/health/files/policies/docs/swd_investing_in_health.pdf (accessed: September 18, 2021)
5. Murphy KM, Topel RH. The value of health and longevity. *J Polit Econ.* (2006) 114:871–904. doi: 10.1086/508033
6. Mihalache IC. Health state of human capital in the economic theory. *Postmodern Openings.* (2019) 10:182–92. doi: 10.18662/po/102
7. Arthur E, Oaikhenan HE. The effects of health expenditure on health outcomes in Sub-Saharan Africa (SSA). *Afr Dev Rev.* (2017) 29:524–36. doi: 10.1111/1467-8268.12287
8. Bein MA, Unlucan D, Olowu G, Kalifa W. Healthcare spending and health outcomes: evidence from selected East African countries. *Afr Health Sci.* (2017) 17:247–54. doi: 10.4314/ahs.v17i1.30
9. Rahman MM, Khanam R, Rahman M. Health care expenditure and health outcome nexus: new evidence from the SAARC-ASEAN region. *Global Health.* (2018) 14:113. doi: 10.1186/s12992-018-0430-1
10. Novignon J, Olakojo SA, Nonvignon J. The effects of public and private health care expenditure on health status in sub-Saharan Africa: new evidence from panel data analysis. *Health Econ Rev.* (2012) 2:22. doi: 10.1186/2191-1991-2-22
11. Boachie MK, Ramu K, Põlajeva T. Public health expenditures and health outcomes: new evidence from Ghana. *Economies.* (2018) 6:58. doi: 10.3390/economies6040058
12. Toader E, Firtescu BN, Oprea F. Determinants of health status and public policies implications – lessons for Romania. *Transylv Rev Adm Sci.* (2017) 52e:128–147. doi: 10.24193/tras.52E.8
13. Reynolds MM, Avendano M. Social policy expenditures and life expectancy in high-income countries. *Am J Prev Med.* (2018) 54:72–9. doi: 10.1016/j.amepre.2017.09.001
14. van den Heuvel WJA, Olaroiu M. How important are health care expenditures for life expectancy? A comparative, European analysis. *J Am Med Dir Assoc.* (2017) 18:276.e9–276.e12. doi: 10.1016/j.jamda.2016.11.027
15. Ahmed S, Hasan MZ, MacLennan M, Dorin F, Ahmed MW, Hasan MM, et al. Measuring the efficiency of health systems in Asia: a data envelopment analysis. *BMJ Open.* (2019) 9:e022155. doi: 10.1136/bmjopen-2018-022155
16. van der Zee J, Kroneman MW. Bismarck or Beveridge: a beauty contest between dinosaurs. *BMC Health Serv Res.* (2007) 7:94. doi: 10.1186/1472-6963-7-94
17. Boisclair D, Décarie Y, Laliberté-Auger F, Michaud PC, Vincent C. The economic benefits of reducing cardiovascular disease mortality in Quebec, Canada. *PLoS ONE.* (2018) 13:e0190538. doi: 10.1371/journal.pone.0190538
18. Herzer D, Nagel K. The impact of adult and non-adult mortality on development: two centuries evidence from a panel of industrial countries. *J Policy Model.* (2019) 41:352–71. doi: 10.1016/j.jpolmod.2019.02.008
19. Kozlova OA, Nifantova RV, Makarova MN. Methods of the assessment of economic losses caused by the mortality of the population employed in regional economy. *Econ Reg.* (2017) 13:511–23. doi: 10.17059/2017-2-16
20. Allin S, Grignon M. Examining the role of amenable mortality as an indicator of health system effectiveness. *Healthc Policy.* (2014) 9:12–19. doi: 10.12927/hcpol.2014.23733
21. Gay J, et al. *Mortality amenable to health care in 31 OECD countries. Estimates and methodological issues. OECD Health Working Papers, No. 55. Paris: OECD Publishing*. (2011).
22. Nolte E, Mckee M. *Does Health Care Save Lives? Avoidable Mortality Revisited*. London: The Nuffield Trust (2004) 139 p.
23. Heijink R, Koolman X, Westert GP. Spending more money, saving more lives? The relationship between avoidable mortality and healthcare spending in 14 countries. *Eur J Health Econ.* (2013) 14:527–38. doi: 10.1007/s10198-012-0398-3
24. Alkire BC, Peters AW, Shrime MG, Meara JG. The economic consequences of mortality amenable to high-quality health care in low- and middle-income countries. *Health Aff.* (2018) 37:988–96. doi: 10.1377/hlthaff.2017.1233
25. OECD. *Gross Domestic Product (GDP)*. (2021). Available online at: https://data.oecd.org/gdp/gross-domestic-product-gdp.htm (accessed: September 18, 2021)
26. OECD. *Health Spending*. (2021). Available online at: https://data.oecd.org/healthres/health-spending.htm#indicator-chart (accessed: September 18, 2021)
27. WHO. *WHO Mortality Database*. (2021). Available online at: https://www.who.int/data/data-collection-tools/who-mortality-database?fbclid=IwAR2gVBBqbMEUf6Y1g505FjN_hg77TkINf_VWGO3-efYrTr-J9sC7_Wkpy7Q (accessed: September 18, 2021)
28. OECD/EUROSTAT. *Avoidable Mortality: OECD/Eurostat Lists of Preventable and Treatable Causes of Death (November 2019 version)*. (2019). Available online at: https://www.oecd.org/health/health-systems/Avoidable-mortality-2019-Joint-OECD-Eurostat-List-preventable-treatable-causes-of-death.pdf (accessed: September 18, 2021)
29. United Nations. *World Urbanization Prospects 2018*. (2018). Available online at: https://population.un.org/wup/ (accessed: September 18, 2021)
30. Børing P, Grøgaard JB. Do older employees have a lower individual productivity potential than younger employees? *Popul Ageing.* (2021). doi: 10.1007/s12062-020-09323-1. [Epub ahead of print].
31. Göbel C, Zwick T. Age and productivity: sector differences. *Economist.* (2012) 160:35–57. doi: 10.1007/s10645-011-9173-6
32. Skirbekk V. Age and productivity potential: a new approach based on ability levels and industry-wide task demand. *Popul Dev Rev.* (2008) 34:191–207.
33. Paris V, Devaux M, Wei L. *Health Systems Institutional Characteristics: A Survey of 29 OECD Countries*. OECD Health Working Papers, No. 50. Paris: OECD Publishing (2010).
34. OECD. *Health Systems Characteristics Survey*. (2016). Available online at: https://qdd.oecd.org/subject.aspx?Subject=hsc (accessed: October 18, 2021).
35. European Commission. *Country Health Profiles 2017*. (2017). Available online at: https://ec.europa.eu/health/state/country_profiles/2017_en (accessed: October 18, 2021).
36. OECD. *Country Health Profiles 2019*. (2019). Available online at: http://www.oecd.org/health/health-systems/country-health-profiles-EU.htm (accessed: October 18, 2021)
37. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. *Multivariate Data Analysis*. Upper Saddle River: Pearson Education Limited (2013).
38. Arellano M. Computing robust standard errors for within-groups estimators. *Oxf Bull Econ Stat.* (1987) 49:431–4. doi: 10.1111/j.1468-0084.1987.mp49004006.x
39. Kassambara A. *Practical Guide to Cluster Analysis in R: Unsupervised Machine Learning*. STHDA (2017) 188 p.
40. Schubert E, Rousseeuw, PJ. Faster k-medoids clustering: improving the PAM, CLARA, and CLARANS algorithms. In: Amato G. Gennaro C, Oria V, Radovanović M, editor. *Similarity Search and Applications. Lecture Notes in Computer Science*. Cham: Springer (2019). p. 171–87. doi: 10.1007/978-3-030-32047-8_16
41. Jarčuška P, Janičko M, Barták M, Gavurová B, Vagašová T. Mortality amenable to health care in European Union countries and its limitations. *Cent Eur J Public Health.* (2017) 25:S16–22. doi: 10.21101/cejph.a4956
42. WHO. *The Top 10 Causes of Death*. (2020). Available online at: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death?fbclid=IwAR0YjwTN7XSalNlUxxXzoXJHOHeJkSqbt934wZ7MZxMPhnf3dLHiStEPT_Q (accessed: September 18, 2021)
43. Dagenais GR, Leong DP, Rangarajan S, Lanas F, Lopez-Jaramillo P, Gupta R, et al. Variations in common diseases, hospital admissions, and deaths in middle-aged adults in 21 countries from five continents (PURE): a prospective cohort study. *Lancet.* (2020) 395:785–94. doi: 10.1016/S0140-6736(19)32007-0
44. Karanikolos M, Mackenbach JP, Nolte E, Stuckler D, McKee M. Amenable mortality in the EU-has the crisis changed its course? *Eur J Public Health.* (2018) 28:864–9. doi: 10.1093/eurpub/cky116
45. Nolasco A, Pereyra-Zamora P, Sanchis-Matea E, Tamayo-Fonseca N, Caballero P, Melchor I, et al. Economic crisis and amenable mortality in Spain. *Int J Environ Res Public Health.* (2018) 15:2298. doi: 10.3390/ijerph15102298

46. Nolte E, McKee M. Variations in amenable mortality–trends in 16 high-income nations. *Health Policy.* (2011) 103:47–52. doi: 10.1016/j.healthpol.2011.08.002
47. Weber A, Clerc M. Deaths amenable to health care: converging trends in the EU? *Health Policy.* (2017) 121:644–52. doi: 10.1016/j.healthpol.2017.03.017
48. Oksuzyan A, Juel K, Vaupel JW, Christensen K. Men: good health and high mortality. Sex differences in health and aging. *Aging Clin Exp Res.* (2008) 20:91–102. doi: 10.1007/BF03324754
49. Ross CE, Masters RK, Hummer RA. Education and the gender gaps in health and mortality. *Demography.* (2012) 49:1157–83. doi: 10.1007/s13524-012-0130-z
50. Singh-Manoux A, Guéguen A, Ferrie J, Shipley M, Martikainen P, Bonenfant S, et al. Gender differences in the association between morbidity and mortality among middle-aged men and women. *Am J Public Health.* (2008) 98:2251–7. doi: 10.2105/AJPH.2006.107912
51. Le Y, Ren J, Shen J, Li T, Zhang CF. The changing gender differences in life expectancy in Chinese cities 2005–2010. *PloS ONE.* (2015) 10:e0123320. doi: 10.1371/journal.pone.0123320
52. Westerling R. Decreasing gender differences in "avoidable" mortality in Sweden. *Scand J Public Health.* (2003) 31:342–9. doi: 10.1177/1403948030310050201
53. Sundmacher L. Trends and levels of avoidable mortality among districts: "healthy" benchmarking in Germany. *Health Policy.* (2013) 109:281–9. doi: 10.1016/j.healthpol.2012.07.003
54. de Abreu DM, César CC, França EB. Gender differences in avoidable mortality in Brazil (1983–2005). *Cad Saude Publica.* (2009) 25:2672–82. doi: 10.1590/S0102-311X2009001200014
55. Lefèvre H, Jougla E, Pavillon G, Le Toullec A. Gender differences in premature mortality and avoidable deaths. *Rev Epidemiol Sante Publique.* (2004) 52:317–31. doi: 10.1016/S0398-7620(04)99061-X
56. Budhdeo S, Watkins J, Atun R, Williams C, Zeltner T, Maruthappu M. Changes in government spending on healthcare and population mortality in the European union, 1995–2010: a cross-sectional ecological study. *J R Soc Med.* (2015) 108:490–8. doi: 10.1177/0141076815600907
57. Golinelli D, Bucci A, Toscano F, Filicori F, Fantini MP. Real and predicted mortality under health spending constraints in Italy: a time trend analysis through artificial neural networks. *BMC Health Serv Res.* (2018) 18:671. doi: 10.1186/s12913-018-3473-3
58. Kjellstrand CM, Kovithavongs C, Szabo E. On the success, cost and efficiency of modern medicine: an international comparison. *J Intern Med.* (1998) 243:3–14. doi: 10.1046/j.1365-2796.1998.00248.x
59. Pritchard C, Porters S, Rosenorn-Lanng E, Williams R. Mortality in the USA, the UK and other Western countries, 1989–2015: what is wrong with the US? *Int J Health Serv.* (2021) 51:59–66. doi: 10.1177/0020731420965130
60. Gavurova B, Toth P, Ciutiene R, Tarhanicova M. The impact of healthcare availability on the amenable mortality: country study. *Econ Sociol.* (2019) 12:236–50. doi: 10.14254/2071-789X.2019/12-3/16
61. Neethling I, Groenewald P, Schneider H, Bradshaw D. Trends and inequities in amenable mortality between 1997 and 2012 in South Africa. *S Afr Med J.* (2019) 109:597–604. doi: 10.7196/SAMJ.2019.v109i8.13796
62. Pereyra-Zamora P, Copete JM, Oliva-Arocas A, Caballero P, Moncho J, Vergara-Hernández C, et al. Changes in socioeconomic inequalities in amenable mortality after the economic crisis in cities of the Spanish Mediterranean coast. *Int J Environ Res Public Health.* (2020) 17:6489. doi: 10.3390/ijerph17186489
63. Costa C, Santana P. Gender and age differences in socio-economic inequalities in total and avoidable mortality in Portugal: a trend analysis. *Fisc Stud.* (2021) 42:123–45. doi: 10.1111/1475-5890.12264
64. Costa C, Freitas A, Almendra R, Santana P. The association between material deprivation and avoidable mortality in Lisbon, Portugal. *Int J Environ Res Public Health.* (2020) 17:8517. doi: 10.3390/ijerph17228517
65. McMinn MA, Seaman R, Dundas R, Pell JP, Leyland AH. Socio-economic inequalities in rates of amenable mortality in Scotland: analyses of the fundamental causes using the Scottish Longitudinal Study, 1991-2010. *Popul Space Place.* (2020). doi: 10.1002/psp.2385. [Epub ahead of print].
66. Unger JP, Morales I, De Paepe P. Objectives, methods, and results in critical health systems and policy research: evaluating the healthcare market. *BMC Health Serv Res.* (2020) 20:1072. doi: 10.1186/s12913-020-05889-w
67. Bloom DE, Cadarette D. Infectious disease threats in the twenty-first century: strengthening the global response. *Front Immunol.* (2019) 10:549. doi: 10.3389/fimmu.2019.00549

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 23 December 2021
doi: 10.3389/fpubh.2021.732061

Breastfeeding Support Rooms and Their Contribution to Sustainable Development Goals: A Qualitative Study

Carolina Belomo De Souza[1], Sonia Isoyama Venancio[2] and Regina Paula Guimarães Vieira Cavalcante da Silva[1]*

[1] Department of Pediatrics, Federal University of Paraná, Curitiba, Brazil, [2] Health Institute, Secretariat of Health of São Paulo, São Paulo, Brazil

Objectives: Breastfeeding support rooms are low-cost interventions that may prolong breastfeeding and improve work performance. Thus, we sought to understand the experiences and perceptions of working women who use breastfeeding support rooms and the potential contribution to sustainable development goals.

Methods: Descriptive and exploratory research was conducted through convenience sampling of women working in companies with breastfeeding support rooms in the state of Paraná, Brazil. A semi-structured questionnaire was applied through interviews and online self-completion.

Results: Fifty-three women between 28 and 41 years old participated in the study. In addition, 88.7% had graduated from college, and 96% were married. From the women's experiences and perceptions, we identified that breastfeeding support rooms contribute to prolonged breastfeeding, improve physical and emotional well-being, allow women to exercise their professional activities comfortably, contribute to women's professional appreciation for the excellent relationship between employees and employers.

Conclusion: In this novel study, we demonstrate how, from a female point of view, breastfeeding support rooms can contribute to 8 of the 17 sustainable development goals and should therefore be encouraged and promoted.

Keywords: breastfeeding, breastfeeding support, breastfeeding promotion, breastfeeding policies, lactation workplace programs, program evaluation, sustainable development, sustainable development goals

OPEN ACCESS

Edited by:
Angela Giusti,
National Institute of Health (ISS), Italy

Reviewed by:
Francesca Zambri,
National Institute of Health (ISS), Italy
Sofia Colaceci,
Saint Camillus International University of Health and Medical Sciences, Italy

****Correspondence:***
Carolina Belomo De Souza
belomo.carolina@gmail.com

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

Received: *28 June 2021*
Accepted: *29 November 2021*
Published: *23 December 2021*

Citation:
De Souza CB, Venancio SI and da Silva RPGVC (2021) Breastfeeding Support Rooms and Their Contribution to Sustainable Development Goals: A Qualitative Study. Front. Public Health 9:732061. doi: 10.3389/fpubh.2021.732061

INTRODUCTION

Raising breastfeeding indicators is an international priority (1). The proven benefits to maternal and child health are indisputable, as the practice of breastfeeding affects the lives and health of women and children and contributes to the development of human capital (2, 3). Moreover, the benefits extend to low, middle, and high-income countries (3).

The relationship between the promotion, protection, and support of breastfeeding and its contribution to the achievement of several Sustainable Development Goals (SDG) is already established, although breastfeeding is not explicitly embedded in the SDG (2, 3). The SDG corresponds to 17 global goals defined in 2015 at the United Nations General Assembly, under A/RES/70/1: Transforming our World: the 2030 Agenda for Sustainable Development (4, 5).

Lack of breastfeeding support, especially in the workplace, discourages women from maintaining breastfeeding (3, 6). Women have been increasingly joining the workforce and the period after the return from maternity leave represents one of the main challenges for continued breastfeeding (7, 8).

International measures to support breastfeeding in the workplace advise that countries respect the minimum standards set by the International Labor Organization (ILO) in conventions No. 183 and No. 191 to ensure maternity and work protection, including requiring maternity leave of at least 14 weeks and breastfeeding breaks during the workday (9).

In Brazil, the Working Women who Breastfeed (*Mulher Trabalhadora que Amamenta*–MTA) action was created in 2010 by the Ministry of Health to bring together strategies to support breastfeeding at work. Later, in 2015, MTA was added to the Breastfeeding and Complementary Foods axis of the National Policy on Integral Attention to the Child's Health (Pnaisc) (10). MTA has three axes: (1) incentive to the optional extension of maternity leave, which is currently 120 days, to 180 days, (2) the right to daycare or a daycare voucher, which is mandatory for all companies with more than 30 women above the age of 16, and (3) the right to two breastfeeding breaks, which are mandatory for all companies until the child is 6 months old, and the incentive to the implement breastfeeding support rooms (BSRs), which is optional for all companies.

The BSRs and breaks to breastfeed or pump breast milk during the workday are low-cost measures that can reduce absenteeism, improve employee performance, commitment, and retention, and reduce barriers for employees who breastfeed (3).

In addition, BSRs and breastfeeding breaks in the workplace can increase a woman's intention to continue breastfeeding after maternity leave (11) and may increase the chances of breastfeeding for 6 months by 25% (3, 12). As a result, BSRs lead to an increase in the rates of both exclusive and continued breastfeeding (13–16) and can contribute to achieving the global goals set by the World Health Organization and United Nations Children's Fund for 2030, which establish the global target of exclusive breastfeeding for 70% of infants <6 months of age, 80% of infants <12 months old, and 60% of infants under 2 years old (1).

To the best of our knowledge, there are no studies investigating BSRs from a user's point of view, nor how BSRs contribute to achieving goals established by the SDG for 2030. Thus, this study aims to understand the perceptions and experiences of female employees who use BSRs and relate these perceptions to the potential achievement of the international goals set for 2030 to raise breastfeeding rates and achieve the SDG. This study is part of doctoral research that evaluated BSRs in southern Brazil.

METHODS

Design

This is exploratory, descriptive, and qualitative research. It was conducted between December 2019 and December 2020 but interrupted for 3 months and adjusted due to the global COVID-19 pandemic.

TABLE 1 | Information collected from women who used Breastfeeding Support Rooms ($N = 53$) Paraná, Brazil, 2019–2020.

Collected information	Questions
Profile of women who used BSRs	• How old are you? • What is your marital status? (married, common law marriage, single, divorced, or widowed) • What is your highest level of education? (incomplete/complete primary education; incomplete/complete secondary education; incomplete/complete undergraduate or graduate education) • How long have you worked for this company? • What position do you currently hold at the company? • How much time do you work per week? • Did you have 180 days of maternity leave? (Yes or No)
Experiences and opinion about BSRs	• How was your experience using your company's breastfeeding support room? • What is your opinion about the breastfeeding support room in companies?

Sampling

The study selected participants *via* convenience sampling, usual for pilot studies, from a population of 130 female employees who used BSRs after returning to work. In addition, we selected female employees from eight companies in the state of Paraná, in southern Brazil, one of the most developed regions of the country, that implemented BSRs and whose BSR was certified by the Ministry of Health until December 2017, which correspond to 88.9% of companies with active BSR in the state.

All women on maternity leave in the year before the beginning of the study and who used the BSR in their companies were eligible for the study. However, we excluded female employees from companies whose BSR had not been used in the 6 months before the start of the study.

Data Collection

The data were collected using a semi-structured questionnaire divided into two parts: (1) the profile of the women who used the BSR: time of employment at the company, position held, weekly working hours; marital status (married, common law, single, divorced, or widowed), education (incomplete/complete primary education, incomplete/complete secondary education, incomplete/complete undergraduate, or graduate education), age, and whether they had a 180-day maternity leave (yes/no), and (2) open questions about their experiences with BSRs: what it was like to use them and their opinion of BSRs in the companies, as seen in **Table 1**.

The study began with the application of the questionnaire through in-person interviews conducted within company BSRs. However, at the beginning of the data collection stage, due to the COVID-19 pandemic, we decided to interrupt the research and reflect on alternative approaches. Therefore, we requested the Ethics Committee to include data collected through online self-completion questionnaires (Google Forms), including a consent form. The companies participating in

the study sent invitations to their female employees, both for the interviews, announcing the date and time that the researcher (first author) would be conducting the interviews and the online self-completion questionnaire submitted within 60 days. The in-person interviews were audio-recorded and transcribed word-for-word. The answers obtained through the online questionnaire were used precisely as they were recorded in the answer sheet.

Data Analysis

The Statistic 10.0 (StatsoftR) program was used for the sample description, and the variables studied were expressed in absolute and relative frequencies.

Qualitative analysis was carried out by the thematic categorical content analysis, following three steps (17): (1) material organization, (2) coding, and (3) result interpretation. From the categories or themes found, we deductively sought to identify their relationship with the SDG. The data were analyzed using the Atlas.ti version 9.0 software (18), which contributed to the data management.

For this study, the criteria proposed by the Journal Article Reporting Standards [American Psychological Association (19)] for qualitative research were respected.

RESULTS

Sample Characteristics

The study included 53 women, 40.8% of BSR users in Paraná. Of these, 8 (15%) female workers participated by semi-structured interview, and 45 (85%) answered an online self-completion questionnaire.

All-female employees included in this study were between 28 and 41 years old. Thirty (72%) women were between 31 and 40 years old, 47 (88.7%) had graduated college, 51 (96%) were married or living in a common-law marriage. Eleven (21%) women have worked for their company from 1 to 5 years and 42 (79%) for 6 years or more. Most of the participants, 43 (81%), had a 40–44 h weekly workday. The types of positions held by the female employees are available in **Table 2**. In addition, all women (100%) had 180 days of maternity leave.

TABLE 2 | Positions occupied by women who used breastfeeding support rooms ($n = 53$), Brazil, 2019–2020.

Categories-*N* (%)	Types of positions	*N* (%)
Administrative-24 (45.2%)	Assistants	2 (3.77%)
	Technicians	6 (11.32%)
	Analysts	12 (22.64%)
	Consultants	2 (3.77%)
	Specialists	2 (3.77%)
Management-6 (11.3%)	Managers	4 (7.54%)
	Coordinators	2 (3.77%)
Health-related-5 (9.5%)	Nurses	3 (5.66%)
	Nutritionists	1 (1.88%)
	Biologists	1 (1.88%)
Customer service-8 (15%)	Call center operators	8 (15.09%)
Research-1 (2%)	Researchers	1 (1.88%)
Operations-9 (17%)	Engineers	4 (7.54%)
	Logistics Planners	1 (1.88%)
	Assemblers	1 (1.88%)
	Laboratory and civil engineering technicians	2 (3.77%)
	Technologists	1 (1.88%)

Experiences With BSR Use

We consider that all the experiences with BSRs were positive. From the participating reports, we identified that the experience categories are related to the fact that the BSRs: (1) allows for breastfeeding continuity, (2) contributes to the bonding and well-being of the child, (3) provides comfort and emotional well-being for the woman, (4) provides comfort and physical well-being for the woman, (5) is related to the adequate, quiet place with all the necessary infrastructure for breastfeeding, and (6) allows women to donate breast milk to a milk bank, as seen in **Table 3**.

However, we identified some difficulties regarding room usage, although they were not indicated as negative by women, such as: (1) distance from the rooms to the workplace, and (2) need to stop using the rooms due to the child's age (**Table 3**).

Women's Perception of BSR

The female participants had positive opinions about the BSRs about (1) the importance of the rooms for different purposes, (2) the respect of working women, and (3) the atmosphere (physical structure and equipment). On the other hand, the negative perceptions are related to (1) little use, (2) the small amount of BSRs implemented by companies, and (3) the need to reinforce this action. The thematic analysis is available in **Table 4**.

Relationship Between the Use and Perceptions About the BSRs and the 2030 Goals to Increase Breastfeeding Rates Worldwide and Achieve SDG

From the codings and themes resulting from the experiences using the BSRs and the opinions of women who use BSRs, we were able to establish the positive relationship between the BSRs and the international goals to raise breastfeeding indicators worldwide, and to several of the SDG.

We observe a strong relationship between BSRs and SDG 8, particularly regarding decent work and economic growth, as breastfeeding in the workplace can promote decent work, women's productivity and contribute to economic growth.

In **Table 3**, some reports show that BSRs provide comfort, physical, and emotional well-being for women to perform their activities, with comments such as "It was wonderful, I felt welcomed, safe, cared for, very calm" (M23); "[...] A major benefit was being able to pump milk and avoid mastitis, which happened when I had my first daughter, precisely because I had no way to pump milk." (M15); and "[...] The room was essential. [...] Also, to relieve any discomfort throughout the day." (M29). In **Table 4**, we can see how the BSR contributes to a good

TABLE 3 | Experiences with breastfeeding support rooms among women ($n = 53$), Brazil, 2019–2020.

Categories	Quotes
Positive points	
Allows continuity of breastfeeding	"[...] it enabled me to continue breastfeeding in my return to work at such a delicate and special moment in my life. [...]" (M3); "[...] helped me maintain breastfeeding without having to introduce formula." (M9); "Great experience. I used up my milk at lunchtime, so I was able to guarantee my babies would drink breast milk for a longer period" (M25); "The room enabled me to continue breastfeeding, and I did not have to introduce formulas to them. [...]. Essential to maintain milk production and ensure milk when I was absent" (M29); "Very important to continue breastfeeding my daughter [...]" (M41); "Very positive, because of it, I can allow my child to exclusively breastfeeding" (M47);
Contributes to the mother-child bond and well-being	"It was extremely important to my son's well-being [...]" (M1); "It was extremely important to extend the mother and child bond" (M4);
Provides comfort and emotional well-being for the woman	"I felt welcomed by having a space prepared [...]" (M3); "Very rewarding, my daughter did not consume any other milk/formula, only breast milk. [...]" (M17); "Wonderful, I felt safe, happy [...]" (M20); "I felt respected because after returning to my job, I was able to pump and feed it to the baby later and for the comfort during the working time" (M21); "It was wonderful, I felt welcomed, safe, cared for. Very calm" (M23); "Wonderful. It brought me peace to be able to continue breastfeeding my son. [...]" (M27);
Comfort and physical well-being for women	"It was a relief. When my first daughter was born, I suffered so much, physically and psychologically, because I had recurrent mastitis and had no place or time to pump for relief. It was depressing. This time the much-requested room was available [...]." (M8); "[...] A major benefit was being able to pump milk and avoid mastitis, which happened when I had my first daughter, precisely because I had no way to pump milk." (M15); "Comfortably pumping milk and having a place to store it was fundamental to keep breastfeeding painlessly" (M18); "[...] I was relieved of swollen breast pain, especially by 4 pm." (M27); "[...] The room was essential. [...] Also, to relieve any discomfort throughout the day." (M29); "Great! I overproduced milk, so I needed to pump, and having a proper environment made all the difference." (M40);
Related to the proper quiet location and with all the necessary infrastructure	"[...] It is evident that every detail in this space has been thought out with great care. I am so thankful for it." (M3); " Wonderful. I had a quiet and private place where I could pump milk [...]." (M9); "I had everything I needed. I wish I had used it longer." (M14); "It was a very good, quiet, appropriate location. Good to have a place to store. [...]" (M15); "[...] it was a comfortable and safe place where I could pump and freeze milk for my child every day. [...]" (M41); "[...]. The option to have a suitable and private place, quiet, makes the moment more appropriate to pump milk." (M51);
Allowed donation to the Human Milk Bank	"[...] I even managed to donate to the milk bank for over a year." (M8); "[...]. For some time, I was able to donate breast milk" (M17); "[...] besides easing the process of donation to the milk bank" (M16); "[...] in addition to allowing me to donate milk" (M33);
Positive unspecified experiences	*"Very important" (M2);* "great" (M22); "Very good" (M26); "Great! Essential!" (M31); "It was great." (M34); "Very good" (M47);
Difficulties encountered	
Distance from rooms	"[...]The only difficulty is that in the branch I worked [...] the breastfeeding room was a 10-min walk from the place where I worked, adding up the time pumping, I ended up staying too long in there, plus the time to return to my workplace. Even though I was a manager, I was still embarrassed." (M11);
Need to stop using the rooms due to the age of the child.	"Using the room was great, but due to company policy, I only had the right to be off work in the first month [...]. I came back from maternity leave, plus vacation time, and my daughter was 7 months old, so by 8 months, I was forced to introduce formula (Suggestion: we should be free to use the room for as long as necessary for other activities... such as for example, a medical examination to ensure that breastfeeding resumes." (M49).

relationship between employees and employers. Once women recognize the importance of the BSRs for the full realization of their professional activities, they realize that BSRs contribute to the appreciation of the women in the workforce since they feel happy and valued professionally: "[...] And a satisfied employee with her needs well-met is more productive at work" (M27) and "[...] and also for performing their job activities smoothly" (M41).

In addition, the discourse surrounding women points to an appreciation of the differential that the company provides for them. Women recognize and value a company that meets their needs as a woman, as a mother, and as a professional: "[...] it is a way for the company to demonstrate that it cares about women and to promote the well-being and health of mothers and children" (M3), and "It makes a difference for women who live in a conflict between their family and work life. The company has a saying: We support you at this moment, everything is fine" (M7).

We observed a potential relationship between BSR availability in work environments and the achievement of SDG 5 concerning gender equality. As observed in **Tables 3**, **4**, BSRs contribute to women having the opportunity to perform their professional activities just as well as men, without physical or emotional stress, feeling valued and recognized professionally.

We can also see indirect relationships between BSRs and the achievement of six other SDGs from the increase in breastfeeding rates, which positively impact the achievement of the following SDG: (1) end poverty (SDG 1): breastfeeding contributes to higher financial income for breastfed adults, (2) zero hunger (SDG 2): breastfeeding reduces hunger and malnutrition, promoting total child growth, and development in the early years of life, (3) good health and well-being (SDG 3): breastfeeding improves the physical and mental health, and well-being of mothers and children, (4) quality education (SDG 4): breastfeeding contributes to an increase in intelligence quotient.

TABLE 4 | Perceptions of female employees about breastfeeding support rooms ($n = 53$), Brazil, 2019–2020.

Perceptions	Quotes
Positive	
Importance of BSRs	"I consider it extremely important with immeasurable repercussions [...]" (M3); "extremely essential" (M4); "It is indispensable [...]" (M8); "They are essential" (M11); "fundamental for those who want to breastfeed" (M18); "There's nothing better, super necessary" (M23); Necessary. Indispensable [...] improves the quality of life of the whole family because if the mother is well, the family will also be" (M26);
Importance of BSRs for women	"Essential for working mothers who are aware of the importance of breast milk." [...] (M1); "Necessary for mothers who breastfeed, regardless of how long." (M10); "A space necessary so that mothers do not have to be exposed or go through constraints when feeding their children. [...] (M17); "It is fundamental to our process [...] (M20) "It is a fundamental support for mothers who want and/or must breastfeed" (M29); "A standout for us mothers" (M32);
Importance of BSRs for the child	"[...] These rooms are essential for the babies' development [...] (M1); "[...] the Ministry of Health proves that breastfeeding contributes to the child's health" (M3); "It is beneficial for mothers and especially for babies who will continue to be breastfed longer" (M24);
Importance of BSRs for breastfeeding	"Essential to encourage exclusive breastfeeding" (M2); [...] Makes a lot of difference in support for breastfeeding" (M12); "encourages breastfeeding and that women breastfeed longer" (M19); "Helps in the process of continuity of breastfeeding and donation of breast milk" (M21); "[...] is essential for the continuity of breastfeeding [...] (M41); "[...] a unique space that contributes to increasing breastfeeding time" (M47);
Importance of BSRs for job performance	"[...] And a satisfied employee with her needs well-met is more productive at work" (M27); "[...] and also for the comfortable performance of their job activities" (M41);
Appreciation of the woman employee	"[...] it is a way for the company to demonstrate that it cares about women and to promote the well-being and health of mothers and children" (M3); "It makes a difference for women who live in conflict between their family l and work life. The company that has one is saying: We support you at this moment, everything is fine" (M7); "Represents the appreciation of the working woman, providing due support in such a difficult moment of returning from family leave and being apart from the baby" (M16); "[...] It demonstrates respect, attention, and care for their employees" (M17); "It is sensational, having an exclusive place for moms to take fresh milk to their child [...] five-star company" (M22);
Ambiance	"Excellent, it has everything necessary" (M5); "Very cozy and quiet room" (M9); "It is comfortable, safe, hygienic and private for the mother" (M30); "The environment makes us well at ease, it is clean and cozy, with a fridge and freezer, hot water in the sink, alcohol, and tissue" (M43); "the environment is very good, clean, calm, totally adequate" (M44); "It is a reserved, clean place, with the necessary appliances (refrigerator, couch, sink, etc.) that makes the woman feel at ease" (M46);
Negative	
Little use	*"It's super interesting. But in practice, it only worked for me [...]" (M14); "[...] but since the room administrator had left the company, the place was a little neglected,one of the faucets didn't work, for example, and it was not cleaned often. But there was a refrigerator, a couch and a key. With this, I realized that few mothers used the room, I think it is a cultural issue and also more difficult for the mothers of the operational team" (M45);*
Little existence	*"There is almost no such space" (M48);*
Need for reinforcement	*"[...] I believe that the importance is even greater for companies that grant only 4 months of maternity leave" (M1); "all companies should have [...] (M12); "indispensable, every company should have" (M13); "I think it should remain and be further developed. With clear policies regarding use that aim to help mothers and families maintain breastfeeding" (M49); "all companies should have one to encourage mothers to continue breastfeeding after returning to work" (M42)*

Breastfed children for longer participate in more educational activities, (5) reducing inequalities (SDG 10): breastfeeding provides the best start in life. With the increase in breastfeeding rates, there is a decrease in infant morbidity and mortality, an increase in physical and emotional well-being, in income when adult, thus reducing social inequalities throughout generations, (6) climate action (SDG 13): breastfeeding is sustainable and does not harm the environment, unlike baby formulas that can contribute to the greenhouse effect and waste generation, and should only be used when necessary. This relationship can be seen in **Table 5**.

DISCUSSION

From the reports of formal female workers, we identified how their experiences using BSRs, their perceptions and opinions on the BSR strategy, and the support for breastfeeding at work as a result of implementing BSRs, can contribute directly to SDG 8 and SDG 5 and consequently lead to six other SDGs as the time women continue breastfeeding increases. Although there are studies that investigate BSRs, we could not find studies with this focus. Our sample corresponded to a little more than 40% of active BSR users in the state of Paraná, which we consider an acceptable standard for studies with self-completion questionnaires.

Most women were middle-aged, between 31 and 40 years old, married or living in a common-law marriage. Regarding the positions occupied by women at work, we observed that most were placed in administrative functions. According to Dagher et al. (7), women who work in an office have a higher chance of initiating breastfeeding. In addition, research shows that the sociodemographic conditions of women in southern Brazil are favorable for exclusive breastfeeding but that it is a challenge to keep breastfeeding for more than 12 months (20).

TABLE 5 | Relationship between Breastfeeding Support Rooms and their contribution to achieving Sustainable Development Goals, Brazil, 2019–2020.

		Relationship with the SDG		SDG directly and indirectly affected by BSRs
	→	BSRs have a strong relationship with SDG	→	SDG 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all
				SDG 5: Achieve gender equality and empower all women and girls
Breastfeeding Support Rooms	→	BSRs contribute to raising the rates of breastfeeding, which has a potential relationship with the SDG	→	SDG 1: End poverty in all its forms everywhere
				SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
				SDG 3: Ensure healthy lives and promote well-being for all of all ages
				SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
				SDG 10: Reduce inequality within and among countries
				SDG 13: Take urgent action to combat climate change and its impacts

The implementation of policies to promote, protect and support breastfeeding has the potential to reinforce breastfeeding in general, including breastfeeding in the work environment and BSR, in addition to contributing to SDG 17 on global partnerships and joint action between governments and civil society.

Most of the women in our study had graduated college, worked up to 8 h a day, and were encouraged by the company and their superiors to take breaks to pump breast milk. These findings corroborate with Tsai (21) in a study conducted in Taiwan with 715 female employees.

We know that the high level of education can be a favorable factor for breastfeeding [Tsai (20, 21)], thus contributing to women having more positive perceptions about the actions that contribute to the maintenance of breastfeeding, including the BSRs. We emphasize, however, that only 6 (11.3%) of the women held higher management positions, and it was unanimous for all users, even female workers, and assistants, to be satisfied with being able to use SAA in the workplace. Furthermore, in our study, 100% of the women had a late return to work after the 180-day maternity leave, and it is common for workers to extend this period with 30 vacation days, resulting in a return to work of around 7 months after the baby is already on complementary feeding. In addition, most women also had the privilege of using BSRs even after the time established in the labor legislation of breaks up to 6 months. We believe that this was due to employers becoming more aware of the importance of breastfeeding.

The Citizen Company (Empresa Cidadã) program, instituted in 2008 by Law 11.770 (22), is aimed at the optional extension of maternity leave from 120 to 180 days through the concession of a tax incentive. The extension of maternity leave is an achievement that has ensured progress for public policies in support of early childhood in Brazil. Six-month maternity leave is associated with an increased prevalence of exclusive breastfeeding (8). All the companies participating in this study have adopted a 180-day maternity leave, and most have also adopted a 20-day paternity leave.

Most of the women had worked for a long time in the company. From their accounts, as seen in **Table 4**, we found that employees perceive that the company, upon implementing BSRs, values their work and provides conditions for a good work performance, contributing strongly to the achievement of SDG 8 and 5. This relationship between BSRs and SDG 8 and 5 was more specifically about promoting decent work, allowing women to find physical and emotional comfort that enables them to be more relaxed, and willing to perform their professional activities on equal grounds.

We noticed that the BSRs contribute to the appreciation of female employees. For example, women reported feeling happy and valued professionally for having rooms available since they feel that the company supports them in their needs. In addition, we found that female employees recognize the company's advantage, which is related to an increase in satisfaction and contentment concerning the company they work for, as observed in some reports in **Table 4**.

This finding corroborates the assertion of Rollins et al. (3) that BSRs can reduce absenteeism, improve work performance, engagement, and workforce retention. We understand that BSRs have a great potential to reduce barriers to continued breastfeeding among working women, promote decent work, which concerns SDG 8, and are a low-cost investment that employers could easily implement.

By allowing women to alleviate their physical discomfort during the workday and find emotional well-being and comfort, the relationship between BSRs and gender equality merges with the relationship between BSRs and decent work. When women can use the BSRs, the environment is considered safe and comfortable. In addition, they have emotional comfort because the woman knows that her child will safely drink her milk stored in an appropriate place during her professional activities and avoid using baby formula. Therefore, women can dedicate themselves to their professional activities more efficiently, allowing for equal working conditions as men, who do not have such concerns. However, to the best of our knowledge, no studies support our findings regarding how BSRs could contribute to gender equality related to SDG 5, seeing as this field is still little explored. Therefore, we highlight the need for further studies on this topic.

In **Tables 3**, **4**, we can see that women relate the importance of the SAA with the maintenance and continuity of breastfeeding.

Moreover, several authors corroborate the relationship between BSRs and increased breastfeeding rates (3, 12–16).

We consider that increasing breastfeeding rates has the potential to positively impact at least six of the SDGs, like Victora et al. (2), who relate the promotion of breastfeeding to several SDGs.

There is a relationship between breastfeeding and reducing poverty and increasing human capital, which, in turn, can also reduce social inequalities. According to Victora et al. (23), breastfeeding improves human capital and significantly affects adult education and income. Breastfed children have better intellectual development for a more extended period (average increase of 3 IQ points). As a result, they can show positive results in school performance and a higher income in the long term. These findings relate to SDGs 1, 4, and 10.

The relationship between breastfeeding, maternal, and child health, included in SDG 3, is supported by several authors. Breastfeeding benefits both children's (2, 3, 23, 24) and women's health (2, 3, 25) and strengthens the emotional bond between the mother and baby. Breastfeeding reduces infant deaths (2, 6, 24, 26, 27) and can prevent 13% of worldwide deaths in children under 5 years of age (6, 26). Extending breastfeeding to an almost universal level could prevent 823,000 annual deaths of children under 5 and 20,000 annual deaths from breast cancer (2).

Breastfeeding ensures food and nutritional security and promotes total growth and development for children. Breastfeeding is a child's first protection against hunger, malnutrition, illnesses, and is also their most lasting investment in physical, cognitive, and social aspects (24) related to SDG 2.

According to the women, BSRs are essential because they can avoid using baby formulas, as seen in **Tables 3**, **4**. This fact can be related to the achievement of SDG 13, which concerns reducing the impacts of climate change. In addition, breastfeeding is sustainable and does not harm the environment, unlike baby formulas, which contribute to the greenhouse effect and waste generation, and thus, should only be used when necessary. According to Rollins et al. (3), breastfeeding has economic and environmental benefits.

Managers have a critical role in the success of breastfeeding for working women (28). We know that lack of breastfeeding support in the workplace and inconvenient breastfeeding conditions discourage women from maintaining the practice (6, 21, 29, 30).

In our study, most women reported that they receive support and encouragement from their companies. However, from the experience of two BSRs users, one of the barriers when using the rooms is related to the fact that they would have liked to have used the BSRs longer. One of these participants was discouraged from using the BSR after her child turned 8 months. This fact indicates that despite the government's efforts to encourage BSRs, this strategy can be improved.

Through Convention 183, the ILO proposes measures to protect maternity and breastfeeding in the workplace, assigning countries the responsibility to institute a period for breastfeeding breaks, the reduction of daily working hours, the duration of breastfeeding breaks, among others, as noted in items 1 and 2 of article 10 (31).

According to Rollins et al. (3), 130 countries have paid breastfeeding breaks, seven countries have unpaid breaks, and 45 countries do not have a policy for breastfeeding at work. In Brazil, the right to a breastfeeding break date back to the 1940s and is included in the labor legislation. Article 396 of the Consolidation of Labor Laws (CLT) determines that a woman should have two 30-min breastfeeding breaks during the workday until the child is 6 months old. The law also incorporates an extension to the 6 months at the discretion of competent authorities, depending on the child's health (32).

These results reinforce the importance of an update to Brazilian labor laws concerning an extension of breaks to breastfeed or pump milk during the workday, either if breastfeeding continues or at least until the child is 2 years old, which is the recommended threshold for breastfeeding.

This right to breastfeed children up to 2 years of age must be established by law and available to all women, regardless of the manager's goodwill. The institutionalization of the right to breastfeed at work for the first 2 years of the child's life would also contribute to achieving the international breastfeeding goals for 2030, which are 80% breastfeeding by age one and 60% by age two (1). To that end, governments, donors, and civilians must commit and invest in the promotion, protection, and support of breastfeeding (3).

There are some limitations to our study that need to be pointed out. First, we focused only on one state in Brazil, which has 76.2% of SAA in the southern region of the country and 8% of the total 200 BSRs certified in Brazil by 2017. Brazil is a very diverse country; thus, it would be beneficial to use complementary studies to verify our findings in other regions. Second, our study involved companies that adhered to other support strategies for working women, such as extending maternity and paternity leave, which may have influenced the positive perception of women about the Breastfeeding Support Rooms. Finally, the use of the online questionnaire instead of in-depth interviews may have made it challenging to capture women's perceptions somehow.

However, despite these limitations, this is the first study in Brazil to gather data on women's experience using BSRs and their perception about it. This is also the first study that points to the great potential relationship between BSRs and the achieving SDG 5 and 8 by promoting decent work, professional appreciation, comfort, and physical and emotional well-being, all factors that contribute to work productivity and economic growth besides impacting other SDGs by increasing breastfeeding rates.

Our findings conclude that the BSR is seen as an important and cheap strategy for female employees. Therefore, countries should invest to promote breastfeeding in the workplace through BSRs because they contribute directly and indirectly to achieving the SDG.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article are in Portuguese and will be provided by the authors, without reservation, upon a request sent *via* email to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Health Sciences Department of the Federal University of Paraná, under Certificate of Presentation of Ethical Appreciation (CAAE) number 65401917.5.3004.5225. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CBS collected, analysed, and interpreted the data and drafted and reviewed the manuscript. SIV and RPGVCS interpreted the data and critically reviewed the manuscript. All authors contributed to the conception and design of the study and approved the final version to be published.

ACKNOWLEDGMENTS

We would like to thank the coordination of the Technical Wing of Child Health and Breastfeeding of the Brazilian Ministry of Health, the Health Care for Children and Adolescents Division of the State Secretary of health in Paraná, and all women and institutions involved in this research.

REFERENCES

1. World Health Organization, United Nations Children's Fund? *Global Breastfeeding Scorecard, 2019: Increasing Commitment to Breastfeeding Through Funding and Improved Policies and Programmes*. (2019). Available online at: https://apps.who.int/iris/handle/10665/326049 (accessed April 27, 2021).
2. 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). 387:75–490. doi: 10.1016/S0140-6736(15)01024-7
3. Rollins NC, Lutter CK, Bhandari N, Hajeebhoy N, Horton S, Martines JC, et al. Why invest, and what it will take to improve breastfeeding practices? *Lancet*. (2016). 387:491–504. doi: 10.1016/S0140-6736(15)01044-2
4. United Nations. *Resolution Adopted by the General Assembly on 25 September 2015*. Available online at: https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (accessed April 27, 2021).
5. Instituto Brasileiro de Geografia e Estatística, Secretaria Especial de Articulação Social. *Objetivos para o Desenvolvimento Sustentável: Indicadores Brasileiros para os Objetivos de Desenvolvimento Sustentável*. (2021). Available online at: https://odsbrasil.gov.br/home/videos (accessed April 27, 2021).
6. Bai YK, Dinour LM, Pope GA. Determinants of the intention to pump breast milk on a University campus. *J Midwifery Womens Health.* (2016). 61:563–70. doi: 10.1111/jmwh.12488
7. Dagher RK, McGovern PM, Schold JD, Randall XJ. Determinants of breastfeeding initiation and cessation among employed mothers: a prospective cohort study. *BMC Pregnancy Childbirth*. (2016) 16:194. doi: 10.1186/s12884-016-0965-1
8. Monteiro FR, Buccini GS, Venâncio SI, Costa TH. Influence of maternity leave on exclusive breastfeeding. *J Pediatria*. (2017) 93:475–81. doi: 10.1016/j.jped.2016.11.016
9. Addati L, Cassirer N, Gilchrist K. *Maternity and Paternity at Work: Law and Practice Across the World International Labour Office*. Geneva: ILO (2014). p. 204. Available online at: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_242615.pdf (accessed April 27, 2021).
10. Ministério da Saúde. Portaria n° 1.130de agosto de 2015. *Institui a política nacional de atenção integral à saúde da criança (PNAISC) no âmbito do sistema único de saúde (SUS)*. (2015). Available online at: http://bvsms.saude.gov.br/bvs/saudelegis/gm/2015/prt1130_05_08_2015.html (accessed April 27, 2021).
11. Tsai SY. Employee perception of breastfeeding-friendly support and benefits of breastfeeding as a predictor of intention to use breast-pumping breaks after returning to work among employed mothers. *Breastfeed Med*. (2014) 9:16–23. doi: 10.1089/bfm.2013.0082
12. Dabritz HA, Hinton BG, Babb J. Evaluation of lactation support in the workplace or school environment on 6-month breastfeeding outcomes in Yolo County, California. *J Hum Lactation. (*2009) 25:182–93. doi: 10.1177/0890334408328222
13. Basrowi RW, Sulistomo AB, Adi NP, Vandenplas Y. Benefits of a dedicated breastfeeding facility and support program for exclusive breastfeeding among workers in Indonesia. *Pediatr Gastroenterol Hepatol Nutr*. (2015) 18:94–9. doi: 10.5223/pghn.2015.18.2.94
14. Lee CC, Chiou ST, Chen LC, Chien LY. Breastfeeding-friendly environmental factors and continuing breastfeeding until 6 months postpartum: 2008-2011 national surveys in Taiwan. *Birth*. (2015) 42:42–248. doi: 10.1111/birt.12170
15. Kozhimannil KB, Jou J, Gjerdingen DK, McGovern PM. Access to workplace accommodations to support breastfeeding after passage of the affordable care. *Act Womens Health Issues*. (2016) 26:6–13. doi: 10.1016/j.whi.2015.08.002
16. Nardi AL, Von Frankenberg AD, Franzosi OS, Espírito-Santo LC. Impacto dos aspectos institucionais no aleitamento materno em mulheres trabalhadoras: uma revisão sistemática. *Ciência Saúde Coletiva*. (2020) 25:1445–62. doi: 10.1590/1413-81232020254.20382018
17. Bardin L. *Análise de conteúdo*. São Paulo: Edições (2016). p. 279.
18. Friese S. *Qualitative Data Analysis With ATLAS.ti, 2nd edn*. London: Sage (2014).
19. American Psychological Association. *Qualitative and Mixed Methods Research*. (2018). Available online at: https://www.apa.org/pubs/highlights/qualitative (accessed April 27, 2021).
20. Universidade Federal do Rio de Janeiro. *Estudo Nacional de Alimentação e Nutrição Infantil ENANI-2019: Resultados preliminares – Indicadores de aleitamento materno no Brasil*. Rio de Janeiro: UFRJ (2020). p. 9. Available online at: https://enani.nutricao.ufrj.br/wp-content/uploads/2020/08/Relatorio-preliminar-AM-Site.pdf (accessed April 27, 2021).
21. Tsai SY. Impact of a breastfeeding-friendly workplace on an employed mother's intention to continue breastfeeding after returning to work. *Breastfeeding Med*. (2013) 8:210–6. doi: 10.1089/bfm.2012.0119
22. Ministério da Economia. *Receita Federal. Programa Empresa Cidadã*. (2021). Available online at: https://receita.economia.gov.br/orientacao/tributaria/isencoes/programa-empresa-cidada/orientacoes (accessed April 27, 2021).
23. Victora CG, Horta BL, Mola CL, Quevedo L, Pinheiro RT, Gigante DP, et al. Association between breastfeeding and intelligence, educational attainment, and income at 30 years of age: a prospective birth cohort study from Brazil. *Lancet*. (2015) 3:e199–205. doi: 10.1016/S2214-109X(15)70002-1
24. Hansen, K. Breastfeeding: a smart investment in people and in economies. *Lancet*. (2016) 387:416. doi: 10.1016/S0140-6736(16)00012-X
25. Chowdhury R, Sinha B, Sankar MJ, Taneja S, Bhandari N, Rollins N, et al. Breastfeeding and maternal health outcomes: a systematic review and meta-analysis. *Acta Paediatr*. (2015) 104:96–113. doi: 10.1111/apa.13102
26. World Health Organization. *Infant and Young Child Feeding: Model Chapter for Textbooks for Medical [Students and Allied Health Professionals]*. Geneva: World Health Organization (2009). Available online at: https://www.who.int/nutrition/publications/infantfeeding/9789241597494/en/ (accessed April 27, 2021).
27. Sankar, MJ, Sinha, B, Chowdhury, R, Bhandari, N, Taneja, S, Martines, J, et al. Optimal breastfeeding practices and infant and child mortality. A systematic review and meta-analysis. *Acta Paediatr*. (2015) 104:3–13. doi: 10.1111/apa.13147

28. Mills SP. Workplace lactation programs: a critical element for breastfeeding mothers' success. *AAOHN J.* (2009) 57:227–31. doi: 10.3928/08910162-20090518-02
29. Chen YC, Wu YC, Chie WC. Effects of work-related factors on the breastfeeding behavior of working mothers in a Taiwanese semiconductor manufacturer: a cross-sectional survey. *BMC Public Health*. (2006) 21:160. doi: 10.1186/1471-2458-6-160
30. Bai YK, Gaits SI, Wunderlich SM. Workplace lactation support by New Jersey employers following US Reasonable Break Time for Nursing Mothers law. *J Human Lactat.* (2015) 31:76–80. doi: 10.1177/0890334414554620
31. International Labour Organization. *Maternity Protection Convention, n° 183*. (2000). Available online at: https://www.ilo.org/dyn/normlex/en/f?p=1000:12100:0::NO::P12100_ILO_CODE:C183 (accessed April 27, 2021).
32. Consolidação das Leis do Trabalho. *Decreto-Lei n° 5.442.* (1943). Available online at: http://www.planalto.gov.br/ccivil_03/decreto-lei/del5452.htm (accessed April 27, 2021).

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 27 January 2022
doi: 10.3389/fpubh.2021.812979

Workplace Bullying and Its Associated Factors Among Medical Doctors in Residency Training in a Tertiary Health Institution in Plateau State Nigeria

Tolulope O. Afolaranmi[1,2]*, *Zuwaira I. Hassan*[1,2], *Benjamin M. Gokir*[3], *Abdulrahman Kilani*[3], *Raphael Igboke*[3], *Kainechukwu G. Ugwu*[4], *Chikwendu Amaike*[5] and *Akinyemi O. D. Ofakunrin*[6]

[1] Department of Community Medicine, University of Jos, Jos, Nigeria, [2] Department of Community Medicine, Jos University Teaching Hospital, Jos, Nigeria, [3] Faculty of Clinical Sciences, University of Jos, Jos, Nigeria, [4] Ginza Medical Centre, Jos, Nigeria, [5] Department of Community Medicine, College of Health and Medical Sciences, Babcock University, Ilishan-Remo, Nigeria, [6] Department of Pediatrics University of Jos, Jos University Teaching Hospital, Jos, Nigeria

Background: Bullying is public health problem globally in workplaces with untold deleterious effects on the health and well-being of individuals at the receiving end. Bullying has been found to disrupt social interaction at workplace thereby creating an unhealthy and seemingly unproductive work environment. Studies have reported varying rates of workplace bullying as high as 83% in Europe, 65% in the Americas and 55% in Asia with very little documented in the contemporary African setting and Nigeria in particular. It therefore became imperative to assess the level of bullying and its associated factors among medical doctors in residency training in a tertiary health institution in Plateau state Nigeria.

Methodology: This was a cross sectional study conducted among resident doctors in Jos University Teaching Hospital between November 2019 and February 2020 using quantitative method of data collection and SPSS version 20 was used for data analysis. Crude and adjusted odds ratios as well as 95% confidence interval were used in this study with a p-value of ≤ 0.05 considered statistically significant.

Results: The mean age of the respondents was 32.3 ± 3.9 years with 78 (62.9%) being 31 years and above. Bullying was currently being experienced by 74 (59.7%) of the respondents with verbal aggression and threats as well as insult and use of derogatory remarks being the forms of bullying experienced by 85.1 and 74.3% of the respondents, respectively. Furthermore, witnessing a colleague being bullied was the sole factor found to be significantly associated with workplace bullying (AOR = 0.18; 95% CI = 0.068–0.449; $p < 0.001$).

Conclusion: Workplace bullying has been found to be in existence and relatively high among medical doctors in residency training in this setting with witnessing someone being bullied as its sole associated factor.

Keywords: workplace, bullying, associated factors, medical doctors, residency training, tertiary health institution, Nigeria

OPEN ACCESS

Edited by:
Stefania Salmaso, Independent Researcher, Rome, Italy

Reviewed by:
Katalin Dr. Papp, University of Debrecen, Hungary
Luenda Charles, Centers for Disease Control and Prevention (CDC), United States

***Correspondence:**
Tolulope O. Afolaranmi
toluene42002@yahoo.com

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

Received: *11 November 2021*
Accepted: *20 December 2021*
Published: *27 January 2022*

Citation:
Afolaranmi TO, Hassan ZI, Gokir BM, Kilani A, Igboke R, Ugwu KG, Amaike C and Ofakunrin AOD (2022) Workplace Bullying and Its Associated Factors Among Medical Doctors in Residency Training in a Tertiary Health Institution in Plateau State Nigeria. Front. Public Health 9:812979. doi: 10.3389/fpubh.2021.812979

INTRODUCTION

Bullying is a public health problem globally in workplaces with untold deleterious effects on the health and well-being of individuals at the receiving end (1, 2). Workplace bullying has been described as constant and regular negative behaviors toward an employee or its work leading to low sense of dignity self worth (2–4). Bullying has been found to disrupt social interaction at workplace thereby creating an unhealthy and seemingly unproductive work environment (5–7). Studies have reported varying rates of workplace bullying as high as 83% in Europe, 65% in the Americas and 55% in Asia with very little documented in the contemporary African setting and Nigeria in particular (8). It is common place that bullying occurs in all workplace settings of which medical profession is not an exemption. It therefore became imperative to assess the level of bullying and its associated factors among medical doctors in residency training in a tertiary health institution in Plateau state Nigeria. This is opined to bring to light the somewhat submerged and unrecognized levels of workplace bullying in this subset of health care workers and provide the platform for structuring home-grown solutions to mitigating it through identified factors potentiating it.

METHODOLOGY

Study Setting

This study was conducted in Jos University Teaching Hospital (JUTH), a tertiary health institution founded in 1975 and affiliated with the University of Jos (9). JUTH is a 600-bed capacity facility located in the Lamingo Area of Jos North Local Government Area (LGA) (9). JUTH offers a vast variety of specialized services in the various aspects of healthcare, research and training and serves as a referral center to the surrounding states in the North central, parts of north western and north eastern part of Nigeria. JUTH being a tertiary health facility has the following service delivery units; surgery, internal medicine, obstetrics and gynecology, pediatrics, community medicine, radiology, ophthalmology, pathology, laboratory medicine, otorhinolaryngology, anesthesia, psychiatry and dentistry among others.

Study Population

The study population comprised of all resident doctors undergoing specialty training in Jos University Teaching Hospital at the time of the study.

Study Design

A cross-sectional study design conducted between November 2019 and February 2020 to assess the level of workplace bullying, its form and predictors among resident doctors in Jos University Teaching Hospital, Plateau State Nigeria using quantitative method of data collection.

Sample Size Estimation

The sample size for this study was determined using the appropriate sample size determination formula for a cross sectional study denoted below (10). Where n is the minimum sample size, Z is the standard normal deviate at 95% confidence interval (1.96), q is the complementary probability (1 − p), d is the precision of the study set at 0.05 and p is the prevalence of workplace bullying from previous similar study being 92.0% (1). This gave a sample size of 124 after addition of 10% to cater for non, poor and or incomplete responses.

Criteria for Inclusion in the Study

All medical doctors in residency training for 6 months and upwards were included in the study while those on either outside posting or leave (annual or sick) were excluded from the study. Six months of training experience was used as the cut off to ensure that the participants had sufficient interaction with both superiors and contemporaries in the course of their respective trainings.

Sampling Technique

A stratified sampling technique was used in order to ensure representativeness of all the departments of specialty training owing to the fact that these departments had varied number of eligible resident doctors. A list of all the eligible resident doctors from the various departments was obtained, serialized and de-identified with unique departmental codes forming the sampling frame. Following which proportion to size technique was used to obtain the number of participants to be sampled from each of the departments. This was done by dividing the number of resident doctors who had met the inclusion criteria per department (psychiatry—11, surgery and its sub-specialties—54, internal medicine—38, Obstetrics and gynecology—44, pediatrics—23, community medicine—41, ophthalmology—18, otorhinolaryngology—12, hematology—7, family medicine—37 and dentistry—11, radiology—17, medical microbiology—7, chemical pathology—8, histopathology—11, Anesthesia—10) by the cumulative total number of all the eligible resident doctors in all the departments of training (349) multiplied by the sample size of 124 for the study. This gave the following number of resident doctors sampled per department: psychiatry—4, surgery and its sub-specialties—19, internal medicine—14, Obstetrics and gynecology—15, pediatrics—8, community medicine—14, ophthalmology—6, otorhinolaryngology—4, hematology—3, family medicine—13 dentistry—4, radiology—6, medical microbiology—3, chemical pathology—3, histopathology—4, anesthesia—4). Thereafter, the respective departmental list was drawn and numbers were allocated to the all the eligible respondents in ascending order forming the departmental sampling frame from which computer generated table of random numbers was used to select determined number of resident doctors for each department, respectively, without replacement.

Data Collection Instrument

A semi-structured self-administered questionnaire adapted from a previous studies comprising of three sections; socio-demographic characteristics, prevalence of workplace bullying and pattern of workplace bullying (11, 12). Three research assistants were trained on the content, method of administration and retrieval of filled questionnaire prior to the commencement

of the study by the principal researcher. Cronbach alpha reliability assessment of the questionnaire was done using SPSS software version 20 where an overall Cronbach alpha score of 0.81 was obtained. The data collection instrument was pretested in among resident doctors in another training institution among 10% of the calculated minimum sample size. This was done in order to correct any ambiguity in the questionnaire and also to estimation of time of administration of the questionnaires.

Data Collection

Data were collected using a paper-based semi-structured self-administered questionnaire. The eligible and selected participants identified with the help of the various departmental focal persons were sampled in their respective departments daily. The departmental focal person helped in the retrieval of all the filled questionnaires for onward collection by the research assistants. Upon the receipt of all the filled questionnaires from departmental focal persons, the trained research assistant reviewed all the questionnaires for completeness and appropriateness of the responses as required. The questionnaires not completely filled were returned for proper filling and retrieved back. Confidentiality and anonymity of the information provided by the participants were assured and maintained.

Ethical Consideration

Ethical clearance was obtained from Jos University Teaching Hospital Institutional Human Research Ethical Committee (JUTH/DCS/IREC/127/XXX/2137). Written informed consent was obtained from all the respondents with confidentiality and anonymity of their responses assured and maintained.

GRADING OF RESPONSE

Explanatory variables in this study were categorized as demographic characteristics of the respondents. The demographic characteristics included age which was age as at last birthday and then categorized into $\leq$ 30 and 31 years and above after plotting a percentile graph and 30 years was found to bifurcated the data into two halves. Furthermore, sex of the respondents was obtained and categorized as male or female based on the responses obtained. Other explanatory variables assessed were marital status assessed as single or married, level of training graded as registrar and senior registrar. Senior registrars are those doctors in residency training who had passed the part—one fellowship/college examinations after spending the mandatory 3 years junior residency phase and are the final phase of their specialty training. Additionally, information on duration in specialty training was elicited in years and graded as $\leq$3 and 4 years and above. Three years was used as the cut-off being the mandatory period for junior residency phase. The outcome measure of the study was the experience of any act of bullying which was elicited with a yes or no response to the question "Have you experienced any form of workplace bullying in the last 6 months in the course of your training?" Following which the respondents were asked to indicate the acts of bullying they had experienced. Bullying was adjudged to have been experienced if the respondents had been exposed to any acts of intimidation, humiliation, degrading, misuse or abuse of power, authority or position which caused any feelings of defenselessness as well as undermining his/her sense of dignity while at work within the last 6 month (3, 4).

DATA ANALYSIS

Data analysis was carried out using Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistical analysis was carried out on quantitative variables such age of the respondent using mean and standard deviation as the summary indices upon the fulfillment of the assumptions of normality. Other explanatory variables such as age group, sex, marital status, religion, level of training, duration of training and field of specialization were presented using frequency table expressed in frequencies and percentages. The primary outcome variable was workplace bullying expressed as experienced and not experienced presented in a frequency table. A stepwise model approach to logistic regression was used in determining the factors influencing workplace bullying where each of the explanatory variables was fed into the logistic regression model singly following which crude odds ratios and 95% confidence intervals were generated, respectively. Furthermore, all these factors were then fed cumulatively into the logistic regression model to establish interaction and allow for these factors to adjust for one another. Adjusted odds ratio and 95% confidence interval were used as point and interval estimates of the measure of the effects of these factors on the experience of workplace bullying. Additionally, a probability value of <0.05 was considered statistically significant.

RESULTS

The mean age of the respondents was 32.3 $\pm$ 3.9 years with 78 (62.9%) being 31 years and above. With regards to sex distribution of the study participants, 91 (73.4%) were males while 95 (76.6%) were in the registrar cadre. Surgery and its sub-specialties accounted for 19 (15.3%) of the respondents, while Internal Medicine, Obstetrics and Gynecology and Community Medicine accounted for 14 (11.3%), 15 (12.1%), and 14 (11.3%) of the respondents, respectively (**Table 1**).

Bullying was currently being experienced in the course residency training at one point or the other by 74 (59.7%) of the respondents while 86 (69.4%) stated that they had witnessed at least a colleague being bullied since commencement of residency training. Verbal aggression and threats, insult and use of derogatory remarks as well as intimidation by superiors were the forms of bullying experienced by 85.1, 74.3, and 60.8% of the respondents, respectively, among participants who had experienced bullying (**Table 2**).

Furthermore, witnessing a colleague being bullied was the only factor influencing bullying in the workplace in this study. The odds of being bullied for those who had not witnessed any of their colleagues being bullied was 0.18 times those who had witnessed same (95% CI = 0.068–0.449; $p < 0.001$) (**Table 3**).

TABLE 1 | Socio-demographic characteristics of the respondents.

Characteristics	Frequency (n =124)	Percentage
Age (Years)		
≤30	46	37.1
31 and above	78	62.9
	Mean ± SD	
Mean age	32.3 ± 3.9 years	
Sex		
Male	91	73.4
Female	33	26.6
Religion		
Christianity	120	96.8
Islam	4	3.2
Level of training		
Registrar	95	76.6
Senior Registrar	29	23.4
Duration in specialty training (years)		
≤3	91	73.4
4 and above	33	26.6
Marital Status		
Single	62	50.0
Married	62	50.0
Field of specialization		
Surgery and its sub-specialties	19	15.3
Internal Medicine	14	11.3
Obstetrics and Gynecology	15	12.1
Peadiatrics	8	6.5
Family Medicine	13	10.5
Community Medicine	14	11.3
Laboratory Medicine	13	10.5
Others*	28	22.6

*SD, Standard Deviation. *Psychiatry, radiology ophthalmology, otorhinolaryngology, anesthesia, dentistry.*
Laboratory Medicine, Hematology, medical microbiology, chemical pathology, histopathology.

TABLE 2 | Prevalence and forms of workplace bullying.

Variables	Frequency n = 124	Percentage
Witnessed colleague(s) being bullied		
Yes	86	69.4
No	38	30.6
Current experience of bullying		
Experienced	74	59.7
Not experienced	50	40.3.
Direction of bullying experienced (n = 74)		
Superior to subordinate	74	100.0
Among peers	0	0.0
Forms of bullying* (n =74)		
Verbal aggregation and threats	63	85.1
Playing of mind games	28	37.8
Social isolation	20	27.0
Insults or derogatory remarks	55	74.3
Intimidation	45	60.8
Neglecting one's opinion	38	51.4

DISCUSSION

Workplace bullying is any anti-social behavior in the workplace resulting in distress, discomfort, physical or psychological harm (13). The prevalence of workplace bullying in this study was relatively high with slightly above half of the respondents having experienced bullying at one point or the other in the course of their postgraduate specialization training. This is similar to what was reported in a Greek study though conducted among health care providers in just one unit of the hospital as against this study having doctors in training from all the different fields of specialty (6). Furthermore, varying burdens of workplace bullying were also reported in studies conducted in different climes with lower prevalence rate found in those carried out in Spain, Taiwan, Portugal and Cyprus in comparison to findings of this study while higher rates were recorded in studies conducted in Turkey, Nigeria and Egypt (5, 14–19).

This variation could be attributable to the difference in the cadres of health care workers studied, the methods of assessment of workplace bullying as well as the culture and societal perception of bullying in these different study settings. Importantly, a harmonious work environment is tantamount to having good treatment outcomes for the end service users, motivation and improved productivity as well as job satisfaction for the health providers and in this context, a fulfilling residency training experience for the trainees. This implies that workplace bullying should either be non-existent or reduced to the barest minimum if the health care system will achieve its intended purposes and produce specialists who would value the importance of good interpersonal relationship and peaceful co-existence.

Furthermore, over two-third of the respondents had witnessed at least a colleague being bullied within a period of 6 months prior to the study which is consistent with what was reported in another study conducted in Europe (6). This has brought to light that bullying cuts across geographic locations and regions and if it goes on unchecked, the possibility of it being taken as the norm and modeled as part of daily routine is high. Hence, it may be imperative for health institutions to develop or have in place anti–workplace bullying system and reporting channels as measures of curbing it. Furthermore, verbal aggression and threats, intimidation, social isolation as well as neglect of one's opinion were expressed as the forms of bullying experienced in this study which corroborate the findings of other studies in addition to direct hostile behavior, being continuously interrupted, being gossiped about, failure to respect privacy, excessive workload, degrading remarks, physical abuse with rage and anger among others being reported (5, 13, 15–19). This is a pointer to the fact that these anti-social behaviors exist in workplaces globally with shared similarities in different countries and regions making workplace bully an emerging public health problem requiring urgent global attention.

TABLE 3 | Multiple logistic regression of factors influencing workplace bullying.

Factors	COR (95%CI)	*P*-value	AOR (95% CI)	*P*-value
Age group (years)				
≤30	1.42 (0.68–2.97)	0.354	1.16 (0.43–3.12)	0.763
31 and above	1	–	1	–
Sex				
Female	0.45 (0.20–1.02)	0.054	0.84 (0.29–2.41)	0.747
Male	1	–	1	–
Marital status				
Single	1.30 (0.64–2.69)	0.464	1.64 (0.63–4.28)	0.312
Married	1	–	–	–
Level of training				
Senior Registrar	0.59 (0.25–1.44)	0.247	0.75 (0.20–2.82)	0.667
Registrar	1	–	–	–
Witnessing a colleague being bullied				
No	0.165 (0.07–0.38)	<0.001	0.18 (0.07–0.45)	<0.001
Yes	1	–	–	–
Duration of training (years)				
4 years and above	0.89 (0.40–1.99)	0.774	0.42 (0.12–1.49)	0.180
≤3 years	1	–	–	–
Field of specialization				
Surgery and its sub-specialties	2.20 (0.64–7.58)	0.213	1.73 (0.43–6.96)	0.442
Internal medicine	4.67 (0.40–53.93)	0.217	3.19 (0.24–43.22)	0.384
Obstetrics and gynecology	1.37 (0.29–6.36)	0.695	1.08 (0.20–5.91)	0.458
Peadiatrics	1.05 (0.26–4.32)	0.946	0.87 (0.17–4.47)	0.867
Family medicine	0.47 (0.07–3.34)	0.448	0.41 (0.05–3.76)	0.433
Community medicine	10.50 (1.02–18.58)	0.002	5.21 (0.24–6.94)	0.055
Laboratory medicine	1.94 (0.32–11.76)	0.469	1.23 (0.15–9.88)	0.847
Others*	1	–	–	–

**Psychiatry, radiology ophthalmology, otorhinolaryngology, anesthesia, dentistry. Laboratory Medicine, Hematology, medical microbiology, chemical pathology, histopathology; COR, Crude Odds Ratio; AOR, Adjusted Odds Ratio.*

Age group, sex, marital status, level of training, witnessing colleague being bullied, duration of training and field of specialization were all adjusted for in the multiple logistic regression model.

With regards to the factors influencing workplace bullying among doctors in the residency training, witnessing a colleague being bullying was found to be the sole factor influencing bullying. However, other similar studies have reported factors such as gender, age, number of years in service, workload, level of education and shift employment as factors influencing bullying in the work place (6, 14, 17, 18). It however, imperative to state that observing someone being bullied could subtly over a period of time model individuals to seeing bullying as normal and then potentiating the desire for bullying other in such individual. Additionally, in view of the diversity of predictors of workplace bullying among health care worker, it important to be context and settings specific in providing interventions targeted at addressing this dangerous act so as to achieve meaningful results. The study stands to contribute to the existing body of knowledge on the existence of bullying among health care providers cutting across various specialties. This in itself has brought to light that bullying is not restricted to any profession or career pathway. However, assessment of bullying in this study was self reported and limited to only medical doctors in specialty training which in a way could be a limitation to the generalizabilty of the findings of the study. Additionally this study had used only quantitative method of data collection while the use of mixed method approach may have provided more insight into more hidden factors influencing bullying in the group of respondents.

CONCLUSION

Workplace bullying has been found to be in existence and relatively high among medical doctors in residency training in this setting with witnessing someone being bullied as its sole predictor. Hence, it is imperative that the acts of bullying be discouraged through sensitization and education so as to forestall modeling bullying as a integral part of specialty training.

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 Institutional Research Ethics Committee of Jos University Teaching Hospital. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

TA and ZH participated in conceptualization and design of the study, literature review, analysis and interpretation of results, drafting and revising the manuscript, and final approval prior to submission for publication. BG, AK, RI, KU, CA, and AO participated in the design of the study, literature review, analysis and interpretation of results, drafting and revising the manuscript, and final approval prior to submission for publication. All authors agreed to be accountable for the content of the work.

FUNDING

This study was supported by the Fogarty International Center (FIC), Office of the Director (OD/NIH), National Institute of Neurological Disorders and Stroke (NINDS/NIH), and the National Institute of Nursing Research (NINR/NIH) of the National Institutes of Health under Award Number D43 TW010130.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.812979/full#supplementary-material

REFERENCES

1. Ely ZS, Marzuki I, Sanjay R. The prevalence, risk factors and outcomes of workplace bullying among junior doctors: a systematic review. *Eur J Work Org Psychol.* (2018) 27:1–19. doi: 10.1080/1359432X.2018.1502171
2. Haq MR, Zia-ud-Din M, Rajvi S. The impact of workplace bullying on employee cynicism with mediating role of psychological contract. *Int J Acad Res Bus Soc Sci.* (2018) 8:127–37. doi: 10.6007/IJARBSS/v8-i8/4445
3. Dickson D. Bullying in the workplace. *Anesthesia.* (2005) 60:1159–161. doi: 10.1111/j.1365-2044.2005.04465.x
4. Rajalakshmi M, Gomathi S. A study on the factors influencing workplace bullying and its impact on employee stress. *Mediter J Soc Sci MCSER.* (2015) 6:292–8. doi: 10.5901/mjss.2015.v6n1p292
5. Nwaneri AC, Onoka AC, Onoka CA. Workplace bullying among nurses working in tertiary hospitals in Enugu, southeast Nigeria: implications for health workers and job performance. *J Nurs Educ Pract.* (2017) 7:69–78. doi: 10.5430/jnep.v7n2p69
6. Chatziioannidis I, Bascialla FG, Chatzivalsama P, Vouzas F, Georgios Mitsiakos G. Prevalence, causes and mental health impact of workplace bullying in the neonatal intensive care unit environment. *BMJ Open.* (2018) 8:e018766. doi: 10.1136/bmjopen-2017-018766
7. LaVan H, Martin W. Bullying in the US workplace: normative and process-oriented ethical approaches. *J Bus Ethics.* (2008) 83:147–165. doi: 10.1007/s10551-007-9608-9
8. Yun S, Kang J. Influencing factors and consequences of workplace bullying. *Asian Nurs Res.* (2018) 12:26–33. doi: 10.1016/j.anr.2018.01.004
9. Jos University Teaching Hospital. *About JUTH*. Available from: http://www.juth.org.ng (accessed August 23, 2021).
10. Ibrahim T. Sample size determination. In: *Research Methodology and Dissertation Writing for Health and Allied Health Professionals*. 1st ed. Abuja: Cress Global Link Limited (2009). p. 75–9.
11. Myoeungun L, Hyunjung K, Donghee S, Sangyun L. Reliability and validity of the workplace harassment questionnaire for Korean finance and Service workers. *Ann Occup Environ Med.* (2016) 28:1–8. doi: 10.1186/s40557-016-0133-0
12. Jan I, Neil T, Paul C, Charlotte R, Amelia K. *Workplace Bullying: Measurements and Metrics to Use in the NHS*. Final report for NHS Employers. (2016). Available online at: https://www.nhsemployers.org/media/employer/documents//campaigns/NHS_employer_bullying_measures_final_report.pdf (accessed October 23, 2021).
13. Fajana S, Owoyemi O, Shadare S, Elegbede T, Gbajumo-Sheriff M. Gender differences: an nntecedent for workplace bullying and harassment in Nigeria workplaces. *Eur J Soc Sci.* (2011) 21:448–55.
14. Ariza-Montes A, Muniz NM, Montero-Simó MJ, Araque-Padilla RA. Workplace bullying among healthcare workers. *Int J Environ Res Public Health.* (2013) 10:3121–39. doi: 10.3390/ijerph10083121
15. Ko YY, Liu Y, Wang CJ, Liao HY, Liao YM, Chen HM. Determinants of workplace bullying types and their relationship with depression among female nurses. *J Nurs Res.* (2020) 28:e92. doi: 10.1097/JNR.0000000000000367
16. Norton P, Costa V, Teixeira J, Azevedo A, Roma-Torres A, Amaro J, et al. Prevalence and determinants of bullying among health care workers in Portugal. *Workplace Health Safety.* (2017) 65:188–96. doi: 10.1177/2165079916666545
17. Zachariadou T, Zannetos S, Chira SE, Gregoriou S, Pavlakis A. Prevalence and forms of workplace bullying among health-care professionals in cyprus: greek version of "Leymann Inventory of Psychological Terror" Instrument. *Saf Health Work.* (2018) 9:339–46. doi: 10.1016/j.shaw.2017.11.003
18. Ekic D, Bede A. The effects of workplace bullying on physicians and nurses. *Aust J f Adv Nurs*. (2014) 31:24–33.
19. El-Houfey AA, Abo El-Maged NSH, Elserogy YM, El Ansari W. Workplace psychological violence among junior physicians employed in an Egyptian University Hospital. *IJRHSN*. (2019) 5:1–47. Available online at: https://gnpublication.org/index.php/hsn/article/view/1111

Author Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the views of the National Institutes of Health.

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 21 February 2022
doi: 10.3389/fpubh.2022.799365

Heat Adaptive Capacity: What Causes the Differences Between Residents of Xiamen Island and Other Areas?

Chaowei Wu[1], Wei Shui[1], Haifeng Yang[2], Meiqi Ma[1], Sufeng Zhu[3], Yuanmeng Liu[1], Hui Li[1], Furong Wu[1], Kexin Wu[1] and Xiang Sun[1]*

[1] Department of Geography and Planning, College of Environment and Safety Engineering, Fuzhou University, Fuzhou, China, [2] Center for Urban Security Development Research, College of Architecture and City Planning, Nanjing University, Nanjing, China, [3] Chinese Research Academy of Environmental Science, Beijing, China

Extreme heat events caused by climate change have serious adverse effects on residents' health in many coastal metropolises in southeast China. Adaptive capacity (AC) is crucial to reduce heat vulnerability in the human-environment system. However, it is unclear whether changes in individual characteristics and socioeconomic conditions likely amplify or attenuate the impacts of residents' heat adaptive capacity (HAC) changes. Moreover, which public policies can be implemented by the authorities to improve the HAC of vulnerable groups remains unknown. We conducted a questionnaire survey of 630 residents of Xiamen, a typical coastal metropolis, in 2018. The effects of individual and household characteristics, and government actions on the residents' HAC were examined by using ordinal logistic regression analysis. Results show that the majority (48.10%) of Xiamen residents had a "medium" HAC level, followed by a "high" level (37.14%). On Xiamen Island, residents who settled locally for one–three years and spent less than one hour outdoors might report weaker HAC, and their HAC would not improve with increased air conditioning units in household. In other areas of Xiamen, residents with more rooms in their households, no educational experience, and building areas <50 m^2 might report better HAC. Further, vulnerable groups, such as local residents and outdoor workers on Xiamen Island, people lacking educational experience and renters in other areas of Xiamen, showed better AC to hot weather than those in previous studies. Low-income groups should be given more attention by local governments and community groups as monthly household income played a positive role in improving Xiamen residents' HAC. Rational green spaces planning and cooling services, such as street sprinkling operations, provided by municipal departments can effectively bring benefits to Xiamen residents. Identification of basic conditions of AC has significant implications for practical promoting targeted measures or policies to reduce health damages and livelihood losses of urban residents during extreme heat events.

Keywords: climate change, extreme heat events, heat vulnerability, adaptive capacity, human-environment system, Xiamen Island, China

OPEN ACCESS

Edited by:
Stefania Salmaso, Independent Researcher, Rome, Italy

Reviewed by:
Wenzhi Cao, Xiamen University, China
Xiaojun Huang, Northwest University, China

***Correspondence:**
Wei Shui
shuiweiman@163.com

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

Received: *21 October 2021*
Accepted: *24 January 2022*
Published: *21 February 2022*

Citation:
Wu C, Shui W, Yang H, Ma M, Zhu S, Liu Y, Li H, Wu F, Wu K and Sun X (2022) Heat Adaptive Capacity: What Causes the Differences Between Residents of Xiamen Island and Other Areas? Front. Public Health 10:799365. doi: 10.3389/fpubh.2022.799365

INTRODUCTION

Extreme heat events around the world are occurring more frequently due to climate change caused by human activities (1). These events have gradually evolved into severe meteorological disasters (2) and have adversely affected the development of human society and health (3, 4). In the past few decades, continuous urbanization has increased the intensity and duration of hot days in coastal metropolitan areas (5, 6). Due to the accelerated concentration of population and capital, extreme heat events are becoming more frequent in developed areas along the southeast coast of China (7–9), such as Xiamen.

Xiamen, an important central city and tourist location, has nearly 4.11 million inhabitants. It has a total area of 1700.61 km^2, of which the land area of Xiamen Island is 157.98 km^2 (including Gulangyu), and the sea area is ∼390 km^2. There are six districts in the Xiamen metropolitan area, among which Siming and Huli are located on Xiamen Island, while Haicang, Jimei, Tong'an, and Xiang'an are located in other areas. Since the early 1980s, temperatures in Xiamen have continued to rise, and heat events have occurred more frequently. According to meteorological data from the Fujian Meteorological Bureau, there were 24 heat wave events from 1980 to 2014, with an average temperature rise of 0.43°C per decade and extreme temperatures of up to 39.2°C. Under the influence of buildings and background winds (10), the intensity of Xiamen's urban heat island may further increase, leading to an expansion of the adverse effects of extreme heat events. Despite Xiamen Island having a large population, favorable economic and social conditions, and an attractive natural environment (**Figure 1**), there has been little verification of whether the residents of Xiamen Island are better able to cope with the health threats of hot weather.

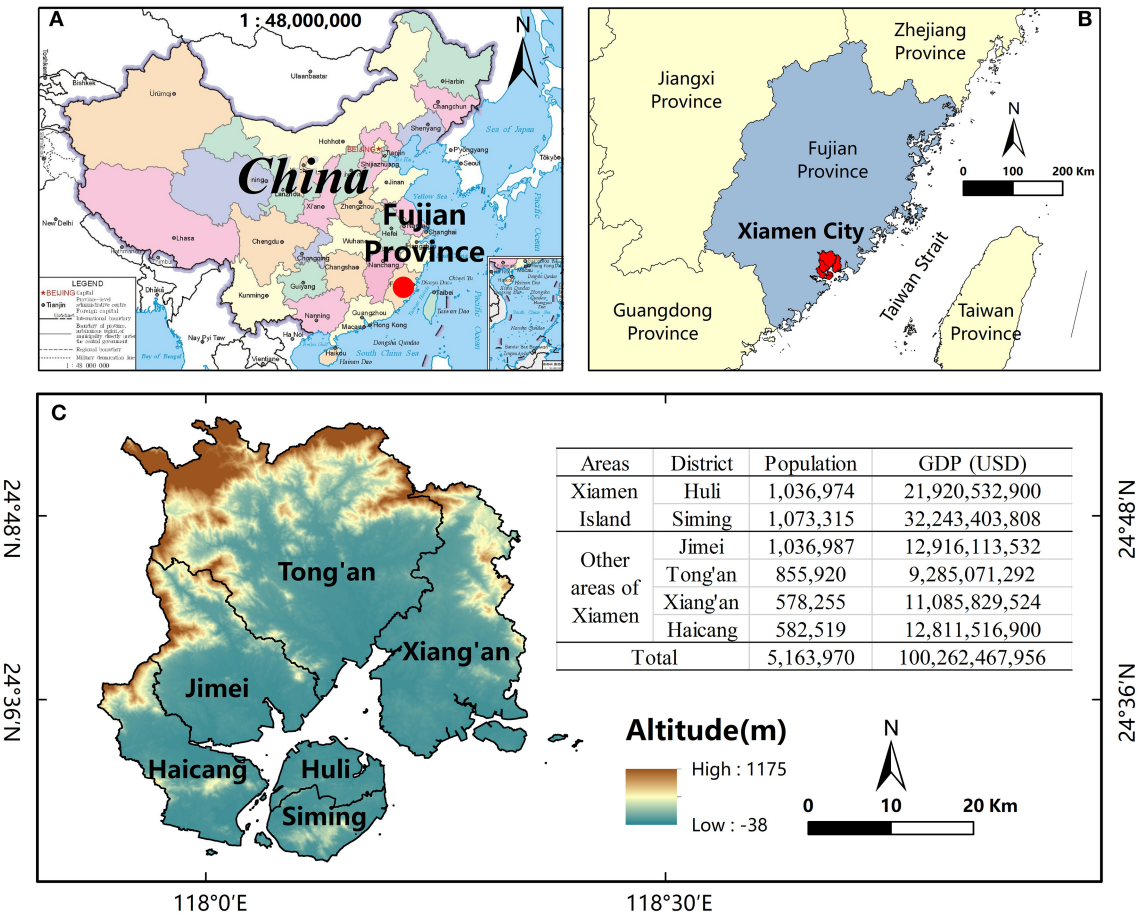
Extreme heat events have threatened the health and livelihood of coastal metropolitan residents (11–13). It has been proven that there is a significant correlation between extreme heat and people's subjective health status. The incidence of cardiovascular, respiratory, and digestive tract diseases caused by scorching weather is on the rise (14–16). However, it is still unclear which groups in coastal metropolitan areas are more sensitive or vulnerable to hot weather, and there is an urgent need to know what measures can people take to cope with potential heat health threats and what targeted policies, such as welfare and public investment, can be developed by community groups and local governments to reduce the loss of life, health, and property during extreme heat events. In the face of these problems, we should treat human society and the natural environment as a unified unit (17). National Research Council of the National Academy of Sciences (18) believes that understanding why some people or regions are better able to cope with the negative impacts of climate change should focus on the geographical differences in exposure, vulnerability, and AC from the perspective of vulnerability, and adaptive capacity of the human-environmental system under external stress (extreme heat).

IPCC's report (19) defines AC as "the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences." The report affirms the importance of AC in assessing vulnerability to climate change. As a crucial component of the vulnerability of the human-environment system, AC can mobilize scarce resources to cope with expectations or current pressures, thus affecting the ultimate potential of achieving sustainable adaptation (20). Therefore, knowing and understanding HAC has become critical for the development of health policies and adaptation actions to enhance the ability of residents to cope with heat stress. HAC studies can also provide information for understanding the primary conditions of adaptation to extreme heat to support the governments, stakeholders, and residents in governance and decision-making. Recently, scholars have attempted to incorporate AC into the conceptual framework for constructing urban heat vulnerability evaluation models in the coupled study of urban heat hazards and human health. These studies used socio-demographic factors (e.g., age, gender), economic status, and incidence of chronic disease as indicators for assessing AC (21–26).

Adaptation is a complex problem (27). AC is measured differently at various temporal and spatial scales, in different cultural contexts, and with different social objectives (22, 28–31). The AC of an individual, city, or community is often affected by a series of decisive factors (29, 32). Therefore, it is imperative to determine how AC is built, what constitutes it, and what hinders or limits it (28). A research report (33), co-authored by the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation and the European Topic Centre on Spatial Information and Analysis, made a proposal to focus on AC from three aspects: "Ability," "Action," and "Awareness." However, the quantitative measurement and spatial characterization of residents' HAC remain a challenging subject, and few studies have been devoted to exploring the means for residents to enhance their AC in the face of pressure in hot weather. From the perspective of the human-environment system, it is necessary to explore residents' HAC in terms of individual characteristics, household characteristics, government actions (34, 35), which allows us to get insight into the mechanisms by which people and the environment work together to cope with external interference (extreme heat) and to explain the composition of factors influencing HAC. In addition, current research on urban heat vulnerability or AC may not be interpreted at the level of individuals and their perceptions, which may have implications for the effective implementation of integrated person-centered health policies. It is increasingly recognized that the development of appropriate adaptation strategies requires a deeper understanding of the impacts of climate change on human beings (13, 36). Although it is relatively rare to collect information about residents' HAC through interviews or questionnaires, these methods are very effective for making observations about exposure, sensitivity, and AC at multiple scales (18, 37–39).

In this study, a questionnaire survey was conducted among the residents of Xiamen to: (1) explore their HAC and identify its significant influencing factors in terms of individual characteristics, household characteristics, government actions; (2) highlight the differences in their HAC and the influencing

Abbreviations: HAC, heat adaptive capacity; AC, adaptive capacity.



Areas	District	Population	GDP (USD)
Xiamen Island	Huli	1,036,974	21,920,532,900
	Siming	1,073,315	32,243,403,808
Other areas of Xiamen	Jimei	1,036,987	12,916,113,532
	Tong'an	855,920	9,285,071,292
	Xiang'an	578,255	11,085,829,524
	Haicang	582,519	12,811,516,900
Total		5,163,970	100,262,467,956

FIGURE 1 | The location of Xiamen City. **(A)** Fujian Province in China; **(B)** Xiamen City in Fujian Province; **(C)** the six districts and elevation map of Xiamen City. Background map source: National Geomatics Center of China. Population data source: the 7th National Census (2020). GDP data source: 2021 Yearbook of Xiamen Special Economic Zone.

factors between Xiamen Island and other areas of Xiamen. Identifying these conditions can provide a scientific reference for policymakers to develop implementable health policies to improve the HAC of residents in metropolitan areas and reduce the health damage caused by extreme heat.

MATERIALS AND METHODS

Selection of Characteristics Associated With Residents' HAC

Residents' HAC should be examined on both a small-scale (individuals and households) and a large-scale (local governments and community groups). To investigate HAC on a smaller scale, individual HAC scales should include personal cognition, attitude, and the methods by which people protected themselves from heat stress (33, 40). HAC, on the individual and household scale, can be measured in terms of age, education level, health status, household economic status, housing conditions, information access, and other factors (22, 24, 41–43). To examine HAC on a larger scale, the impact of cooling programs and services provided by the community and municipality on the behaviors and ability of individuals to withstand heat waves should be investigated, since the residents directly experience and benefit from these services and facilities. HAC, on a larger scale, is influenced by the construction of urban cooling facilities, medical support configuration, heat forecasts, early warning information pushing, municipal cooling operations, and landscape configuration, among others (22, 24, 41, 44). This can serve as a reference for recommendations on the facilities and services that local governments should provide to cope with urban heat waves. Based on the perspective of the human-environment system, this approach is conducive to a deeper understanding of the challenges, needs, and practices of the city in the face of extreme heat events.

Combining the literature point of view and the consultation results of experts in related fields, we list the characteristics associated with residents' HAC that were used in our questionnaire and analysis (**Table 1**).

TABLE 1 | Characteristics associated with residents' HAC.

Scales	Indicators	Characteristics
Individuals	Personal characteristics	Gender (45, 46)
		Age (21, 47)
		Body Mass Index (24)
		Education level (21–23)
		Health status (22)
		Hours spent outdoors per day (48)
	Awareness and action to prevent heat waves	Obtain hot weather information initiatively (40)
		Go out for cooling centers initiatively (40)
Households	Household characteristics	Number of family members (49)
		Monthly household income (22, 47)
		Building area (50)
		Number of air conditioning units in household (43, 51)
		Number of fans in household
		Years of local residence
		Number of rooms in household
Local governments and community groups	Convenience of accessing various facilities or spaces	Access to cooling facilities (21, 41)
		Access to medical support facilities (45)
		Access to public transportation facilities
		Access to river-waterfront spaces (21)
		Access to green spaces (52, 53)
	Frequency of various services provided by community and municipality	Frequency of releasing hot weather information (40)
		Frequency of street sprinkling operations by municipal departments

Data Collection

Data collection was divided into two steps: questionnaire design and formal implementation. In the first stage, the questionnaire was designed objectively based on the 22 characteristics listed in **Table 1** (the questionnaire can be obtained in **Supplementary Data Sheet 1**). Residents living in Xiamen City were the target population for the survey. A five-point Likert scale was used to measure subjective questions, which facilitated the subsequent quantitative analysis. At the end of the questionnaire, participants were asked to rate their own HAC based on their responses to the previous questions. A semantic difference scale was used to classify the rating scale into five levels: lowest, low, medium, high, and highest. The scale and questions were evaluated by several experts before the questionnaire was completed. A pre-survey was conducted, and the questionnaire was further optimized based on the feedback. Finally, the survey was conducted in Xiamen, China from August 7 to August 14, 2018, employing the formal questionnaire.

Survey sites were determined based on spatial and random sampling. A total of 57 locations were selected in Xiamen Island and other areas of Xiamen, mainly in parks, shopping complexes, universities, and residential areas. The participants completed the questionnaire independently. For those with limited capacity to read and write, the investigator dictated the questions and filled in their answers. To ensure the authenticity and validity of the information, the questionnaires were filled in for 10–30 min. A total of 691 questionnaires were distributed, and 630 valid questionnaires were returned, with a valid return rate of 91.17%.

Statistical Method

For data analysis, IBM SPSS 21.0 (International Business Machines Corporation, Armonk, NY, USA) was used. To identify the differences between Xiamen Island and other areas of Xiamen in terms of individual characteristics, household characteristics, and government actions, a descriptive analysis was conducted, followed by ANOVA and Chi-square test. Finally, an ordinal logistic regression model was used to identify the factors that significantly influenced residents' HAC. The ordinal logistic regression model was established according to the following steps: ① suspicious variables affecting residents' HAC were analyzed using a univariate ordinal logistic regression model, and the statistically significant variables were selected (significance level was set at $p < 0.15$); ② screened variables in Step 1 were diagnosed by multicollinearity, and variables with a variance inflation factor >2 were eliminated; ③ the remaining variables were analyzed using an ordinal logistic regression model (significance level was set at $p < 0.05$).

Model Specification

This study used a logistic regression model to further identify the factors influencing residents' HAC. The independent variables of the model are the characteristics selected in **Table 1**, which have been conceptualized as questions in the questionnaire. The options for the questions were coded as numbers before the analysis for easy input into the model. Residents' HAC was chosen as the dependent variable. Since the dependent variable was ordinal, the ordinal logistic regression model was chosen for this study.

Suppose the dependent variable Y has k levels, and the probability of each level was explained as $\pi_1, \pi_2, \pi_3, \ldots, \pi_k$, then $\pi_1 + \pi_2 + \pi_3 + \ldots + \pi_k = 1$. The effect of P different factors (the explanatory variables were denoted as x) on the probability of each category of the explanatory variables can be analyzed as a $k-1$ model (54), constructed as follows:

$$-\ln\left[-ln(\pi_1)\right] = \alpha_1 + \beta_1 x_1 + \ldots + \beta_p x_p \quad (1)$$

$$-\ln\left[-ln(\pi_1 + \pi_2)\right] = \alpha_2 + \beta_1 x_1 + \ldots + \beta_p x_p \quad (2)$$

$$-\ln\left\{-\ln\left[\pi_1 + \pi_2 + \ldots + \pi_{k-1}\right]\right\} = \alpha_{k-1} + \beta_1 x_1 + \ldots + \beta_p x_p \quad (3)$$

where α is the threshold (constant term), and β is the position parameter (regression coefficient).

RESULTS

Supplementary Tables 2, **3** show that the proportion of male participants is greater than females (55.40% males and 44.60%

females), comparable to the gender distribution of the resident population in Xiamen in the 7th National Census in 2020 (52.68% males and 47.32% females). The results of the Chi-square test show that there were no statistically significant differences in the characteristics associated with participants' HAC, except for the number of fans in household, regardless of whether the participants lived on Xiamen Island or other areas of Xiamen. Overall, 92.06% of participants reported their HAC as "medium" or above, of which almost half (48.10%) described their HAC as "medium." (**Supplementary Tables 2**, **3** can be obtained in **Supplementary Data Sheet 2**).

Table 2 presents the three ordinal logistic regression models constructed in this study. The models are statistically significant, the degree of fit is good, and the hypothesis of "comparative advantage" of the model is established. The parallel lines test shows that the individual regression equations created by the model are parallel to each other. Therefore, the three models were suitable for studying the factors influencing residents' HAC.

All Areas of Xiamen

Table 2 shows that among individuals' characteristics, education level and hours spent outdoors per day had significant effects on participants' HAC. Participants with no educational background were likely to have higher HAC than those with education level at university and above. Participants who spent less than one hour outdoors showed a significant disadvantage in HAC compared to those who spent more than eight hours outdoors.

From the household aspects, the number of rooms in household and monthly household income had a positive effect on participants' HAC. As the number of rooms in household increased, participants' HAC would significantly improve. Participants with a monthly household income of more than RMB 20,000 were likely to report better HAC than those with a monthly household income of <RMB 2,000, RMB 2,000–5,000, and RMB 5,000–10,000.

Neither variable had a significant effect on participants' HAC in terms of their awareness and action to prevent heat-stroke. However, the convenience of accessing green spaces significantly affected participants' HAC, as demonstrated by the participants who found it "hard" and "general" to access green spaces were likely to report lower HAC compared to participants who found it "very easy" to access green spaces. When participants perceived that the municipalities "never" and "seldom" sprinkled water on the streets, they were likely to report lower HAC than those who perceived that the municipalities "always" sprinkled water on the streets.

Xiamen Island and Other Areas of Xiamen

Table 2 shows that the factors significantly influencing the participants' HAC on Xiamen Island and those in other areas of Xiamen were different.

Participants from Xiamen Island reported their HAC that was not influenced by their education background, but participants from other areas of Xiamen with no educational background reported significantly better HAC than those with university and higher education level. For participants living on Xiamen Island, if they spent less than one an hour outdoors per day, their HAC was more likely to be weaker than those who spent more than eight hours outdoors. In contrast, those living in other areas of Xiamen were not affected by the hours spent outdoors per day.

In terms of household characteristics, participants' HAC was influenced by monthly household income, regardless of whether they lived on Xiamen Island or in other areas. Participants living on Xiamen Island with a monthly household income of more than RMB 20,000 were likely to report better HAC than those with RMB 2,000–5,000. However, in other areas of Xiamen, participants with a monthly household income of more than RMB 20,000 were likely to report better HAC than those with <RMB 2,000 and those with RMB 5,000–10,000.

Years of local residence and number of air conditioners units in household had significant effects on the participants' HAC on Xiamen Island, indicating that participants who had lived locally for only one–three years might report weaker HAC than those who had lived locally for more than 10 years, and that participants' HAC might decrease as the number of air conditioners units in household increased. However, the above two factors had no impact on participants living in other areas of Xiamen, whose HAC was chiefly influenced by building area and number of rooms in household. Participants with <50 m^2 of building area were likely to report higher HAC than those with more than 200 m^2. On the other hand, participants with more rooms in their households might report stronger HAC.

The convenience of accessing green spaces had significant effect on participants' HAC regardless of whether they lived on Xiamen Island or other areas of Xiamen. On Xiamen Island, participants who found it "very difficult," "difficult," "fair," and "easy" to access green spaces were likely to report weaker HAC compared to those with green spaces close at hand, while for participants living in other areas of Xiamen, only those who found it "difficult" to access green spaces might report weaker HAC.

DISCUSSION

This survey reflected the potential need of Xiamen residents to withstand hot weather. Unlike previous studies that used macroeconomic statistics (22, 41, 55), this study used semi-structured interviews to obtain a large sample of data, which provided a more comprehensive picture of residents' HAC. In the past, the Siming and Huli (Xiamen Island) had advantages over the four districts (other areas of Xiamen) in many aspects such as population, education, capital, healthcare, natural environment; the region's ability to cope with high temperatures could have been enhanced employing these. The Xiamen government had been actively implementing an integration strategy to promote the joint development of Xiamen Island and other areas of Xiamen in recent years. The local governments took equity and fairness into account in the integrated development of metropolitan areas. **Supplementary Table 3** shows that the participants' HAC did not show statistically significant differences between Xiamen Island and other areas of Xiamen, which also indicated the achievements of the Xiamen government's

TABLE 2 | Factors significantly influencing residents' HAC based on results of ordinal logistic regression.

Factors	Model I (All areas of Xiamen)			Model II (Xiamen Island)			Model III (Other areas of Xiamen)		
	Estimate	95% CI		Estimate	95% CI		Estimate	95% CI	
		Lower	Upper		Lower	Upper		Lower	Upper
Number of air conditioning units in household	-	-	-	–0.092*	–0.179	–0.006	-	-	-
Number of rooms in household	0.095*	0.009	0.182	-	-	-	0.195**	0.054	0.337
[Education level = 1]	4.297***	2.084	6.511	-	-	-	3.607*	0.836	6.379
[Education level = 2]	0.631	−0.535	1.798	-	-	-	−0.982	−2.943	0.979
[Education level = 3]	0.411	−0.110	0.932	-	-	-	0.249	−0.499	0.997
[Education level = 4]	0.231	−0.176	0.638	-	-	-	0.486	−0.126	1.098
[Education level = 5]	0[a]	-	-	-	-	-	0[a]	-	-
[Hours spent outdoors per day = 1]	–1.051**	–1.772	-0.330	–1.283*	–2.416	–0.150	-	-	-
[Hours spent outdoors per day = 2]	−0.312	−0.936	0.312	−0.365	−1.365	0.635	-	-	-
[Hours spent outdoors per day = 3]	−0.602	−1.258	0.054	−0.745	−1.811	0.322	-	-	-
[Hours spent outdoors per day = 4]	−0.363	−1.138	0.412	0.503	−0.854	1.860	-	-	-
[Hours spent outdoors per day = 5]	0[a]	-	-	0[a]	-	-	-	-	-
[Building area = 1]	-	-	-	-	-	-	1.808*	0.134	3.481
[Building area = 2]	-	-	-	-	-	-	0.663	−0.875	2.201
[Building area = 3]	-	-	-	-	-	-	0.488	−0.973	1.949
[Building area = 4]	-	-	-	-	-	-	0.456	−1.199	2.111
[Building area = 5]	-	-	-	-	-	-	0[a]	-	-
[Years of local residence = 1]	-	-	-	0.144	−0.821	1.109	-	-	-
[Years of local residence = 2]	-	-	-	–0.880*	–1.712	–0.048	-	-	-
[Years of local residence = 3]	-	-	-	0.047	−0.783	0.877	-	-	-
[Years of local residence = 4]	-	-	-	−0.303	−1.045	0.438	-	-	-
[Years of local residence = 5]	-	-	-	0[a]	-	-	-	-	-
[Monthly household income = 1]	–1.486***	–2.285	–0.687	−1.117	−2.296	0.063	–1.989**	–3.231	–0.747
[Monthly household income = 2]	–0.942**	–1.621	–0.264	–1.446**	–2.440	–0.453	−0.936	−1.931	0.059
[Monthly household income = 3]	–0.842**	–1.401	–0.283	−0.576	−1.430	0.278	–1.339**	–2.167	–0.510
[Monthly household income = 4]	−0.441	−0.997	0.115	−0.640	−1.490	0.211	−0.549	−1.395	0.297
[Monthly household income = 5]	0[a]	-	-	0[a]	-	-	0[a]	-	-
[Access to green spaces = 1]	0.335	−0.922	1.591	–2.795*	–5.065	–0.525	0.745	−0.761	2.252
[Access to green spaces = 2]	–1.074**	–1.853	–0.296	–1.754**	–3.015	–0.493	–1.274*	–2.428	–0.120
[Access to green spaces = 3]	–0.878*	–1.596	–0.161	–1.873**	–3.072	–0.674	−0.462	−1.420	0.495
[Access to green spaces = 4]	−0.507	−1.090	0.076	–1.390**	–2.429	–0.351	−0.108	−0.830	0.614
[Access to green spaces = 5]	0[a]	-	-	0[a]	-	-	0[a]	-	-
[Frequency of street sprinkling = 1]	–0.970*	–1.833	–0.108	-	-	-	-	-	-
[Frequency of street sprinkling = 2]	–0.824*	–1.520	–0.127	-	-	-	-	-	-
[Frequency of street sprinkling = 3]	−0.534	−1.199	0.132	-	-	-	-	-	-
[Frequency of street sprinkling = 4]	−0.449	−1.093	0.196	-	-	-	-	-	-
[Frequency of street sprinkling = 5]	0[a]	-	-	-	-	-	-	-	-
Model Fitting Information:	$\chi^2 = 131.870$, $p < 0.001$			$\chi^2 = 88.304$, $p < 0.001$			$\chi^2 = 83.748$, $p < 0.001$		
Goodness of Fit:	Pearson $\chi^2 = 2628.604$, $p < 0.01$			Pearson $\chi^2 = 1475.595$, $p < 0.001$			Pearson $\chi^2 = 1258.823$, $p < 0.01$		
Cox and Snell	0.192			0.282			0.245		
Test of Parallel Lines:	–2 Log Likelihood: 1097.708, $\chi^2 = 166.293$, $p = 0.457$			–2 Log Likelihood: 419.653, $\chi^2 = 86.025$, $p = 0.999$			–2 Log Likelihood: 459.365, $\chi^2 = 147.220$, $p = 0.223$		

Link function: Logit.

[a]*This parameter is redundant; thus, it is set to zero.*

**Significant at the 0.05 level.*

***Significant at the 0.01 level.*

****Significant at the 0.001 level.*

efforts in the fields of employment, education, and urban infrastructure construction.

In this study, factors such as gender, age, BMI, health status, and the number of family members had no significant effects on residents' HAC. This is inconsistent with findings suggesting that the elderly and people with poor health status were heat sensitive and faced a higher health risk (22, 56, 57). It is to be noted that the proportion of children and elderly population in the study was small, and which might lead to a bias of the level of residents' HAC. However, this finding is similar to research conducted in Oakland, a coastal metropolis adjacent to San Francisco Bay. While a high percentage of low-income individuals lived in the urban center of Oakland, they did not demonstrate significant heat vulnerability and poor AC due to the lack of green spaces, old age, or health issues (22). Xiamen is a coastal metropolis with a large local population of older adults (according to the data of the 7th National Census, the population of Xiamen aged 60 and above was 493,579, accounting for 9.56%; an increase of 2.63% from the 6th National Census). Recently, Xiamen had established an "old-age service system" that is "home-based, community-supported, institutionally supplemented, and medical care-combined" covering both urban and rural areas (58). Xiamen's well-developed medical infrastructure and "old-age service system" can help treat the elderly who have suffered from the effects of heat waves.

Our results indicated that participants who lacked educational experience might report stronger HAC. However, our study might not provide a good representation of this group since only four such participants were surveyed. People with only high school education or less are associated with higher rates of heat-related deaths in previous studies (22, 59). Further research may be needed to investigate whether groups lacking educational experience are vulnerable and susceptible to heat in a coastal Chinese metropolis such as Xiamen. This finding also indicated no statistical difference in the ability of the participants with higher education levels to cope with hot weather. In **Supplementary Table 3**, the education level of participants was mainly concentrated at the university level and above. It is undeniable that residents with higher education levels have more experience and knowledge dealing with the health threats of hot weather.

We found that participants who spent less than an hour outdoors reported significantly weaker HAC than those who spent more than 8 h outdoors, especially in participants from Xiamen Island. This finding, to the best of our knowledge, is novel. During the study, we also found that many people who worked long hours outdoors, such as food delivery workers, leaflet distributors, marketing staff, and sanitation workers, indicated strong AC to hot weather. While they believed that the heat makes their work more difficult and burdensome, they were not afraid. Another interesting finding in our results is that the more air conditioning units the participants had in their households on Xiamen Island, the lower their HAC. Cheung and Jim (43) found that air conditioning units in poorly ventilated houses led to the deterioration of indoor air quality, and pressure in hot weather was also observed. Poor ventilation was associated with sick building syndrome (SBS) (51, 60). Therefore, we recommend that residents living on Xiamen Island do not stay indoors for a long time, and opening windows to get fresh air is essential.

Monthly household income had been affirmed to reduce heat vulnerability for residents in several studies (22, 24, 25, 41), this is consistent with the results of our study. Low-income individuals in Seoul had a higher mortality rate during hot weather (61). Low-income families also tended to have higher heat vulnerability (25) and lack air-conditioning equipment (37). To be sure, income, as found in previous studies, also plays a role in reducing heat risk for individuals and households in coastal metropolitan areas.

Our survey results showed that most participants (43.46%) from Xiamen Island had resided there locally for more than 10 years. They reported significantly higher HAC than those who had only lived there for one–three years. However, notably, the effect of years of local residence was not significant for participants from other areas of Xiamen. Compared to migrant workers and graduates who have lived locally for a shorter period, those who settled in Xiamen Island for a more extended period were more aware of the heat wave patterns occurring in the area. Since they know how to access cooling and medical resources faster, they may be better equipped to cope with the heat. This reflects the importance of personal experiences in withstanding natural disasters (62).

Our findings showed that more rooms in household might have stronger HAC, as reported by participants in the other areas of Xiamen. The number of rooms and building areas indirectly reflects the living conditions and economic status of the residents. Typically, the larger the living area, the better the ventilation and space for activities. Lim and Skidmore (25) found that people living in mobile or rented homes were more vulnerable to extreme heat. However, participants living in houses with a building area of <50 m^2 in the other areas of Xiamen reported stronger HAC. This may reflect a unique group; renters, who share a whole house, to save money despite the small sizes of the rooms. It also indicates that these groups in Xiamen may not rely on the cooling environment provided by their housing. The methods and resources renters utilize to cope with heat are worth exploring further.

In our survey, participants who rarely obtained information about hot weather (29.74 and 31.48% for Xiamen Island and other areas of Xiamen, respectively) and who were less likely to go out to find cooling centers (33.01 and 35.80% for Xiamen Island and other areas of Xiamen, respectively) accounted for a large proportion of the participants. The participants did not seem interested in obtaining information about the hot weather and cooling centers. Considering the pleasant climate of coastal metropolitan areas, residents may not have worried about the effects of high temperatures. In Xiamen, the average number of air conditioning units reported by participants was 2.43. Since they had one fan in their households at least, it was considered adequate cooling equipment, and there was no need for them to go out and find a public cooling center initiatively.

Various facilities and cooling services, especially green spaces and sprinkling water on the streets, provided by the local governments and community groups, had been

confirmed in this study to have a positive impact on residents' HAC. Green spaces have been shown to alleviate the urban heat island effect (52). They provided health benefits for residents who can enjoy staying under the shade of trees (53), which could help improve personal HAC. For cities, sprinkling water on the streets is an effective measure for mitigating a surface urban heat island (63). Which can also contribute to a cooler and healthier living environment for urban residents.

Limitations

One major drawback of this study is that it was only conducted in one metropolis along the southeastern coast of China. The sample size of 630 participants is not representative of the entire population of Xiamen, nor is it representative of coastal metropolises like Xiamen. Although this study involved the specific characteristics of individuals coping with heat risk in material and economic aspects, it did not explore the impact of environmental differences in nature and culture on residents' HAC. Furthermore, we could not completely rule out subjectivity in the questionnaire survey. Finally, not all the results can be directly compared with those of other studies, and further comparative studies are needed to extend the approach of this study to other coastal metropolises.

CONCLUSION

In the context of global warming, metropolises are increasingly becoming threatened by extreme heat such that those lacking the measures and capacity to withstand heat-related disasters may experience severe losses. It is essential to focus on the regional prerequisites of Xiamen compared with other countries and climate zones, and gain insight into residents' HAC at multiple scales for detailed, targeted strategies against extreme heat. For this, a questionnaire survey was conducted among residents of Xiamen to gather information about their HAC. The findings and methods employed in this study can be easily extended to other similar coastal metropolitan areas. This investigation is vital for urban residents and local governments because extreme heat events are directly related to human health and community well-being. For cities, authorities urgently need to develop people-centered preparedness plans and disposal measures to reduce heat disaster losses and achieve sustainable urban development for the decades to come.

There is a spatial heterogeneity in the factors influencing residents' HAC, and the influencing mechanisms of individual characteristics and socioeconomic conditions also vary across different areas of Xiamen city. In our study, groups sensitive to heat in previous studies, including local residents and outdoor workers on Xiamen Island and people with lower education levels and renters in other areas of Xiamen, did not show low HAC levels. Further research should explore why these groups may be well-equipped to cope with hot weather.

Our findings confirmed the role of monthly household income, the convenience of accessing green spaces, and city cooling services in improving residents' HAC and living environments. Local governments and community groups should implement targeted plans to prevent potential health injuries to residents with lower household income levels during extreme heat events. Authorities in Xiamen should create plans for urban green spaces and provide cooling services, like sprinkling water on the streets during hot days, which would mitigate the damage caused by extreme heat events and improve residents' HAC.

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.

ETHICS STATEMENT

Approval of all ethical and experimental procedures and protocols was granted by the Ethics Committee of Fuzhou University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

WS: conceptualization and research design. CW: software and results analysis. CW and HY: writing—original draft preparation. CW, HY, MM, SZ, YL, HL, FW, KW, and XS: review and editing. All authors have read and agreed to the published version of the manuscript.

FUNDING

This research was funded by National Key Research and Development Plan Program of China (2016YFC0502905).

ACKNOWLEDGMENTS

We would like to thank all participants involved in this study, as well as the funding support from the National Key Research and Development Plan Program of China. We would like to express our sincere thanks to Shuting Chen, Haiyuan Huang, Duoduo Lin, Dong Lin, Ya'nan Wang, Bingxiong Fan, Xiaomei Jian, and Yin Fu for interviewing participants in the current study and for their work and efforts during the hot days.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.799365/full#supplementary-material

REFERENCES

1. Seneviratne SI, Zhang X, Adnan M, Badi W, Dereczynski C, Di Luca A, et al. Weather and climate extreme events in a changing climate. In: Masson Delmotte V, Zhai P, Pirani A, Connors SL, Péan C, Berger S, Caud N, Chen Y, Goldfarb L, Gomis MI, Huang M, Leitzell K, Lonnoy E, Matthews JBR, Maycock TK, Waterfield T, Yelekçi O, Yu R, Zhou B, editors. *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge; New York, NY: Cambridge University Press (in press). 1–345. Available online at: https://www.ipcc.ch/report/ar6/wg1/
2. Fischer EM, Knutti R. Anthropogenic contribution to global occurrence of heavy-precipitation and high-temperature extremes. *Nat Clim Chang.* (2015) 5:560–4. doi: 10.1038/nclimate2617
3. Stillman JH. Heat Waves, the New Normal: Summertime temperature extremes will impact animals, ecosystems, and human communities. *Physiology.* (2019) 34:86–100. doi: 10.1152/physiol.00040.2018
4. Easterling DR, Meehl GA, Parmesan C, Changnon SA, Karl TR, Mearns LO. Climate extremes: observations, modeling, and impacts. *Science.* (2000) 289:2068–74. doi: 10.1126/science.289.5487.2068
5. Yang X, Yue W, Xu H, Wu J, He Y. Environmental consequences of rapid urbanization in Zhejiang province, East China. *Int J Environ Res Public Health.* (2014) 11:7045–59. doi: 10.3390/ijerph110707045
6. Li D, Zhou T, Zou L, Zhang W, Zhang L. Extreme high-temperature events over East Asia in 15°C and 2°C warmer futures: analysis of NCAR CESM low-warming experiments. *Geophys Res Lett.* (2018) 45:1541–50. doi: 10.1002/2017GL076753
7. Luo M, Lau N-C. Heat waves in Southern China: synoptic behavior, long-term change, and urbanization effects. *J Clim.* (2017) 30:703–20. doi: 10.1175/JCLI-D-16-0269.1
8. Wang Y, Chen L, Song Z, Huang Z, Ge E, Lin L, et al. Human-perceived temperature changes over South China: long-term trends and urbanization effects. *Atmos Res.* (2019) 215:116–27. doi: 10.1016/j.atmosres.2018.09.006
9. Yang X, Ruby Leung L, Zhao N, Zhao C, Qian Y, Hu K, et al. Contribution of urbanization to the increase of extreme heat events in an urban agglomeration in east China. *Geophys Res Lett.* (2017) 44:6940–50. doi: 10.1002/2017GL074084
10. Wang F, Wang YW. Potential role of local contributions to record-breaking high-temperature event in Xiamen, China. *Weather Clim Extremes.* (2021) 33:100338. doi: 10.1016/j.wace.2021.100338
11. Huang W, Kan H, Kovats S. The impact of the 2003 heat wave on mortality in Shanghai, China. *Sci Total Environ.* (2010) 408:2418–20. doi: 10.1016/j.scitotenv.2010.02.009
12. Guirguis K, Gershunov A, Tardy A, Basu R. The impact of recent heat waves on human health in California. *J Appl Meteorol Climatol.* (2014) 53:3–19. doi: 10.1175/JAMC-D-13-0130.1
13. Nori-Sarma A, Benmarhnia T, Rajiva A, Azhar GS, Gupta P, Pednekar MS, et al. Advancing our understanding of heat wave criteria and associated health impacts to improve heat wave alerts in developing country settings. *Int J Environ Res Public Health.* (2019) 16:2089. doi: 10.3390/ijerph16122089
14. Peters A, Schneider A. Cardiovascular risks of climate change. *Nat Rev Cardiol.* (2021) 18:1–2. doi: 10.1038/s41569-020-00473-5
15. Whitman S, Good G, Donoghue ER, Benbow N, Shou W, Mou S. Mortality in Chicago attributed to the July 1995 heat wave. *Am J Public Health.* (1997) 87:1515–8. doi: 10.2105/AJPH.87.9.1515
16. Gostimirovic M, Novakovic R, Rajkovic J, Djokic V, Terzic D, Putnik S, et al. The influence of climate change on human cardiovascular function. *Arch Environ Occup Health.* (2020) 75:406–14. doi: 10.1080/19338244.2020.1742079
17. Turner BL, Matson PA, McCarthy JJ, Corell RW, Christensen L, Eckley N. e al. Illustrating the coupled human-environment system for vulnerability analysis: three case studies. *Proc Natl Acad Sci U S A.* (2003) 100:8080–5. doi: 10.1073/pnas.1231334100
18. National Research Council. *Understanding the Changing Planet: Strategic Directions for the Geographical Sciences*. Washington, DC: The National Academies Press (2010). p. 41–48.
19. IPCC. Climate Change 2013: The Physical Science Basis. In: Stocker TF, Qin D, Plattner GK, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex B, Midgley PM, editors. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge; New York, NY: Cambridge University Press (2013). p. 1–1535.
20. Araya-Muñoz D, Metzger MJ, Stuart N, Wilson AMW, Alvarez L. Assessing urban adaptive capacity to climate change. *J Environ Manage.* (2016) 183:314–24. doi: 10.1016/j.jenvman.2016.08.060
21. Johnson DP, Stanforth A, Lulla V, Luber G. Developing an applied extreme heat vulnerability index utilizing socioeconomic and environmental data. *Appl Geogr.* (2012) 35:23–31. doi: 10.1016/j.apgeog.2012.04.006
22. Reid CE, O'Neill MS, Gronlund CJ, Brines SJ, Brown DG, Diez-Roux AV, et al. Mapping community determinants of heat vulnerability. *Environ Health Perspect.* (2009) 117:1730–6. doi: 10.1289/ehp.0900683
23. Uejio CK, Wilhelmi OV, Golden JS, Mills DM, Gulino SP, Samenow JP. Intra-urban societal vulnerability to extreme heat: the role of heat exposure and the built environment, socioeconomics, and neighborhood stability. *Health Place.* (2011) 17:498–507. doi: 10.1016/j.healthplace.2010.12.005
24. Wolf T, McGregor G. The development of a heat wave vulnerability index for London, United Kingdom. *Weather Clim Extremes.* (2013) 1:59–68. doi: 10.1016/j.wace.2013.07.004
25. Lim J, Skidmore M. Heat vulnerability and heat island mitigation in the United States. *Atmosphere.* (2020) 11:558. doi: 10.3390/atmos11060558
26. Ho HC, Knudby A, Chi G, Aminipouri M, Lai DY-F. Spatiotemporal analysis of regional socio-economic vulnerability change associated with heat risks in Canada. *Appl Geogr.* (2018) 95:61–70. doi: 10.1016/j.apgeog.2018.04.015
27. Barnett J. O Neill S. *Maladaptation Glob Environ Chang.* (2010) 20:211–3. doi: 10.1016/j.gloenvcha.2009.11.004
28. Adger WN, Dessai S, Goulden M, Hulme M, Lorenzoni I, Nelson DR, et al. Are there social limits to adaptation to climate change? *Clim Change.* (2009) 93:335–54. doi: 10.1007/s10584-008-9520-z
29. Andrijevic M, Byers E, Mastrucci A, Smits J, Fuss S. Future cooling gap in shared socioeconomic pathways. *Environ Res Lett.* (2021) 16:094053. doi: 10.1088/1748-9326/ac2195
30. Hansen A, Nitschke M, Saniotis A, Benson J, Tan Y, Smyth V, et al. Extreme heat and cultural and linguistic minorities in Australia: perceptions of stakeholders. *BMC Public Health.* (2014) 14:550. doi: 10.1186/1471-2458-14-550
31. Stock R, Birkenholtz T, Garg A. Let the people speak: improving regional adaptation policy by combining adaptive capacity assessments with vulnerability perceptions of farmers in Gujarat, India. *Clim Dev.* (2019) 11:138–52. doi: 10.1080/17565529.2017.1410089
32. Smit B, Pilifosova O, Burton I, Challenger B, Huq S, Klein R, et al. *Adaptation to Climate Change in the Context of Sustainable Development and Equity*. Cambridge: Cambridge University Press (2001). 877-912 p.
33. The European Topic Centre on Climate Change Impacts VaAECaTETCoSIaAES. *Urban Vulnerability Indicators, A Joint Report of ETC-CCA and ETC-SIA*. (2012). Available online at: https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/tp_3-2012 (accessed October 6, 2021).
34. Leal Filho W, Echevarria Icaza L, Neht A, Klavins M, Morgan EA. Coping with the impacts of urban heat islands. A literature based study on understanding urban heat vulnerability and the need for resilience in cities in a global climate change context. *J Clean Prod.* (2018) 171:1140–9. doi: 10.1016/j.jclepro.2017.10.086
35. Howarth C, Kantenbacher J, Guida K, Roberts T, Rohse M. Improving resilience to hot weather in the UK: the role of communication, behaviour and social insights in policy interventions. *Environ Sci Policy.* (2019) 94:258–61. doi: 10.1016/j.envsci.2019.01.008
36. Adger WN. Social capital, collective action, and adaptation to climate change. *Econ Geogr.* (2003) 79:387–404. doi: 10.1111/j.1944-8287.2003.tb00220.x
37. Harlan SL, Brazel AJ, Prashad L, Stefanov WL, Larsen L. Neighborhood microclimates and vulnerability to heat stress. *Soc Sci Med.* (2006) 63:2847–63. doi: 10.1016/j.socscimed.2006.07.030
38. Hayden MH, Wilhelmi OV, Banerjee D, Greasby T, Cavanaugh JL, Nepal V, et al. Adaptive capacity to extreme heat: results from a household survey in Houston, Texas. *Weather Clim Soc.* (2017) 9:787–99. doi: 10.1175/WCAS-D-16-0125.1
39. Watkins LE, Wright MK, Kurtz LC, Chakalian PM, Mallen ES, Harlan SL, et al. Extreme heat vulnerability in Phoenix, Arizona: a comparison of all-hazard

and hazard-specific indices with household experiences. *Appl Geogr.* (2021) 131:102430. doi: 10.1016/j.apgeog.2021.102430
40. Wilhelmi OV, Hayden MH. Connecting people and place: a new framework for reducing urban vulnerability to extreme heat. *Environ Res Lett.* (2010) 5:014021. doi: 10.1088/1748-9326/5/1/014021
41. Bradford K, Abrahams L, Hegglin M, Klima K. A heat vulnerability index and adaptation solutions for Pittsburgh, Pennsylvania. *Environ Sci Technol.* (2015) 49:11303–11. doi: 10.1021/acs.est.5b03127
42. Bao J, Li X, Yu C. The construction and validation of the heat vulnerability index, a review. *Int J Environ Res Public Health.* (2015) 12:7220–34. doi: 10.3390/ijerph120707220
43. Cheung PK, Jim CY. Impacts of air conditioning on air quality in tiny homes in Hong Kong. *Sci Total Environ.* (2019) 684:434–44. doi: 10.1016/j.scitotenv.2019.05.354
44. Weber S, Sadoff N, Zell E, de Sherbinin A. Policy-relevant indicators for mapping the vulnerability of urban populations to extreme heat events: a case study of Philadelphia. *Appl Geogr.* (2015) 63:231–43. doi: 10.1016/j.apgeog.2015.07.006
45. Cutter SL, Boruff BJ, Shirley WL. Social vulnerability to environmental hazards. *Soc Sci Q.* (2003) 84:242–61. doi: 10.1111/1540-6237.8402002
46. Yip FY, Flanders WD, Wolkin A, Engelthaler D, Humble W, Neri A, et al. The impact of excess heat events in Maricopa County, Arizona: 2000–2005. *Int J Biometeorol.* (2008) 52:765–72. doi: 10.1007/s00484-008-0169-0
47. Cutter SL, Finch C. Temporal and spatial changes in social vulnerability to natural hazards. *Proc Natl Acad Sci USA.* (2008) 105:2301. doi: 10.1073/pnas.0710375105
48. Lan Q, Liu C, Ling S. Research on measurement of symbiosis degree between national fitness and the sports industry from the perspective of collaborative development. *Int J Environ Res Public Health.* (2019) 16:2191. doi: 10.3390/ijerph16122191
49. Nkondze M, Masuku M, Manyatsi A. Factors affecting households vulnerability to climate change in Swaziland: a case of mpolonjeni area development programme (ADP). *J Agric Sci.* (2013) 5:108–22. doi: 10.5539/jas.v5n10p108
50. Samuelson H, Baniassadi A, Lin A, Gonzalez PI, Brawley T, Narula T. Housing as a critical determinant of heat vulnerability and health. *Sci Total Environ.* (2020) 720:137296. doi: 10.1016/j.scitotenv.2020.137296
51. Tagliabue LC, Re Cecconi F, Rinaldi S, Ciribini ALC. Data driven indoor air quality prediction in educational facilities based on IoT network. *Energy Build.* (2021) 236:110782. doi: 10.1016/j.enbuild.2021.110782
52. Zhang Y, Murray AT, Turner IBL. Optimizing green space locations to reduce daytime and nighttime urban heat island effects in Phoenix, Arizona. *Landsc Urban Plan.* (2017) 165:162–71. doi: 10.1016/j.landurbplan.2017.04.009
53. Kondo MC, Fluehr JM, McKeon T, Branas CC. Urban green space and its impact on human health. *Int J Environ Res Public Health.* (2018) 15:445. doi: 10.3390/ijerph15030445
54. Xue W. *SPSS Statistical Analysis Method and Its Application*. Beijing: Electronic Industry Press (2013). p. 235–6.
55. Yin Ze, Yin J, Zhang X. Multi-scenario-based hazard analysis of high temperature extremes experienced in China during 1951-2010. *J Geogr Sci.* (2013) 23:436–46. doi: 10.1007/s11442-013-1020-z
56. Schwartz J. Who is sensitive to extremes of temperature?: a case-only analysis. *Epidemiology.* (2005) 16:67–72. doi: 10.1097/01.ede.0000147114.25957.71
57. Dumenu WK, Obeng EA. Climate change and rural communities in Ghana: social vulnerability, impacts, adaptations and policy implications. *Environ Sci Policy.* (2016) 55:208–17. doi: 10.1016/j.envsci.2015.10.010
58. Xiamen Municipal Government Office. *Notice of the Xiamen Municipal Government Office on the Publication of the Action Plan to Promote the Development of Elderly Services (2020-2022)*. (2020). Available online at: http://zfgb.xm.gov.cn/gazette/6703 (accessed October 20, 2021).
59. Marie S ON, Antonella Z, Joel S. Modifiers of the temperature and mortality association in seven US cities. *Am J Epidemiol.* (2003) 157:1074–82. doi: 10.1093/aje/kwg096
60. Fisk WJ, Mirer AG, Mendell MJ. Quantitative relationship of sick building syndrome symptoms with ventilation rates. *Indoor Air.* (2009) 19:159–65. doi: 10.1111/j.1600-0668.2008.00575.x
61. Kim Y, Joh S. A vulnerability study of the low-income elderly in the context of high temperature and mortality in Seoul, Korea. *Sci Total Environ.* (2006) 371:82–8. doi: 10.1016/j.scitotenv.2006.08.014
62. Boamah SA, Armah FA, Kuuire VZ, Ajibade I, Luginaah I, McBean G. Does previous experience of floods stimulate the adoption of coping strategies? Evidence from cross sectional surveys in Nigeria and Tanzania. *Environments.* (2015) 2:565–85. doi: 10.3390/environments2040565
63. Meng C. Mitigating the surface urban heat island: mechanism study and sensitivity analysis. *Asia-Pac J Atmos Sci.* (2017) 53:327–38. doi: 10.1007/s13143-017-0036-1

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.

frontiers in Public Health

ORIGINAL RESEARCH
published: 10 March 2022
doi: 10.3389/fpubh.2022.801984

Acceptance and Willingness to Pay for Vaccine Against Human Papilloma Virus (HPV) Among Parents of Boys in Central Vietnam

Lan Hoang Nguyen, Thuy Bich Thi Le, Nhu Quynh Nguyen Le and Nhan Thanh Thi Tran*

Faculty of Public Health, University of Medicine and Pharmacy, Hue University, Hue, Vietnam

Human papilloma virus (HPV) vaccine for adolescents was recommended as an effective prevention strategy of HPV-related cancers. In Vietnam, HPV vaccination has not been introduced to male adolescent. This study was conducted to examine the acceptance of having boys vaccinated against HPV and its underlying reasoning, and to identify their parent's willingness to pay (WTP) for HPV vaccination in central Vietnam. 785 parents of boys were directly interviewed based on a structured questionnaire. Parent's acceptability of HPV vaccine for their sons was identified by one question with response on 3-point scale (agree, don't know, and disagree). Multivariate logistic regression model was used to determine contributing factors to participant's acceptance. Bidding game method was applied to elicit WTP values for HPV vaccination with initial bid of 161.2 USD. The results showed that 49.2% of parents agreed to have their sons vaccinated against HPV. Factors that influenced parent's acceptance including son's age older than 12 years (*OR* = 1.5; 95% *CI*: 1.08–1.98); being eldest son (*OR* = 1.6; 95% *CI*: 1.13–2.19), being mother (*OR* = 1.4; 95% *CI*: 1.01–1.91), parents with high educational level (*OR* = 1.7; 95% *CI*: 1.11–2.47) and their knowledge of HPV and HPV vaccine (*OR* = 1.8; 95% *CI*: 1.23–2.65). Average WTP value for full doses of HPV vaccine was 137.5 USD, ranging between 9 USD and 188.3 USD. Parents' knowledge of HPV and HPV vaccine was the only factor affecting WTP value (Rho: 0.11; *p*-value: 0.030). The findings suggest a strategy be introduced for HPV vaccination to male adolescents in Vietnam.

Keywords: HPV vaccine, acceptance, parents, male adolescent, willingness to pay

OPEN ACCESS

Edited by:
Stefania Salmaso,
Independent Researcher, Rome, Italy

Reviewed by:
Ralitsa Raycheva,
Plovdiv Medical University, Bulgaria
Arcadio A. Cerda,
University of Talca, Chile
Harapan Harapan,
Syiah Kuala University, Indonesia

****Correspondence:***
Lan Hoang Nguyen
nhlan@hueuni.edu.vn

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

Received: *26 October 2021*
Accepted: *09 February 2022*
Published: *10 March 2022*

Citation:
Nguyen LH, Le TBT, Le NQN and Tran NTT (2022) Acceptance and Willingness to Pay for Vaccine Against Human Papilloma Virus (HPV) Among Parents of Boys in Central Vietnam. Front. Public Health 10:801984. doi: 10.3389/fpubh.2022.801984

INTRODUCTION

Human papilloma virus (HPV) is a common group of viruses that are mainly transmitted through sexual contact. Globally, HPV infection has been considered as one of the most common viral infections with an estimation of 32.1% HPV-positive women in 2011. In men, the global prevalence rate of genital HPV infection is almost similar to that in women (2–44%). The prevalence of HPV infection is higher in developing countries and young people (1). There are more than 100 HPV types, and high-risk types are responsible for oropharyngeal cancers and anogenital cancers in both sexes such as cervical, anal, vulvar, vaginal, and penile cancers. Worldwide, cervical cancer is ranked fourth among most common cancers in women with an estimated 570,000 new cases in 2018 representing 7.5% of all female cancer deaths: more than 85% of these occurred in low- and middle-income countries (2, 3).

Human papilloma virus vaccine has been considered as an effective prevention strategy for HPV-related cancers. Until now there are three HPV vaccines, Cervarix for females, Gardasil and Gardasil-9 for females and males, which are licensed by the US Food and Drug Administration (FDA) (4). The Centers for Disease Control and Prevention (CDC) in the USA recommends HPV vaccination for adolescents aged 11–12 years, but it can start at age 9 through 26 if they were not adequately vaccinated previously. Two doses of HPV vaccine are recommended for adolescents ages 9–14 while three-dosed schedule is for people ages 15–26 (5).

According to WHO, 100 countries introduced HPV vaccine into their national vaccination program by 2019; however, they have focused on girls and young women as target population (6). Medical literature proved that HPV vaccination of boys has many benefits including preventing genital warts and HPV-related anogenital and oral cancers in men, preventing anal cancer in MSM group (Men who have Sex with Men) as well as preventing transmission of HPV to female sexual partners, which would decrease HPV-related anogenital cancers in women (7), but HPV vaccination for adolescent boys was approved in few countries and therein rates of vaccine coverage in this group have still much lower than in female group (8–11). Currently, a meta-analysis from 79 studies in 15 countries revealed that proportion of HPV vaccine uptake among parents for their daughters, sons, and both was 46.5, 20.3, and 39.8%, respectively (8). For the countries which offered HPV vaccination for boys, common reasons to impede HPV vaccine uptake among the parents were limited knowledge of HPV vaccine benefits for boys, awareness of availability of HPV vaccine for males, and out of pocket cost of the vaccine (12–16).

In Vietnam, the prevalence of HPV infection among women varied across population ranging between 2 and 11% (17). Information about HPV infection in men was still limited. However, current reports showed that prevalent rate of HPV infection was 25% among male patients with sexually transmitted infections (STIs) and was 23 to 79.6% among patients with penile cancer (18, 19). In 2008, the Ministry of Health approved two types of HPV vaccines including Cervarix and Gardasil with the purpose of preventing cervical cancer for girls and young women. Because these vaccines are not included in the expanded immunization program of the country, users must pay for HPV vaccination, ranging from 45 to 100 USD per dose depending on the provider. Consequently, coverage of HPV vaccination in target group in Vietnam was low. One of the main obstacles in expanding the HPV vaccination program was thought to be lack of national budget for the implementation. Presently, with the support of some international organizations, Vietnam would plan the expansion of HPV vaccination in the country in accordance with the priorities of the local health sector. Consequently, users only pay a much lower price than market price to receive HPV vaccine (20). However, target population for the expansion is still girls only. In line with recommendation of HPV vaccination for males as one of effective solutions for fighting cervical cancers in females as well as HPV-related cancers in both sexes (7), the present study was conducted with the aim of examining acceptance for HPV vaccination for boys and its deciding factors among their parents, and identifying willingness to pay for HPV vaccination for their son. Findings from the study would provide evidences to support Ministry of Health to introduce HPV vaccine to male adolescents in the country.

MATERIALS AND METHODS

Study Setting and Participants

A cross-sectional study was conducted at secondary schools in Hue city which is the capital of Thua Thien Hue province located in central Vietnam. The city has 27 wards which are administrative divisions of the city. These wards are divided into two regions, north and south of Huong river. In 2020, the city has 24 secondary schools with 19,600 students. In Vietnam, secondary schools include 4 grades from sixth to ninth grade, which usually involve students ages 11–15.

The study randomly selected four schools as representatives of geographical regions of the city. Two schools are among 13 schools on the north and others are among 11 schools on the south of the river; then at each region, one school in the central city and another in its periphery were also randomly chosen on the basis of their location on the map of the city. Participants, who were parents of male students and agreed to enroll in the study, were invited to interview. In each school, we conducted interviews after class with the support of homeroom teachers. A total of 785 parents completed the interview giving a response rate of 92.6%.

Data Collection

Data were collected in December 2020 when all schools organized a parent meeting at the beginning of a new school year. After the meeting finished, parents were interviewed directly at the classroom using a structured questionnaire. The interviewers, who were staff and graduated students of the Faculty of Public Health in University of Medicine and Pharmacy, Hue University, were trained on the content of the questionnaire and skills of interview.

Instruments

Structured Questionnaire

The questionnaire consisted of three parts: part 1 was personal characteristics of participants and their sons, family history of HPV-related diseases and HPV vaccination of sons; part 2 was questions to assess parent's knowledge of HPV infection and HPV vaccine; and part 3 was about parent's acceptance and the price of WTP for HPV vaccination for their sons. The questionnaire was pre-tested on 20 random parents of boys ages 11–15 in Hue city and revised before implementing data collection. These parents were not selected from study settings.

Assessment of Knowledge About HPV Infection and HPV Vaccine

The knowledge about HPV infection and HPV vaccine was measured by 14 statements (true/false/don't know), with the convention that 1 point for a correct answer and 0 point for wrong or "don't know" answer. The maximum possible total score for knowledge was 14. The knowledge was rated as "good"

for total score of 7 and above; total scores below 7 were characterized as "not good." The questions about knowledge of HPV infection and its vaccine were developed on the basis of document on HPV of CDC (21). The reliability of the tool assessing knowledge was evaluated using Cronbach's alpha. The results showed that the internal consistency of the tool was good with Cronbach's alpha of 0.90.

Acceptance and Eliciting WTP

Parent's acceptability of HPV vaccine for their sons was identified by one question "do you agree to vaccinate against HPV for your son?" with response on 3-point scale (agree, don't know, disagree). Parents who chose the answer "agree" were continued to be interviewed to obtain a maximum price that they were willing to pay for full doses of HPV vaccine for their son. The bidding game method of contingent valuation was used to elicit WTP price for two doses of Gardasil vaccine. In this study, the initial bid was 3,580,000 VND (about 161.2 USD) that was the current market price for two doses of Gardasil at the time of the survey. The parents would be asked "are you willing to have your son vaccinated against HPV with a price of 3,580,000 VND?" If the answer was "yes," the next questions would increase price incrementally by 200,000 VND (9 USD) until the answer was "no." Then maximum WTP was final price that received the answer "yes." If their answer was "no," the next questions would decrease price incrementally by 200,000 VND until the answer was "yes," and that was maximum WTP. These incremental levels were on the basis of pre-survey on 20 parents of boys ages 11–15 in Hue city. In the study, the lowest price was suggested to be 2,980,000 VND (134.2 USD); however, parents could choose any price in case they could not accept that lowest price. WTP price was presented in both VND and USD. The exchange rate used was that in effect on December 15, 2020 (1 USD = 22,203 VND).

Data Analysis

Descriptive statistics including frequency and percentage was used to summarize the personal characteristics of parents and their sons and the acceptability of HPV vaccination for sons. Multivariate logistic regression model was employed to identify the determinants of parent's acceptability of HPV vaccination for their sons. WTP for HPV vaccination was presented by mean, *SD*, median, and min–max. However, data of WTP was not a normal distribution; non-parametric tests (Mann–Whitney *U* test was used to compare two groups and Kruskal–Wallis test was used to compare three groups) and spearman correlations were used to reveal factors affecting WTP price. An alpha value of 0.05 was considered statistically significant.

RESULTS

Characteristics of Participants and Their Sons

Table 1 describes the main characteristics of 785 parents and their sons. Two-thirds of the participants were mothers. Mean age of parents was 42.9 ($SD = 6.1$) ranging between 29 and 62. Their educational levels were rather high with 44.8% of them attaining college degree or higher. More than half of the parents had unstable income. Twenty-one participants (2.7%) had no income; they were either unemployed or housewife. Most of the participants were maintaining marital status (94.6%). There were 24 parents (3.1%) whose households were classified as poor or near poor. Almost all of them (98.1%) reported that no one of their family suffered a HPV-related disease. The number of children of each parent ranged from 1 to 7 (mean 2.2; $SD = 0.7$) and their average number of sons were 1.5 ($SD = 0.6$) ranging between 1 and 5. Majority of the parents indicated that both father and mother were responsible for making decision on their children's health. The number of male students whose parents participated in the study was distributed higher into sixth and seventh grades. Their mean age was 12.4 years ($SD = 1.2$) ranging between 11 and 15. More than half of the boys were the eldest son. There were 22 sons (2.8%) who suffered either a chronic disease or a birth defect. None of boys was vaccinated against HPV before.

The knowledge about HPV and HPV vaccine of parents was described in **Table 2**. More than two-third of them had not ever heard of HPV. Only 18.9% of parents achieved good level of knowledge of HPV infection and HPV vaccine. Information including benefits of vaccine against HPV infection and HPV-related cancers, sex at risk due to HPV infection and who should be vaccinated against HPV were known by a larger percentage of the parents. In contrast, only a few of parents (<8%) knew ideal age to receive HPV vaccination, dose of HPV vaccine for children under 15 years old, and asymptomatic HPV infection.

Acceptability of HPV Vaccine for Boys and Its Determinants

The study showed that 49.2% of the parents agreed to have their son vaccinated against HPV vaccine.

Results from multivariate logistic regression analysis revealed factors affecting parents' intention to have their sons vaccinated (**Table 3**). Parents of the boys who were older than 12 and were the eldest son were likely 1.5 times ($OR = 1.5$; 95% *CI*: 1.08–1.98) and 1.6 times ($OR = 1.6$; 95% *CI*: 1.13–2.19) to accept HPV vaccination for their sons more than their counterparts, respectively. The mothers were 1.4 times more likely than the fathers to agree to have their son HPV vaccinated ($OR = 1.4$; 95% *CI*: 1.01–1.91). The parents with good knowledge of HPV infection and HPV vaccine were more likely to accept HPV vaccine compared to those with worse knowledge ($OR = 1.8$; 95% *CI*: 1.23–2.65). The parents who attained college degree or higher were more likely to get HPV vaccine for their sons than those with a lower level of education ($OR = 1.7$; 95% *CI*: 1.11–2.47).

The study did not find a significant association between participant's acceptance of HPV vaccination for their sons and other variables including demographical characteristics of parents, their marital status and occupation, economic situation of household, family history of HPV-related diseases, number of children, number of sons, and disease of sons (p-values > 0.05) (**Supplementary Table 1**).

TABLE 1 | Characteristics of participants and their sons ($n = 785$).

Participants		*n*	Percentage
Relations with students	Mother	472	60.1
	Father	313	39.9
Age (years)	Mean (SD): 42.9 (6.1)	Median: 42 Min: 29	Max: 62
Educational level	Secondary school and lower	249	31.8
	High school	184	23.4
	College and higher	352	44.8
Occupation	Stable income	349	44.4
	Unstable income	415	52.9
	No income	21	2.7
Marital status	Living with wife/husband	743	94.6
	Separation/divorce/ widowed	42	5.4
Economic classification of household	Poor/near poor	24	3.1
	Normal	761	96.9
Family history of HPV related diseases	Yes	15	1.9
	No	770	98.1
Number of children	Mean (SD): 2.2 (0.7)	Median: 2 Min: 1	Max: 7
Number of sons	Mean (SD): 1.5 (0.6)	Median: 1 Min: 1	Max: 5
Decision-maker on children's health issues	Father	65	8.3
	Mother	199	25.3
	Both	521	66.4
Their son			
Grade	Sixth	207	26.4
	Seventh	226	28.8
	Eighth	165	21.0
	Ninth	187	23.8
Age (years)	Mean (SD): 12.4 (1.2)	Median: 12 Min: 11	Max: 15
The eldest son	Yes	416	53.0
	No	369	47.0
Chronic diseases/birth defect	Yes	22	2.8
	No	763	97.2
Have been vaccinated against HPV	Yes	0	0.0
	No	785	100

TABLE 2 | Knowledge about Human papilloma virus (HPV) and HPV vaccine of the parents ($n = 785$).

	n	Percent
Heard of HPV		
Yes	208	26.5
No/don't remember	577	73.5
Knowledge about HPV and HPV vaccine		
Good	148	18.9
Not good	637	81.1
Right answers about HPV		
HPV is a sexually transmitted disease	144	18.3
There are many types of HPV	130	16.6
HPV may infect both sexes	178	22.7
HPV can infect you without symptom	56	7.1
HPV infection can cause genital warts	116	14.8
HPV infection can cause cervical cancer in women	156	19.9
HPV infection can cause penis cancer in men	112	14.3
HPV infection can cause other anogenital and oropharyngeal cancers in both sexes	136	17.3
HPV infection can be prevented by vaccine against HPV	197	25.1
HPV-related cancers can be prevented by vaccine against HPV	198	25.2
Vaccine is used for people who are diagnosed free HPV infection	176	22.4
Both sexes are vaccinated to prevent HPV infection	191	24.3
The greater immune response to vaccinate against HPV is at ages 11 or 12 years	31	3.9
Children under 15 years old need two doses of HPV vaccine	58	7.4

Willingness to Pay for HPV Vaccination for Sons

On average, WTP amount for two doses of HPV vaccine was 3,053,005 VND (about 137.5 USD) ranging from 200,000 VND (9 USD) to 4,180,000 VND (188.3 USD). Among the parents who accepted to get their sons vaccinated, 63.7% of them were willing to pay <3,580,000 VND (161.2 USD) for two doses of Gardasil (**Table 4**).

Table 5 showed that the knowledge of HPV and HPV vaccine was the only factor associated with WTP price for HPV vaccination among parents. This is a positive but weak correlation (Rho: 0.11). No other variables were found significantly related to WTP price for HPV vaccination in the study ($p > 0.05$) (**Supplementary Tables 2A,B**).

DISCUSSION

Acceptability of HPV Vaccine for Boys

One noticeable finding is that no participant reported prior HPV vaccination for their sons (**Table 1**). In line with the recommendation of WHO, Vietnam introduced HPV vaccine for girls ages 9–13 as a public health measure against cervical cancer (20, 22). Accordingly, communication messages encouraging HPV vaccination have focused on adolescent girls. A study by Tran et al. (23) in Hanoi reported that 100% of the male participants thought HPV vaccine was for females only. Authors also indicated that women were more interested in information of HPV vaccine than men. In our study, although two-thirds of

TABLE 3 | Factors related to acceptability of parents for HPV vaccination for their sons*.

Factors		OR	95% CI	*p*-value
Age of son	≤12	1		
	>12	1.5	1.08–1.98	0.014
The eldest son	No	1		
	Yes	1.6	1.13–2.19	0.007
Relations with son	Father	1		
	Mother	1.4	1.01–1.91	0.046
Educational level	Secondary school and below	1		
	High school	1.3	0.89–2.03	0.149
	College and higher	1.7	1.11–2.47	0.013
Knowledge of HPV and HPV vaccine	Not good	1		
	Good	1.8	1.23–2.65	0.003

**This table presented only results which showed statistically significant associations.*

TABLE 4 | Willingness to pay for HPV vaccination for sons among the parents (*n* = 386).

		VND	USD
WTP	Mean (SD)	3,053,005 (763,645)	137.5 (34.4)
	Median	3,180,000	143.2
	Range	200,000–4,180,000	9–188.3
Number of participants at WTP levels (cut off point = market price of Gardasil vaccine)			
Cut off point = 3,580,000 VND ($162 US)		*n*	Percentage
	<cut off point	246	63.7%
	≥cut off point	140	36.3%

TABLE 5 | Factors associated with WTP for HPV vaccine among the participants (*n* = 386).

		WTP
Total mean score of knowledge	Rho	0.11
	p-value	0.028

the parents were mothers, only 26.5% of them had ever heard of HPV or HPV vaccine (**Table 2**). This result was much lower than that those in previous studies in Vietnam and in the world (24–27). Nguyen et al. (24) found that 71.3% of women ages 18–49 in Hanoi were aware of HPV vaccine. A study in Thailand reported that 52% of the parents had heard of HPV and HPV vaccine (25). Sitaresmi et al. (26) showed that 49.2 and 48.8% of the parents in Indonesia had known about HPV infection and HPV vaccine, respectively, and there were 70.5% of the parents in Texas, USA who knew these issues (27). As a result, our participants had lack knowledge of HPV and its vaccine. Only 18.9% of the parents achieved good level of knowledge about HPV and HPV vaccine. Questions of benefits of vaccine against HPV received the highest percentage of correct answers while only a few of the parents knew correctly the ideal age for receiving vaccine and the recommended number of doses of vaccine for adolescents under 15 years old (**Table 2**). The results were similar to those of Nguyen et al. (24) among child-bearing aged women in Hanoi. Communication efforts should be improved to provide comprehensive information about HPV and its vaccine, especially including male adolescents as part of the target group. Not only does HPV vaccination for male protect them from getting HPV-related cancer, but also prevent the transmission of HPV to female sexual partners. This is necessary in light of the low coverage of HPV vaccination among girls and gender imbalance in Vietnam (28, 29).

Although the level of awareness of HPV and HPV vaccine was low among parents in the study, nearly half of them agreed to have their sons vaccinated against HPV in the future. The results from the multivariate analyses indicated that the strongest factor for accepting HPV vaccination was knowledge of HPV and HPV vaccine among the parents.

This finding is consistent with many previous studies in Vietnam as well as in other countries (20, 25, 31). A study in Thailand found that parents with better knowledge were related to higher acceptance of HPV vaccination for their children (25). A systematic review by Rodriguez et al. (30) showed similar findings. In Vietnam, Nguyen Minh et al. (31) demonstrated that a health education program on HPV knowledge improved the vaccination intention among mothers of teenage boys. Experiences from many countries also confirmed that in order to accept a vaccine, the population must have background knowledge about the importance of the vaccine and its safety (32, 33). Understandably, highly educated parents should have had more access to information sources regarding HPV and HPV vaccine and thus they were more willing to get their sons vaccinated against HPV than those with lower educational level. Our finding agreed with a study by Kimberly et al. (9) in the USA. However, in contrast to higher acceptation of the fathers toward vaccination for their children described in that study, we found that mothers expressed more desire to have their son HPV- vaccinated. This is explained by the difference in culture. In Vietnamese traditional society, mothers are expected to take good care of their children; they have stronger willingness to protect their children from diseases through vaccination. The finding is supported by a study in China which has the same familial culture (34). The Vietnamese traditional culture also explains for more willingness to get HPV vaccination for eldest son among the participants. According to this viewpoint, father and eldest son are decision-makers and spokespersons in a family (35). Son's age was also a factor in the parent's decision in the present study. The parents of boys older than 12 expressed more acceptances to have their son vaccinated than those of younger ones. This is in line with earlier studies. The parents thought that vaccination would affect a child's physical development (36) or believed that their children were not at risk because of no sexual activity (10, 13, 36, 37). The perception of the parents could lead to a missed opportunity to prevent their children from HPV

infection. Indeed, a survey in Vietnam in 2009 found that 44% of adolescents age 14 or older had pre- marital sex, and the majority of them had unsafe first intercourse (38). Communication should emphasize the need of getting the vaccine before the first sexual experience and clearly indicate that a greater immune response can be achieved when vaccination happens at age 11 or 12 (5, 21).

WTP for HPV Vaccination

The present study showed that there was a demand to get the sons vaccinated against HPV among their parents. Average WTP price was 137.5 USD for full doses of HPV vaccine, accounting for 6% of annual income per capita in 2020 in Vietnam (39). This value is 23.7 USD lower than current market price of two doses of Gardasil vaccine. Recently, Tran et al. reported that adult men were willing to pay an average amount of 166.2 USD for three-dosed course of HPV vaccine, accounting for nearly 7% of annual income per capita in Vietnam in 2016 (16). It is suggested that two doses of HPV vaccine for adolescents not only provide the most effective protection, but also save money for households. Average elicited WTP price was higher than that from earlier studies done in the world in terms of absolute monetary values as well as compared to annual income per capita. The average WTP for full dose of HPV vaccine was 8.85 USD in Ethiopia (40), 11.88 USD in Nigeria (41), 5.26 USD in Malaysia (42), a range of 9.23 USD to 30.78 USD in Thailand (43), and 252.71 USD in Chile (44). Apparently, the success in National Expanded Immunization Program in Vietnam has persuaded parents to believe in vaccine programs as a worthwhile investment for their children's health. Although the participants expressed a desire to get HPV vaccine for their son, two-thirds of the respondents were willing to pay the amount of money that was lower than the market price. The aforementioned studies also confirmed that cost of vaccination was a barrier to HPV vaccine uptake (30, 37, 45, 46). The Government's subsidies should be considered when it introduces HPV vaccine for male adolescents in the country.

The knowledge of parents about HPV and its vaccine were the only factor affecting WTP price from the study; however, this correlation was weak. A better awareness of HPV and HPV vaccine by the participants raised their WTP price for HPV vaccination. Similarly, studies found that individuals who recognized high risk of COVID-19 tended to pay more for vaccine than those who saw it as low risk (47, 48). Cerda et al. (49) also emphasized the importance of providing knowledge about COVID-19 to people to combat the pandemic.

The study has some limitations. First, this is a school-based survey; the sample was randomly selected but based on a list of parents who were present at the parent meeting of the school. Selection bias could be a potential problem. Second, the study was conducted in Hue city where many of traditional family values remained unchanged. In addition, income per capita in study setting was much lower than that in big cities of Vietnam. These can limit ability to generalize findings of the study. Third, the incremental level by 200,000 VND that resulted from a pilot survey could limit choice of respondents. Despite these limitations, this is the first study in Vietnam to identify the demand of HPV vaccine for male adolescents among their parents. The results can support health policy makers to introduce HPV vaccination for males in the country.

CONCLUSION

There was a demand for HPV vaccination for male adolescents among our sampled parents; however, their WTP price for the current vaccine was lower than its market price. Public awareness of HPV and HPV vaccine for both sexes need to be strengthened and sustained. The vaccine against HPV should be introduced to male adolescents besides girls and young women in Vietnam. Government's subsidies should be considered to encourage HPV vaccination for both sexes in the country. This will contribute to reduce not only HPV-related diseases in men, but also the risk of cervical cancer in women.

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 study proposal was approved by the Ethics Committee for Biomedical Research of University of Medicine & Pharmacy, Hue University (No: H2020/082, dated June 3, 2020). In addition, approval for data collection at the sites was obtained by directors of secondary schools. The interview of study subjects was performed with their verbal permission after they were given adequate information about the study.

AUTHOR CONTRIBUTIONS

LN: conception, design of the study, data analysis, and writing the manuscript. TL and NL: data collection, data entering, and data analysis. NT: data collection. All authors have read and agreed to the published version of the manuscript.

FUNDING

The research was supported by the research funds from Hue University (DHH 2020- 04- 113).

ACKNOWLEDGMENTS

We would like to thank board of managers of secondary schools participated in the study for their support of data collection. We would also like to thank Dr. Duc Minh Nguyen for his editorial assistance.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.801984/full#supplementary-material

REFERENCES

1. Kombe Kombe AJ, Li B, Zahid A, Mengist HM, Bounda GA, Zhou Y, et al. Epidemiology and burden of human papillomavirus and related diseases, molecular pathogenesis, and vaccine evaluation. *Front Public Health.* (2020) 8:552028. doi: 10.3389/fpubh.2020.552028
2. World Health Organization. *Human Papillomavirus (HPV) and Cervical Cancer*. (2020). Available online at: https://www.who.int/news-room/fact-sheets/detail/human-papillomavirus-(hpv)-and-cervical-cancer (accessed July 6, 2021).
3. Bruni L, Albero G, Serrano B, Mena M, Gómez D, Muñoz J, et al. *Human Papillomavirus and Related Diseases in the World.* Summary Report 17 June 2019. ICO/IARC Information Centre on HPV and Cancer (HPV Information Centre). Available online at: http://www.hpvcentre.net (accessed June 25, 2021).
4. Centers for Disease Control and Prevention. *Human Papillomavirus (HPV) Vaccination: What Everyone Should Know*. (2020). Available online at: https://www.cdc.gov/vaccines/vpd/hpv/public/index.html (accessed February 20, 2021).
5. Centers for Disease Control and Prevention. *HPV Vaccine Recommendations*. (2020). Available online at: https://www.cdc.gov/vaccines/vpd/hpv/hcp/recommendations.html (accessed February 20, 2021).
6. World Health Organization. *Major Milestone Reached as 100 Countries Have Introduced HPV Vaccine Into National Schedule*. (2019). Available online at: https://www.who.int/news/item/31-10-2019-major-milestone-reached-as-100-countries-have-introduced-hpv-vaccine-into-national-schedule (accessed February 20, 2021).
7. Velan B. Acceptance on the move public reaction to shifting vaccination realities. *Hum Vaccin.* (2011) 7:1261–70. doi: 10.4161/hv.7.12.17980
8. Newman PA, Logie CH, Lacombe-Duncan A, Baiden P, Tepjan S, Rubincam C, et al. Parents' uptake of human papillomavirus vaccines for their children: a systematic review and meta- analysis of observational studies. *BMJ Open*. (2018) 8:e019206. doi: 10.1136/bmjopen-2017-019206
9. Nguyen HK, Santibanez TA, Stokley S, Lindley MC, Fisher A, Kim D, et al. Parental vaccine hesitancy and its association with adolescent HPV vaccination. *Vaccine.* (2021) 39:2416–23. doi: 10.1016/j.vaccine.2021.03.048
10. Patel PR, Berenson AB. Sources of HPV vaccine hesitancy in parents. *Hum Vaccin Immunother.* (2013) 9:2649–53. doi: 10.4161/hv.26224
11. Printz C. HPV vaccine uptake remains low. *Cancer*. (2013) 119:2947–8. doi: 10.1002/cncr.28278
12. Alexander AB, Stupiansky NW, Ott MA, Herbenick D, Reece M, Zimet GD. Parent-son decision-making about human papillomavirus vaccination: a qualitative analysis. *BMC Pediatr*. (2012) 12:192. doi: 10.1186/1471-2431-12-192
13. Oldach BR, Katz ML. Ohio Appalachia public health department personnel: human papillomavirus (HPV) vaccine availability, and acceptance and concerns among parents of male and female adolescents. *J Commun Health.* (2012) 37:1157–63. doi: 10.1007/s10900-012-9613-5
14. Gilkey MB, Moss JL, McRee AL, Brewer NT. Do correlates of HPV vaccine initiation differ between adolescent boys and girls? *Vaccine.* (2012) 30:5928–34. doi: 10.1016/j.vaccine.2012.07.045
15. Reiter PL, McRee AL, Kadis JA, Brewer NT. HPV vaccine and adolescent males. *Vaccine*. (2011) 29:5595–602. doi: 10.1016/j.vaccine.2011.06.020
16. Huon J-F, Grégoire A, Meireles A, Lefebvre M, Péré M, Coutherut J, et al. Evaluation of the acceptability in France of the vaccine against papillomavirus (HPV) among middle and high school students and their parents. *PLoS ONE.* (2020) 15:e0234693. doi: 10.1371/journal.pone.0234693
17. Nguyen VS, Nguyen KM, Dimberg J, Matussek A, Henningsson AJ. Prevalence of cervical infection and genotype distribution of human papilloma virus among females in da Nang, Vietnam. *Anticancer Res.* (2017) 37:1243–7. doi: 10.21873/anticanres.11440
18. Le HHL, Bi X, Ishizaki A, Le VH, Nguyen VT, Hosaka N, et al. Human papillomavirus infection in male patients with STI-related symptoms in Hanoi, Vietnam. *J Med Virol.* (2016) 88:1059–66. doi: 10.1002/jmv.24422
19. Le HHL, Bi X, Ishizaki A, Le VH, Nguyen TV, Ichimura H. Low concordance of oral and genital HPV infection among male patients with sexually transmitted infections in Vietnam. *BMC Infect Dis.* (2019) 19:578. doi: 10.1186/s12879-019-4175-0
20. Nhan Dan online. *US$400,000 Supports HPV Vaccine Deployment in Vietnam*. (2019). Available online at: https://en.nhandan.vn/society/item/7727702-us$400-000-supports-hpv-vaccine-deployment-in-vietnam.html (accessed July 6, 2021).
21. Centers for Disease Control and Prevention. *Genital HPV infection- CDC Fact Sheet.* (2017). Available online at: https://www.cdc.gov/std/hpv/stdfact-hpv.htm (accessed February 20, 2021).
22. World Health Orgnization. *HPV vaccine communication. Special considerations for a unique vaccine: 2016 update*. Geneva: World Health Organization (2017).
23. Tran XB, Than PTQ, Doan TTN, Nguyen HLT, Hoang TM, Nguyen THT, et al. Knowledge, attitude, and practice on and willingness to pay for human papillomavirus vaccine: a cross-sectional study in Hanoi, Vietnam. *Patient Prefer Adherence.* (2018) 12:945–54. doi: 10.2147/PPA.S165357
24. Nguyen TNP, Le TTX, Le TH, Do TTT, Jin KO, Won YJ, et al. Knowledge of cervical cancer and human papillomavirus vaccines among child-bearing aged women in Hanoi, Vietnam. *Asian Pac J Cancer Prev.* (2020) 21:1951–7. doi: 10.31557/APJCP.2020.21.7.1951
25. Grandahl M, Paek SC, Grisurapong S, Sherer P, Tydén T, Lundberg P. Parents' knowledge, beliefs, and acceptance of the HPV vaccination in relation to their socio-demographics and religious beliefs: a cross-sectional study in Thailand. *PLoS ONE.* (2018) 13:e0193054. doi: 10.1371/journal.pone.0193054
26. Sitaresmi MN, Rozanti NM, Simangunsong LB, Wahab A. Improvement of parent's awareness, knowledge, perception, and acceptability of human papillomavirus vaccination after a structured-educational intervention. *BMC Public Health.* (2020) 20:1836. doi: 10.1186/s12889-020-09962-1
27. Berenson AB, Rahman M. Gender differences among low income women in their intent to vaccinate their sons and daughters against human papillomavirus infection. *J Pediatr Adolesc Gynecol.* (2012) 25:218–20. doi: 10.1016/j.jpag.2012.01.003
28. PATH and Vietnam National Institute of Hygiene and Epidemiology. *Evaluating HPV Vaccine Delivery Strategies in Vietnam*. Seattle, WA: PATH (2010).
29. UNFPA. *The Imbalanced Sex Ratio at Birth in Viet Nam: New Insights and Policy Recommendations*. (2018). Available online at: https://vietnam.unfpa.org/en/publications/imbalanced-sex-ratio-birth-viet-nam-new-insights-and-policy-recommendations (accessed February 20, 2021).
30. Rodriguez SA, Mullen PD, Lopez DM, Savas LS, Fernandez ME. Factors associated with adolescent HPV vaccination in the US: a systematic review of reviews and multilevel framework to inform intervention development. *Prev Med.* (2020) 131:105968. doi: 10.1016/j.ypmed.2019.105968
31. Nguyen MD, Taneepanichskul N, Hajek R. Effectiveness of a health talk education program on human papillomavirus (HPV) knowledge, attitudes, and intentions to vaccinate children among mothers of secondary school boys in thua thien hue Province, Vietnam. *Risk Manag Healthc Policy.* (2020) 13:1207–14. doi: 10.2147/RMHP.S259097
32. Jindal HA, Kaur A, Murugan S. Human papilloma virus vaccine for low and middle income countries: a step too soon? *Hum Vaccin Immunother.* (2017) 13:2723–5. doi: 10.1080/21645515.2017.1358837
33. Dott FR, Lirane EDF, José TOA, Jorge ETR, Seyi SE, Akele RY, et al. Acceptance of COVID-19 vaccination at different hypothetical efficacy and safety levels in ten countries in Asia, Africa, and South America. *Narra J.* (2021) 1:55. doi: 10.52225/narra.v1i3.55
34. Zhou M, Qu S, Zhao L, Campy KS, Wang S. Parental perceptions of human papillomavirus vaccination in central China: the moderating role of socioeconomic factors. *Hum Vaccin Immunother.* (2019) 15:1688–96. doi: 10.1080/21645515.2018.1547605
35. Galanti GA. Vietnamese family relationships A lesson in cross-cultural care. *West J Med.* (2000) 172:415–6. doi: 10.1136/ewjm.172.6.415
36. Cover JK, Nguyen QN, LaMontagne DS, Dang TTH, Nguyen TH, Le TN. Acceptance patterns and decision-making for human papillomavirus vaccination among parents in Vietnam: an in-depth qualitative study post-vaccination. *BMC Public Health.* (2012) 12:629. doi: 10.1186/1471-2458-12-629
37. Holman DM, Benard V, Roland KB, Watson M, Liddon N, Stokley S. Barriers to human papillomavirus vaccination among us adolescents: a systematic review of the literature. *JAMA Pediatr.* (2014) 168:76–82. doi: 10.1001/jamapediatrics.2013.2752

38. World Health Organization. *Health of Adolescents in Vietnam*. Manila: WHO Regional Office for Western Pacific (2011). p. 12.
39. General Statistics Office. *Socio-Economics Situation in the Fourth Quarter and the Whole Year 2020*. (2021). Available online at: http://www.gso.gov.vn/en/data-and-statistics/2021/01/socio-economic-situation-in-the-fourth-quarter-and-the-whole-year-2020/ (accessed June 30, 2021).
40. Tarekegn AA, Yismaw AE. Health professionals' willingness to pay and associated factors for human papilloma virus vaccination to prevent cervical cancer at college of medicine and health sciences university of Gondar, Northwest Ethiopia. *BMC Res Notes*. (2019) 12:58. doi: 10.1186/s13104-019-4085-7
41. Umeh IB, Nduka SO, Ekwunife OI. Mothers' willingness to pay for HPV vaccines in Anambra state, Nigeria: a cross sectional contingent valuation study. *Cost Eff Resour Alloc*. (2016) 14:8. doi: 10.1186/s12962-016-0057-0
42. Maharajan MK, Rajiah K, Fang Num KS, Yong NJ. Knowledge of human papillomavirus infection, cervical cancer and willingness to pay for cervical cancer vaccination among ethnically diverse medical students in Malaysia. *Asian Pac J Cancer Prev*. (2015) 16:5733–9. doi: 10.7314/APJCP.2015.16.14.5733
43. Kruiroongroj S, Chaikledkaew U, Thavorncharoensap M. Knowledge, Acceptance, and willingness to pay for human papilloma virus (HPV) vaccination among female parents in Thailand. *Asian Pac J Cancer Prev*. (2014) 15:5469–74. doi: 10.7314/APJCP.2014.15.13.5469
44. 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 Mex*. (2014) 56:48–55. doi: 10.21149/spm.v56i1.7322
45. Le TTX, Nguyen TNP, Do TTT, Nguyen HT, Le TH, Nguyen TC, et al. Intention to pay for HPV vaccination among women of childbearing age in Vietnam. *Int J Environ Res Public Health*. (2020) 17:3144. doi: 10.3390/ijerph17093144
46. Li X, Wong I, McGhee S, Kwan M, Wong C, Ip D, et al. Mothers' preference and willingness to pay for human papillomavirus vaccination for their daughters: a discrete choice experiment. *Hong Kong Med J*. (2018) 24:S34–6.
47. Vo XN, Nguyen THT, Nguyen VP, Tran QV, Vo QT. Using contingent valuation method to estimate adults' willingness to pay for a future coronavirus 2019 vaccination. *Value Health Reg Issues*. (2021) 24:240–6. doi: 10.1016/j.vhri.2021.01.002
48. Harapan H, Abram LW, Amanda Y, Wira W, Samsul A, Alex KG, 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
49. Cerda AA, García LY. Factors explaining the fear of being infected with COVID-19. *Health Expectations*. (2021) 00:1–7. doi: 10.1111/hex.13274

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.

frontiers | Frontiers in Public Health

ORIGINAL RESEARCH
published: 26 April 2022
doi: 10.3389/fpubh.2022.760143

3D Differential Equation Model for Patients' Choice of Hospital in China

Xiaoxia Zhao [1], Lihong Jiang [2] and Kaihong Zhao [3]**

[1] Faculty of Management and Economics, Kunming University of Science and Technology, Kunming, China, [2] First People's Hospital of Yunnan Province, Kunming, China, [3] Department of Applied Mathematics, Kunming University of Science and Technology, Kunming, China

The number of patients in a hospital is a direct indicator of patients' choice of hospital, which is a complex process affected by many factors. Based on the national medical system and patients' preference for high-grade hospitals in China, this study establishes a three-dimensional differential equation model for calculating the time variation of the number of visits to three grades of hospitals. We performed a qualitative analysis of the system. We carried out a subsequent numerical simulation to analyze the impact on the system when the rate of leapfrog treatment and the maximum capacity of doctors and treatments changed. The results show that the sustainability of China's three levels of hospitals mainly depends on the level of hospital development. The strength of comprehensive health improvement at specific levels is the key to increasing the service efficiency of medical resources.

Keywords: patients' choice of hospital, number of visits, differential equation model, qualitative analysis, simulation analysis

OPEN ACCESS

Edited by:
Stefania Salmaso, Independent Researcher, Rome, Italy

Reviewed by:
Zhouhong Li, Yuxi Normal University, China
Quanman Li, Zhengzhou University, China

****Correspondence:***
Xiaoxia Zhao
xiaoxiazhao@kmust.edu.cn
Kaihong Zhao
zhaokaihongs@126.com

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

Received: *17 August 2021*
Accepted: *28 March 2022*
Published: *26 April 2022*

Citation:
Zhao X, Jiang L and Zhao K (2022) 3D Differential Equation Model for Patients' Choice of Hospital in China. Front. Public Health 10:760143. doi: 10.3389/fpubh.2022.760143

INTRODUCTION

Hospital selection is the first step for a patient to seek medical treatment, which is a complex process affected by many factors, including the patient's medical behavior, the location of the hospital, the hospital's medical competencies, and the general medical system (1, 2). In the UK, general practitioners complete 90% of outpatient and emergency visits, and the referral rate by general practitioners to specialists is only 5% (3, 4). The number of cases handled by primary medical institutions in the United States, Australia, and Canada exceeds 80% (5–7). Meanwhile, the Chinese medical system is overly dependent on urban large-scale general hospitals for primary medical treatment. Rather than considering the severity of their illness, many Chinese patients choose a hospital based on the comprehensive nature of its medical facilities (e.g., the convenience of location, medical insurance, and other conditions), which is not conducive to the long-term development of the medical system (8–10). The leading cause of this phenomenon is the insufficient supply and uneven distribution of high-quality medical resources in the country and the lack of reasonable procedures available for patient medical treatment (11). To address this issue, the Chinese government began reforming the medical system in 2009. Officials suggested it was necessary to increase the capital input of grassroots-level hospitals and strengthen the training of their medical personnel to balance the allocation of high-quality medical resources and relieve the pressure on large urban hospitals from the high demand for treatment (12, 13).

Considering the scientific literature on patients' choice of hospital, scholars have done questionnaire surveys, and descriptive statistics (14–17), multiple logit and utility maximization nested logit models (2, 18–21), cross-sectional studies (22), demand models (23), dynamic models

(24), and game models (25). The process of hospital selection changes with time, and the differential equation model is a suitable method for expressing the temporal nature of this process. It can reveal the internal dynamic relationship of actual events and help us predict future developments, providing a basis for making better decisions. In the fields of economics (26, 27), epidemiology (28), and sustainable science before (29) have applied differential equation models. However, they have had few applications for patients' choice of hospital.

Therefore, based on the preference of Chinese patients for choosing a higher-than-average grade of hospital, this study establishes a differential equation model for hospital selection by patients and analyzes the temporal development of this process assuming that China's medical policy does not change. Because the topological structure of this model is irreversible, it can well describe the influence of patients' high medical preferences on the system. At the same time, the sensitivity of the parameters can be discerned through the numerical simulation of changes in the model parameters to provide a reference for decision makers to allocate medical resources rationally.

The remainder of this paper is organized as follows: Section China's Healthcare System introduces the status quo of China's medical system and patients' medical preferences, section Model Description describes the process of establishing the model, section Equilibrium Points and Stability Analysis provides an analysis of the existence of the equilibrium point under different parameters of the model and an analysis of the conditions of equilibrium stability, section Simulation Analysis details the numerical simulation to prove these analyses, and Section Conclusions summarizes the study and provides some suggestions for medical policy regulations.

CHINA'S HEALTHCARE SYSTEM

Since the foundation of the People's Republic of China, the Chinese government has been improving the fairness and accessibility of medical resources. However, many issues remain (30, 31). To provide residents with systematic and continuous medical services, the hierarchical design of China's hospitals is highly robust. Hospitals are categorized into three levels based on a comprehensive range of factors (e.g., functions, facility levels, and quality of medical services): first-level hospitals (FLHs) mainly providing daily healthcare services for nearby patients, second-level hospitals (SLHs) providing medical services for patients, and third-level hospitals (TLHs), primarily responsible for treating severe diseases. Since its establishment, China's medical system has made significant progress, the average life expectancy has dramatically improved, and the neonatal mortality rate has significantly decreased.

Nonetheless, China's healthcare system faces extraordinary challenges under the social background of a large aging population, urbanization, and changes in the spectrum of diseases. The allocation of high-quality medical resources in China is imbalanced, with TLHs mainly concentrated in economically developed cities and fewer high-quality medical resources in economically underdeveloped areas. Consequently, one of the most severe problems facing the Chinese medical system is the difficulty and high cost of receiving medical treatment. Not all residents can enjoy high-quality, continuous, and affordable medical services (32–34).

China lacks an effective primary care system (35). Since the late 1970s, the country has not implemented an area-based designated medical treatment policy for residents, so people freely choose hospitals. Thus, patients from different regions and with other diseases can enjoy the same health services, which provides more significant space for the development of medical institutions. However, because the medical resources and the conditions of FLHs are not as good as those of SLHs and TLHs, patients' trust in FLHs is low (10, 36). Many patients use their freedom to seek medical treatment in any establishment to choose SLHs and TLHs that are higher than the level they require, which puts an unreasonable burden on such facilities. It reduces the treatment opportunities for patients with severe illnesses in need of high-quality medical resources and increases the difficulty and cost of treatment. Additionally, the number of visits to SLHs and TLHs has been rising. The volume of diagnoses and treatments in TLHs has declined, resulting in excessive medical resources in SLHs and TLHs and insufficient medical resources in FLHs. Such conduct disrupts the standard order of therapy and is not conducive to the sustainable development of China's medical system.

Another problem is funding. Coupled with low financial investment by the Chinese government, the registration fee and outpatient price of doctors are insufficient to preserve the public service nature of hospitals. Hence, examination, treatment, and medicine have become high, increasing hospitals' revenues. It has led to the Matthew effect between hospitals, that is, the more patients admitted to TLHs and SLHs, the higher the income of TLHs and SLHs, the fewer patients admitted to FLHs, the more serious the shortage of high-quality medical resources, as shown in **Table 1** (38, 39).

Overall, many factors influence the current medical preferences of Chinese residents. Still, if we don't address them, these problems may lead to the collapse of the healthcare system (12, 40). For China's healthcare reform to succeed in the long term, the government must ensure sustainable funding, improve technology in primary hospitals, address the shortage of general practitioners, and make systematic healthcare affordable for citizens.

In 2016, to improve the medical situation in China, the Chinese government issued *Healthy China 2030*, which focuses on improving the fairness of medical care in urban and rural areas to optimize public healthcare systems (36). The policy is an important measure to narrow the gap between China's healthcare system and developed countries and provide residents with the higher health standards of such countries.

MODEL DESCRIPTION

The purpose of the Chinese hospital grading design is to enable patients to receive reasonable and continuous medical services according to the severity of their illness. However, the number of

TABLE 1 | The medical resources and services of Chinese hospitals in 2019 (37).

Classification	Number of hospitals	Certified doctors	Number of beds	Number of visits (10,000)
FLHs	11,264	135,471	651,045	22,965
SLHs	9,687	720,121	2,665,974	134,343
TLHs	2,749	1,030,988	2,777,932	205,701
Total	23,700	1,886,580	6,094,951	363,009

patients choosing a higher hospital grade when seeking medical treatment exceeds normal demand, which is not sustainable for the long-term development of China's medical system. If the Chinese government does not intervene, the future of people's choice of hospitals will stunt the progress of development in China's healthcare system.

The number of hospital visits can reflect the choice of hospital. To explore the future state of Chinese patients' choice of hospital, we made assumptions based on the current actual medical conditions in China. We established a differential equation model of the number of visits to hospitals of each level over time. The establishment process of the model is described below.

We assume that the system is closed, and the number of visits is continuous and a differentiable function. We use $x(t)$, $y(t)$, and $z(t)$ for the number of visits to FLHs, SLHs, and TLHs at time t, and x_0, y_0, and z_0 to represent the initial value when $t = 0$.

Due to resource limitations, the growth rate of the number of visits also conforms to the natural law of restraining growth, it will gradually decrease with the increase in the number of visits. When the number of visits reaches maximum capacity, its growth rate will be zero and no longer increase. Thus, we use $r(x)$, $r(y)$, and $r(z)$ to represent the growth rate of the number of visits to FLHs, SLHs, and TLHs, respectively. Thus, the following expression is obtained:

$$r(x) = \begin{cases} r_f, x(t) = 0, \\ 0, x(t) = m_f, \end{cases} \tag{1}$$

$$r(y) = \begin{cases} r_s, y(t) = 0, \\ 0, y(t) = m_s, \end{cases} \tag{2}$$

$$r(z) = \begin{cases} r_t, z(t) = 0, \\ 0, z(t) = m_t, \end{cases} \tag{3}$$

where r_f, r_s, and r_t indicate the inherent increase rate of the number of visits to FLHs, SLHs, and TLHs, and they reflect the number of visits to an ideal state without resource constraints. m_f, m_s, and m_t represent the maximum capacity of the number of visits of FLHs, SLHs, and TLHs, respectively. Therefore, the above three equations can be expressed as:

$$r(x) = -\frac{r_f}{m_f}x(t) + r_f, \tag{4}$$

$$r(y) = -\frac{r_s}{m_s}y(t) + r_s, \tag{5}$$

$$r(z) = -\frac{r_t}{m_t}z(t) + r_t. \tag{6}$$

Then, the process of the number of visits to the three levels of hospitals changing over time can be expressed as:

$$\begin{cases} \frac{dx(t)}{dt} = r(x)x(t) = -\frac{r_f}{m_f}x^2(t) + r_f x(t), \\ \frac{dy(t)}{dt} = r\left(y\right)y\left(t\right) = -\frac{r_s}{m_s}y^2\left(t\right) + r_s y\left(t\right), \\ \frac{dz(t)}{dt} = r(z)z(t) = -\frac{r_t}{m_t}z^2(t) + r_t z(t). \end{cases} \tag{7}$$

We know that a substantial number of patients prefer high-level hospitals for medical treatment. We used α to indicate the leapfrog medical treatment rate from FLHs to SLHs, β to indicate the leapfrog medical treatment rate from SLHs to TLHs, and η to represent the leapfrog medical treatment rate from FLHs to TLHs. Accordingly, αx represents the number of visits from FLHs to SLHs per unit of time, βy represents the number of visits from SLHs to TLHs per unit of time, and ηx represents the number of visits from FLHs to TLHs per unit of time. Thus, Equation (7) can be rewritten as:

$$\begin{cases} \frac{dx(t)}{dt} = -\frac{r_f}{m_f}x^2(t) + r_f x(t) - \alpha x(t) - \eta x(t), \\ \frac{dy(t)}{dt} = -\frac{r_s}{m_s}y^2(t) + r_s y(t) + \alpha x(t) - \beta y(t), \\ \frac{dz(t)}{dt} = -\frac{r_t}{m_t}z^2(t) + r_t z(t) + \eta x(t) + \beta y(t). \end{cases} \tag{8}$$

Additionally, the number of visits will decrease due to deaths in the population and patients abandoning treatment. We define c_f, c_s, and c_t as the churn rate of the number of visits to FLHs, SLHs, and TLHs, so the loss of their number of visits per unit of time are $c_f x(t)$, $c_s y(t)$, and $c_t z(t)$, respectively. Finally, Equation (8) can be expressed as:

$$\begin{cases} \frac{dx(t)}{dt} = -\frac{r_f}{m_f}x^2(t) + r_f x(t) - \alpha x(t) - \eta x(t) - c_f x(t), \\ \frac{dy(t)}{dt} = -\frac{r_s}{m_s}y^2(t) + r_s y(t) + \alpha x(t) - \beta y(t) - c_s y(t), \\ \frac{dz(t)}{dt} = -\frac{r_t}{m_t}z^2(t) + r_t z(t) + \eta x(t) + \beta y(t) - c_t z(t). \end{cases} \tag{9}$$

where $r_f, r_s, r_t > 0, m_f, m_s, m_t > 0, c_f, c_s, c_t > 0$, and $\alpha, \beta, \eta > 0$ are certain constants.

This non-linear system (9) describes the changes in Chinese patients' visits to hospitals of this level over time. In the next section, we focus on finding the equilibrium points of the system and analyzing their stability, which is very important for practical applications, because, in reality, the initial data or parameters of each system will inevitably change. According to the analysis results, we can estimate the development status of hospitals at all levels in China.

EQUILIBRIUM POINTS AND STABILITY ANALYSIS

Equilibrium Points

The zero solutions of Equation (9) are the equilibrium points. Let $\frac{dx(t)}{dt} = 0$, $\frac{dy(t)}{dt} = 0$, and $\frac{dz(t)}{dt} = 0$. When four non-negative equilibrium points are obtained:

$$(1)\ E_1^* = (x_1^*, y_1^*, z_1^*),$$

where

$$x_1^* = 0, y_1^* = 0, z_1^* = 0. \tag{10}$$

Clearly, this trivial equilibrium always exists, and the practical significance is that there will be no patients choosing a hospital.

$$(2)\ E_2^* = (x_2^*, y_2^*, z_2^*),$$

where

$$x_2^* = 0, y_2^* = 0, z_2^* = \frac{m_t(r_t - c_t)}{r_t}. \tag{11}$$

We can see that this non-trivial equilibrium exists if and only if $r_t > c_t$, which means that there are z_2^* patients concentrated in TLHs, and no patients choose FLHs and TLHs.

$$(3)\ E_3^* = (x_3^*, y_3^*, z_3^*)$$

where

$$x_3^* = 0, y_3^* = \frac{m_s(r_s - \beta - c_s)}{r_s}, z_3^* = \frac{m_t}{2r_t}\left(r_t - c_t + \sqrt{(r_t - c_t)^2 + \frac{4\beta r_t m_s(r_s - \beta - c_s)}{r_s m_t}}\right). \tag{12}$$

This non-trivial equilibrium exists if and only if $r_s > \eta + c_s$, which indicates that there are y_3^* patients concentrated in SLHs and z_3^* patients concentrated in TLHs, and no patients concentrated in FLHs.

$$(4)\ E_4^* = (x_4^*, y_4^*, z_4^*),$$

where

$$x_4^* = \frac{m_f(r_f - \alpha - \eta - c_f)}{r_f},$$

$$y_3^* = \frac{m_s}{2r_s}\left(r_s - \beta - c_s + \sqrt{(r_s - \beta - c_s)^2 + \frac{4\alpha r_s m_f\left(r_f - \alpha - \eta - c_f\right)}{r_f m_s}}\right), \tag{13}$$

$$z_4^* = \frac{m_t}{2r_t}(r_t - c_t + \sqrt{(r_t - c_t)^2 + \frac{4r_t}{m_t}[\frac{\eta m_f(r_f - \alpha - \eta - c_f)}{r_f} + \frac{m_s}{2r_s}(r_s - \beta - c_s + \sqrt{(r_s - \beta - c_s)^2 + \frac{4\alpha r_s m_f(r_f - \alpha - \eta - c_f)}{r_f m_s}})]}.$$

This non-trivial equilibrium exists if and only if $r_f > \alpha + \eta + c_f$, which indicates that all three levels of hospitals have patients, and their number in each level is x_4^*, y_3^*, and z_4^*. This state of the medical system is better than that of the above three cases.

Let

$(H_1): r_t > c_t$,

$(H_2): r_s > \beta + c_s$,

$(H_3): r_f > \alpha + \eta + c_f$.

It is not difficult to draw the following conclusions based on the above discussion.

Theorem 4.1. For the equilibrium points of the system (9), the assertions hold as follows:

(1) If condition (H_1) holds, then the system has one trivial equilibrium, E_1^*, and one non-trivial equilibrium, E_2^*

(2) If condition (H_2) holds, then the system has one trivial equilibrium, E_1^*, and one non-trivial equilibrium, E_3^*

(3) If condition (H_3) holds, then the system has one trivial equilibrium, E_1^*, and one non-trivial equilibrium, E_4^*

(4) If conditions (H_1) and (H_2) hold, then the system has one trivial equilibrium, E_1^*, and two non-trivial equilibria, E_2^* and E_3^*

(5) If conditions (H_1) and (H_3) hold, then the system has one trivial equilibrium, E_1^*, and two non-trivial equilibria, E_2^* and E_4^*

(6) If conditions (H_2) and (H_3) hold, then the system has one trivial equilibrium, E_1^*, and two non-trivial equilibria, E_3^* and E_4^*

(7) If conditions (H_1), (H_2), and (H_3) hold, then the system has one trivial equilibrium, E_1^*, and three non-trivial equilibria, E_2^*, E_3^*, and E_4^*

Stability Analysis

This section analyzes the Lyapunov stability of the equilibrium points to predict the future state of China's medical system. We used $E^* = (x^*, y^*, z^*)$ to denote the arbitrary equilibrium, and the linearized system of (9) at E^* is

$$\frac{du(t)}{t} = Au(t), \tag{14}$$

where $u(t) = (x(t), y(t), z(t))^T$, and

$$A = \begin{bmatrix} -\frac{2r_f}{m_f}x + r_f - \alpha - \eta - c_f & 0 & 0 \\ \alpha & -\frac{2r_s}{m_s}y + r_s - \beta - c_s & 0 \\ \eta & \beta & -\frac{2r_t}{m_t}z + r_t - c_t \end{bmatrix} \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{11} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix}, \tag{15}$$

The characteristic determinant of the system (9) satisfies the following relation:

$$|\lambda E - A| = 0, \tag{16}$$

The characteristic equation of System (9) is

$$\lambda^3 - (a_{11} + a_{22} + a_{33})\lambda^2 + (a_{11}a_{22} + a_{22}a_{33} + a_{11}a_{33})\lambda - a_{11}a_{22}a_{33} = 0. \tag{17}$$

Only if all characteristic roots of the system are negative or the real parts of the characteristic roots are negative is this system locally stable at the equilibrium point. In the following section, we discuss the characteristic roots of each equilibrium point.

$$(1)\ E^* = E_1^*$$

The characteristic equation of system (9) is

$$(\lambda - r_f + \alpha + \eta + c_f)(\lambda - r_s + \beta + c_s)(\lambda - r_t + c_t) = 0. \quad (18)$$

The eigenvalues of the characteristic Equation (18) are $\lambda_1 = r_f - \alpha - \eta - c_f$, $\lambda_2 = r_s - \beta - c_s$, and $\lambda_3 = r_t - c_t$. Thus, E_1^* is stable only if $r_f < \alpha + \eta + c_f$, $r_s < \beta + c_s$, and $r_t < c_t$.

$$(2)\ E^* = E_2^*$$

The characteristic equation of system (9) is

$$(\lambda - r_f + \alpha + \eta + c_f)(\lambda - r_s + \beta + c_s)(\lambda + r_t - c_t) = 0. \quad (19)$$

The eigenvalues of the characteristic equation (10) are $\lambda_1 = r_f - \alpha - \eta - c_f$, $\lambda_2 = r_s - \beta - c_s$, and $\lambda_3 = c_t - r_t$. Thus, E_2^* is stable if and only if $r_f < \alpha + \eta + c_f$, $r_s < \beta + c_s$, and $r_t > c_t$.

$$(3)\ E^* = E_3^*$$

The characteristic equation of system (9) is

$$(\lambda - r_f + \alpha + \eta + c_f)(\lambda + r_s - \beta - c_s)\left(\lambda + \sqrt{(r_t - c_t)^2 + \frac{4\beta r_t m_s (r_s - \beta - c_s)}{r_s m_t}}\right) = 0. \quad (20)$$

The eigenvalues of the characteristic Equation (2) are $\lambda_1 = r_f - \alpha - \eta - c_f$, $\lambda_2 = \beta + c_s - r_s$, and $\lambda_3 = -\sqrt{(r_t - c_t)^2 + \frac{4\beta r_t m_s (r_s - \beta - c_s)}{r_s m_t}}$. Therefore, E_3^* is stable if and only if $r_f < \alpha + \eta + c_f$ and $r_s > \beta + c_s$.

$$(4)\ E^* = E_4^*$$

The characteristic equation of System (9) is

$$(\lambda - r_f + \alpha + \eta + c_f)\left(\lambda + \sqrt{(r_s - \beta - c_s)^2 + \frac{4\alpha r_s m_f (r_f - \alpha - \eta - c_f)}{r_f m_s}}\right)\left(\lambda + \sqrt{(r_t - c_t)^2 + \frac{4r_t}{m_t}\left[\frac{\eta m_f (r_f - \alpha - \eta - c_f)}{r_f} + \frac{m_s}{2r_s}\left(r_s - \beta - c_s + \sqrt{(r_s - \beta - c_s)^2 + \frac{4\alpha r_s m_f (r_f - \alpha - \eta - c_f)}{r_f m_s}}\right)\right]}\right) = 0. \quad (21)$$

It is clear that E_4^* is stable if and only if $r_f > \alpha + \eta + c_f$.

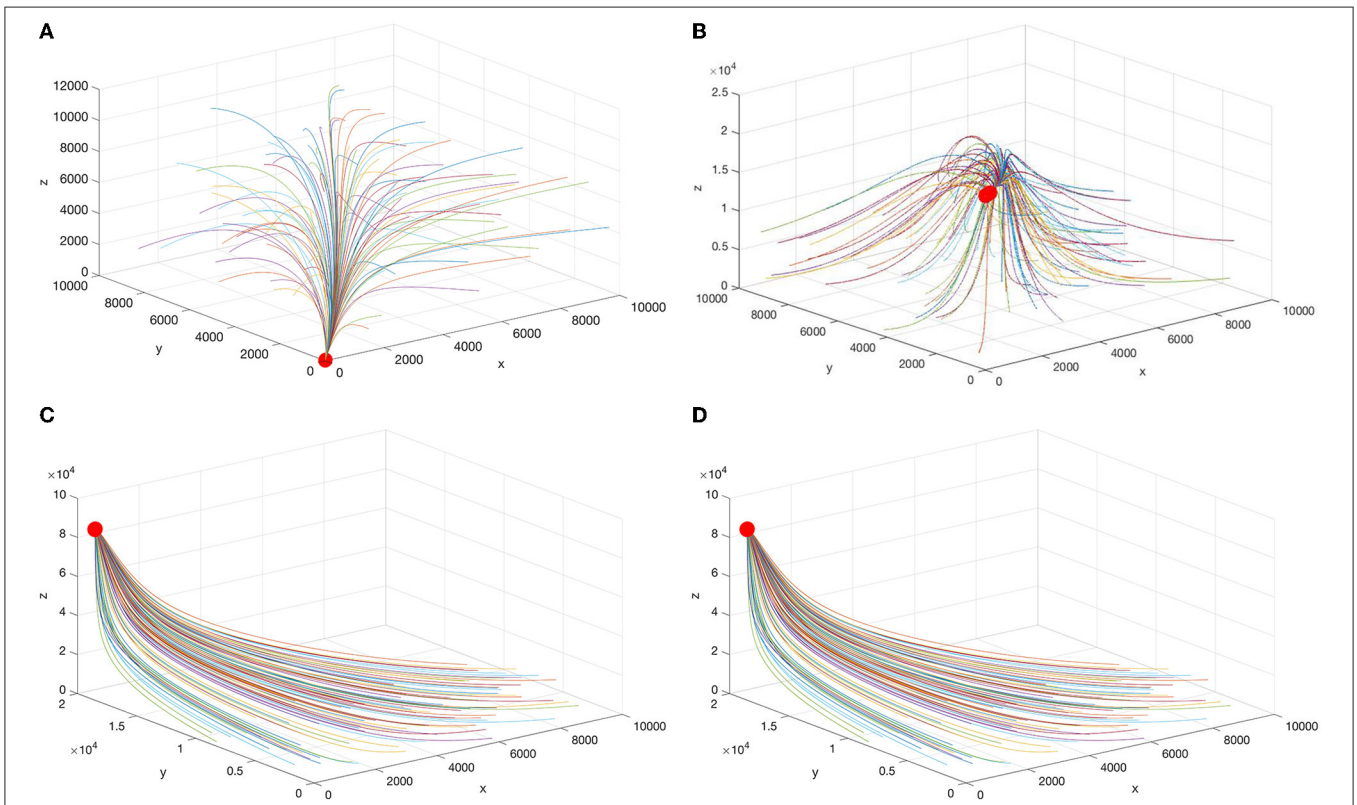


FIGURE 1 | Schematic diagram of the equilibrium points under different parameters. **(A)** E_1^*, **(B)** E_2^*, **(C)** E_3^*, and **(D)** E_4^*.

Based on the above discussions of (18) through (21), we can obtain the following significant conditions and conclusions:

Theorem 4.2. The following statements are true:

(1) If condition (H_4) holds, then E_1^* is locally asymptotically stable
(2) If condition (H_5) holds, then E_2^* is locally asymptotically stable
(3) If condition (H_6) holds, then E_3^* is locally asymptotically stable
(4) If condition (H_7) holds, then E_4^* is locally asymptotically stable

where

$$(H_4): r_f < \alpha + \eta + c_f, r_s < \beta + c_s, \text{ and } r_t < c_t,$$
$$(H_5): r_f < \alpha + \eta + c_f, r_s < \beta + c_s, \text{ and } r_t > c_t,$$
$$(H_6): r_f < \alpha + \eta + c_f \text{ and } r_s > \beta + c_s,$$
$$(H_7): r_f > \alpha + \eta + c_f.$$

Figure 1 shows the phase trajectories and equilibrium points for different parameters. In the above discussion, we can see that all three levels of hospitals in China will have patients only if the inherent growth rate of the number of visits to FLHs is greater than the churn rate and the leapfrog medical treatment rate of patients from FLHs to higher hospitals. Therefore, FLHs play a fundamental role in the sustainable development of China's entire medical system.

SIMULATION ANALYSIS

Parameter Fitting

This section predicts the future patient distribution among Chinese hospitals based on the current medical treatment situation. We selected the medical data of three levels of hospitals from January to November of each year from 2011 to 2018 from the Chinese Journal of Health Statistics (37), which includes no reports for December of each year. Then, MATLAB software was applied to fit the parameters in Equation (9) by the least square method to obtain $\alpha = 0.044$, $\beta = 0.037$, $\eta = 0.030$, $m_f = 9000.1$, $m_s = 29899.2$, $m_t = 42999.8$, $r_f = 0.0982$, $r_s = 0.1096$, $r_t = 0.0020$, $c_f = 0.0010$, $c_s = 0.0406$, and $c_t = 0.0271$. The obtained determination coefficient was $R^2 = 0.965$, closer to 1, and better fitting, as shown in **Figure 2**. The actual sampling date has obvious seasonal periodic changes that are not considered in this system.

Note that the data obtained meet the stability condition of the equilibrium point E_4^*, and the number of visits to the three levels of hospitals is calculated to be $x_4^* = 4555.04$, $y_4^* = 13028.5$, and $z_4^* = 18978.6$. There are significant gaps between these and the maximum capacities.

Parameter Sensitivity Analysis

Impact of Leapfrog Medical Treatment Rate

We kept other paraments unchanged to analyze the influence of different leapfrog medical treatment rates in hospitals of all levels. Further, numerical simulation was carried out for the three cases greater than, equal to, and less than the fitting value of the higher hospital-seeking rate, as shown in **Figures 3–5**.

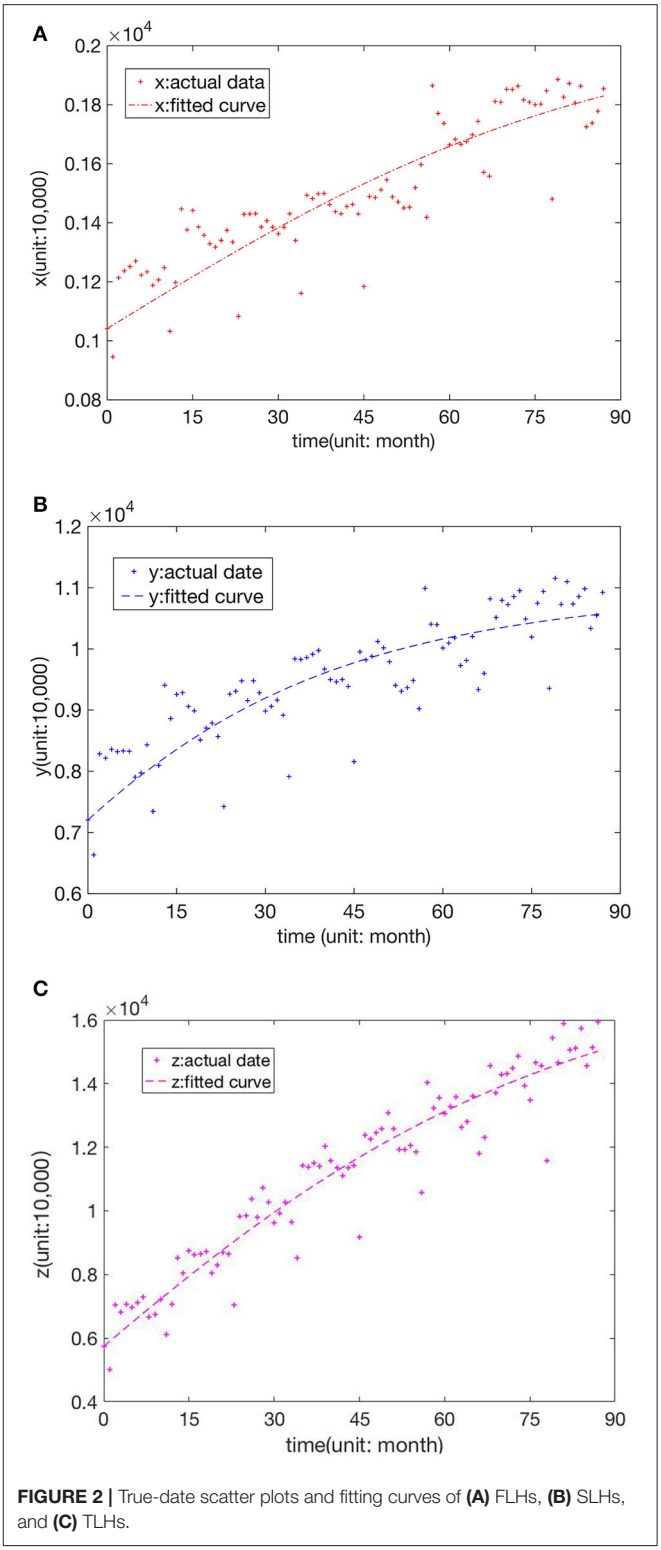


FIGURE 2 | True-date scatter plots and fitting curves of **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

We can see that the number of visits to hospitals of all levels typically declines with the increase in α, η. The change in β does not affect x, and an increase in β leads to a decrease in y. When β is greater than or equal to the fitted value, z remains unchanged,

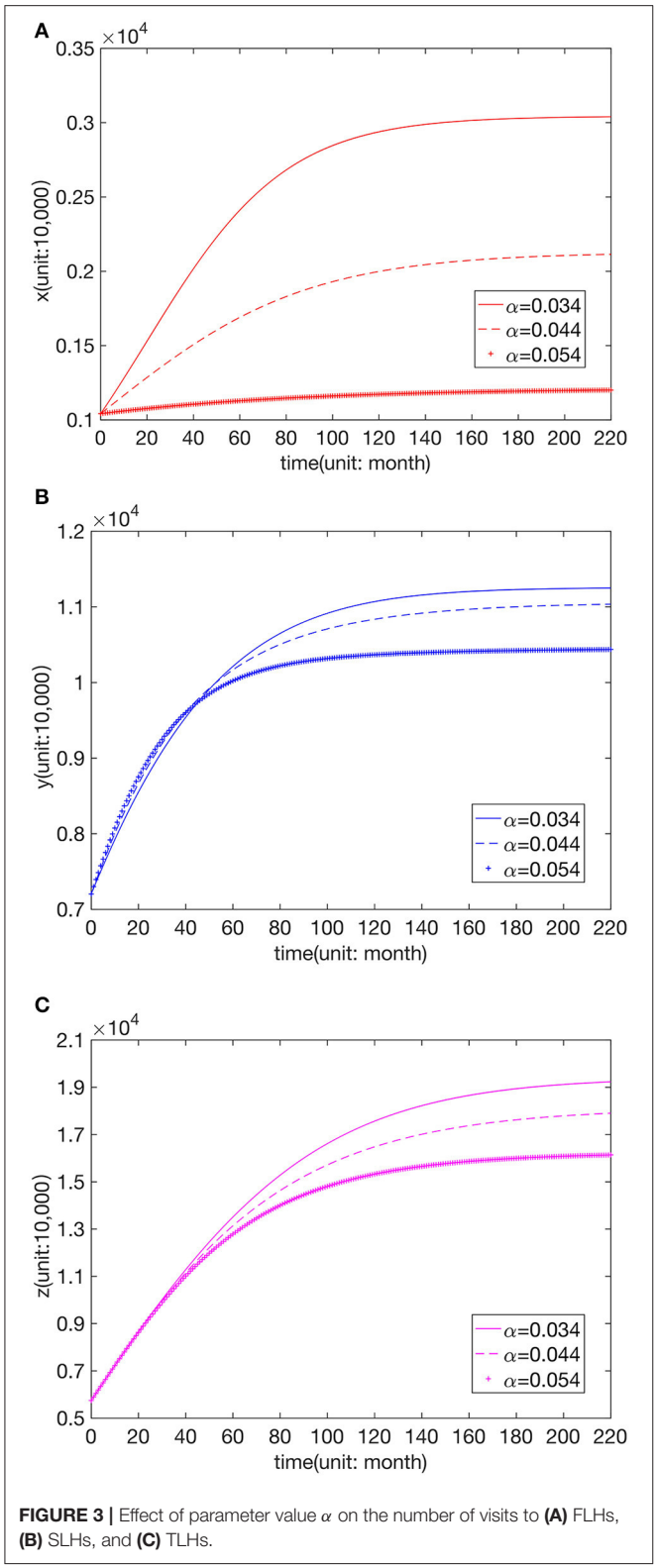


FIGURE 3 | Effect of parameter value α on the number of visits to **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

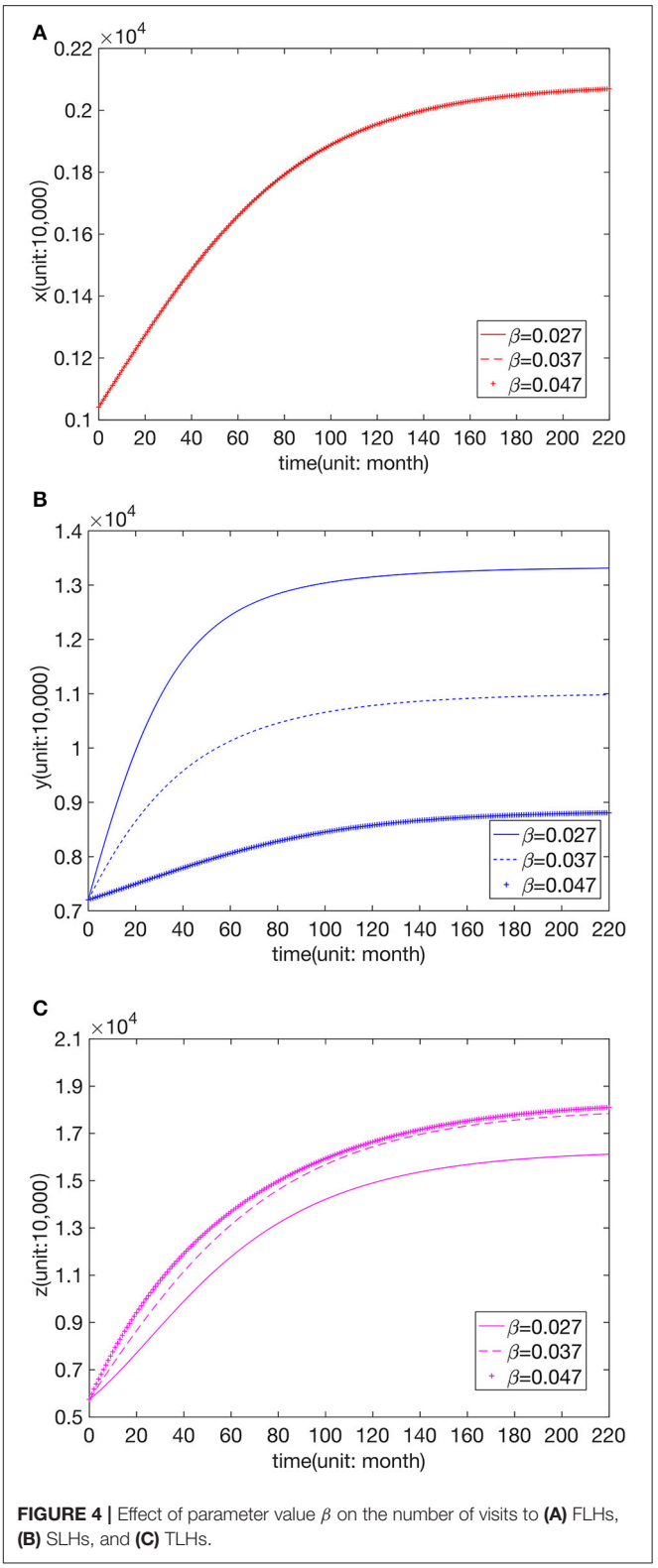


FIGURE 4 | Effect of parameter value β on the number of visits to **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

but when β is less than the fitted value, z decreases with the reduction in β.

From the above analysis, it can be seen that the leapfrog medical treatment rate from FLHs to senior hospitals will affect the patient distribution of the entire Chinese medical system, and the increase in the leapfrog consultation rate will reduce the number of visits to all levels of hospitals. When the leapfrog medical treatment rate from SLHs to TLHs decreases, the number

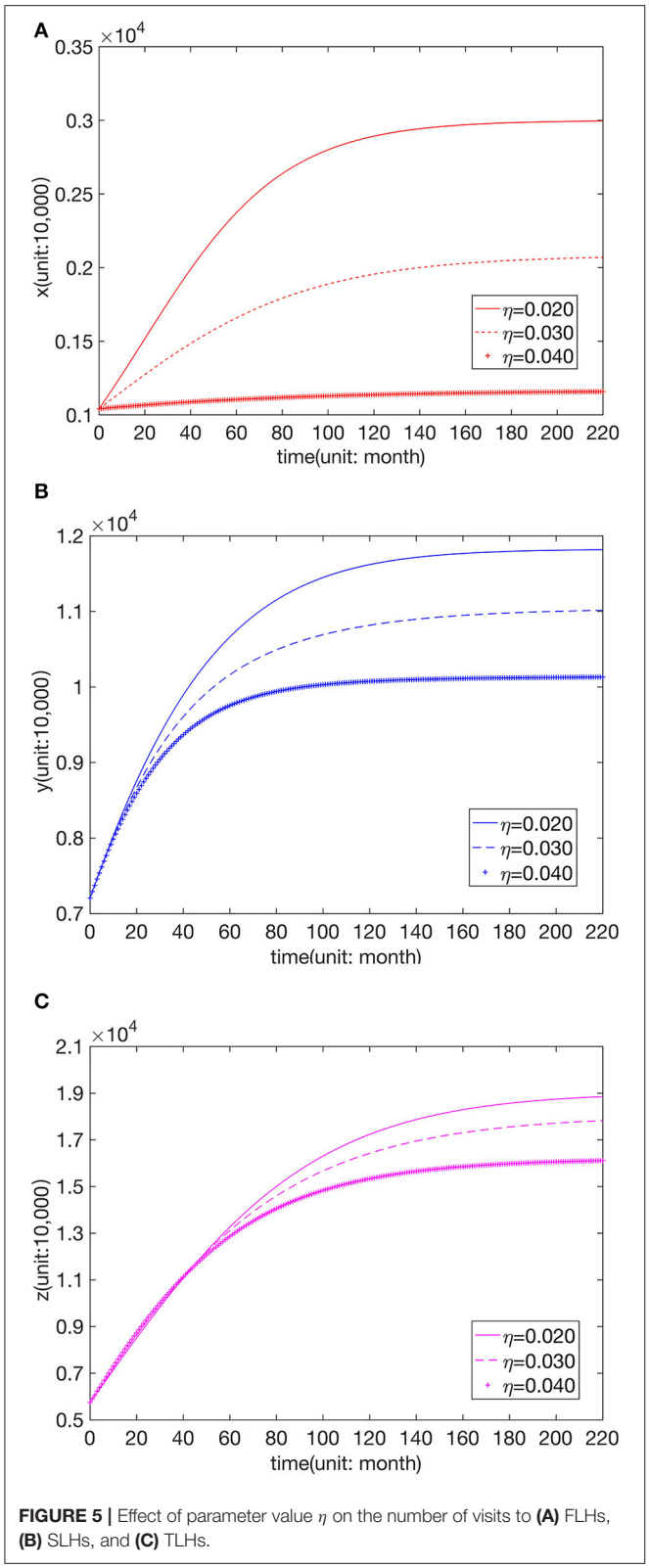


FIGURE 5 | Effect of parameter value η on the number of visits to **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

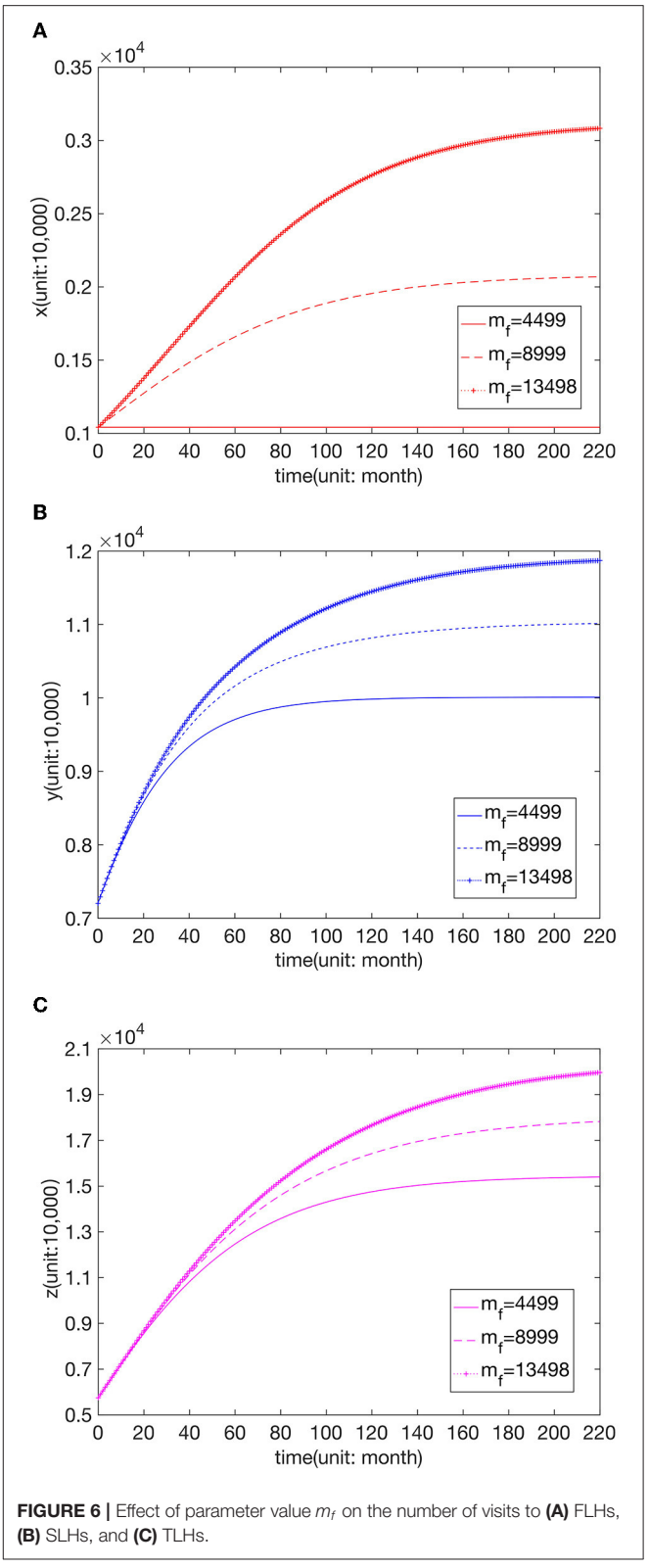


FIGURE 6 | Effect of parameter value m_f on the number of visits to **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

of visits to SLHs increases, and that to TLHs reduces. In contrast, the distribution of FLH patients is not affected.

Impact of Maximum Visiting Capacity

To analyze the influence of the maximum patient capacity on the number of visits to hospitals at all

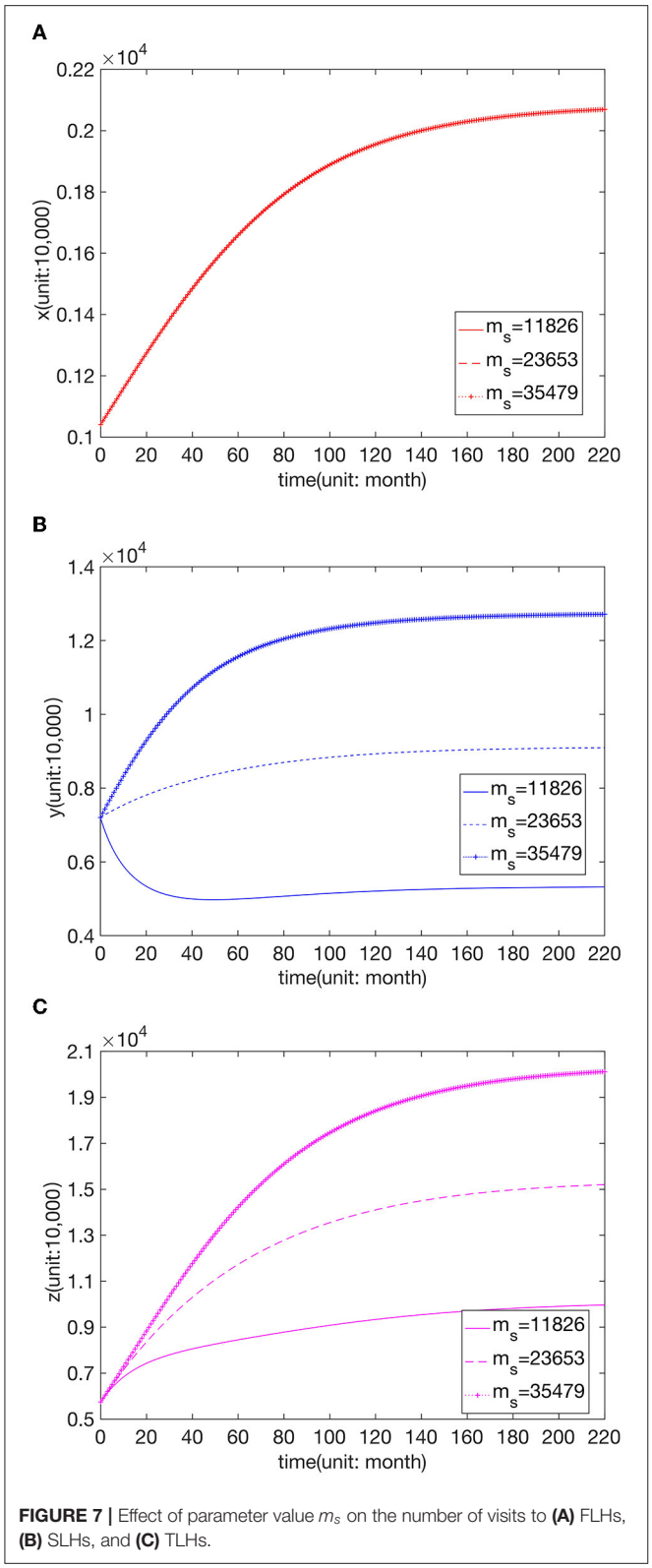


FIGURE 7 | Effect of parameter value m_s on the number of visits to **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

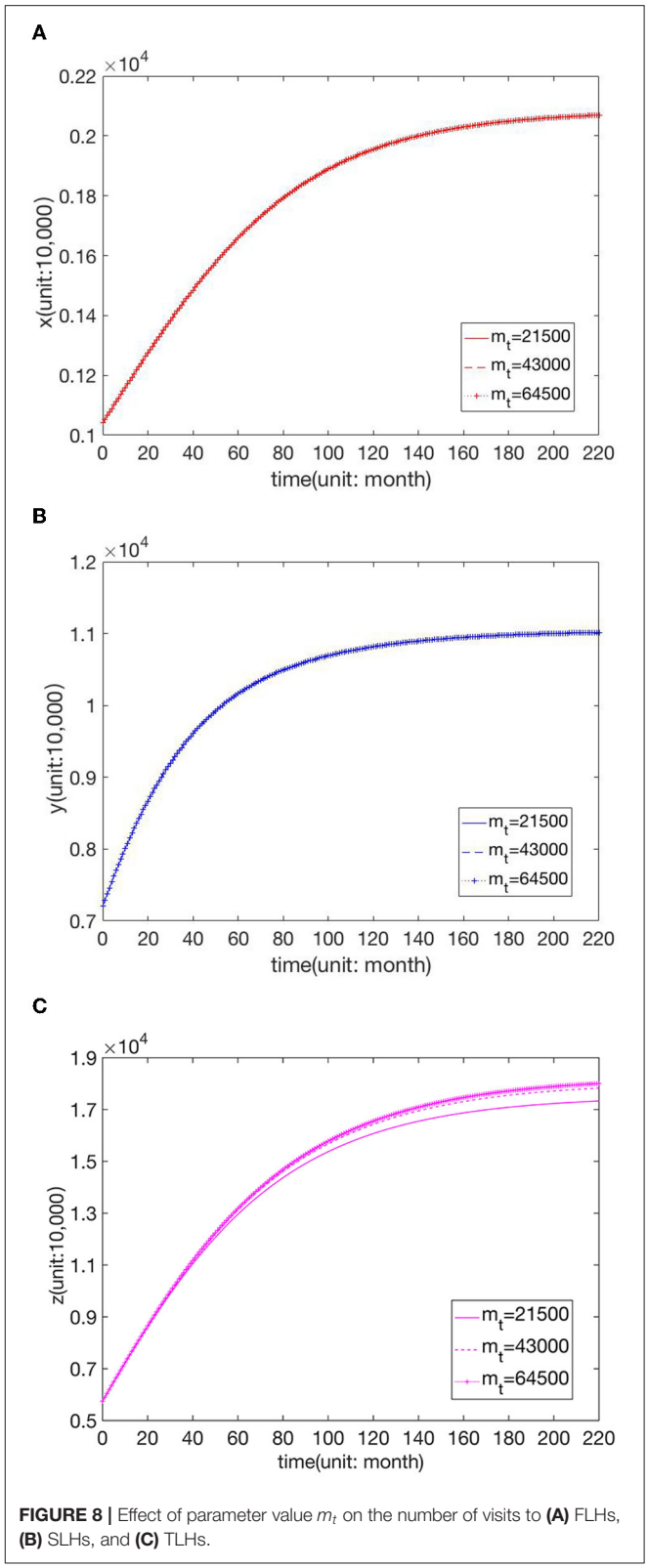


FIGURE 8 | Effect of parameter value m_t on the number of visits to **(A)** FLHs, **(B)** SLHs, and **(C)** TLHs.

levels, we kept the other parameters unchanged and conducted a numerical simulation for the three cases with the maximum patient capacities of 0.5, 1, and 1.5 times, respectively.

We know that the increase in parameters m_f, m_s, and m_t indicates that the comprehensive strength of the hospitals is improved, and thus the maximum capacity of patients is

increased. **Figures 6A–C** shows the changes in the number of visits to hospitals of the three grades when $m_f = 4,499$, $m_f = 8,999$, and $m_f = 13,499$, respectively. **Figures 7A–C** presents the changes in the number of visits to hospitals of the three grades when $m_s = 11,826$, $m_s = 23,653$, and $m_s = 35,479$, respectively. **Figures 8A–C** shows the changes in the number of visits to hospitals of the three grades when $m_t = 21,500$, $m_t = 43,000$, and $m_t = 64,500$, respectively. We can see that the number of visits grows with the rise of m_f. And the shift in m_s does not affect x, while y and z increase with the increase of m_f. And the change in m_t does not affect x and y, while z increases with the rise of m_t, but this effect is not apparent.

CONCLUSIONS

Based on the current data of the Chinese medical system and patients' medical treatment level, this study establishes three differential equation models for the variation of hospital visits over time. It forecasts the development trend of Chinese hospital outpatient visits by analyzing the system's dynamic behavior. Finally, a simulation of the influence of the main parameters on the system was performed. In this manner, we can understand the situation of Chinese patients' choice of hospital and provide a basis for decision-makers to allocate the available medical resources rationally.

In different situations, the system has zero point, boundary equilibrium point, and positive equilibrium point. Among them, the positive equilibrium point means that all three levels of hospitals have patients, which is the basis of the sustainable development of China's medical system. According to the stable condition of the positive equilibrium point, one can see that controlling the rate of patients from FLHs to higher-level hospitals and reducing the loss of patients play a pivotal role in the long-term development of Chinese hospitals. Using previously recorded actual medical data to estimate the model's parameters, we conclude that, in the future development state of China's hospitals at all levels, there will be patients in all three levels of hospitals. Still, the allocation rate of medical resources will be below, and the growth rate of patients in FLHs and SLHs will gradually slow down.

By analyzing the influence of change in the rate of leapfrog medical treatment and the maximum patient capacity of the hospitals on the system, we found that the number of visits to hospitals at all levels in China was negatively correlated with the leapfrog medical treatment from FLHs to higher-level hospitals. The change in the leapfrog medical treatment rate from SLHs to TLHs was negatively correlated with the number of visits to SLHs and positively correlated with the number of visits to SLHs and TLHs, respectively no effect on the number of visits to FLHs. Therefore, from achieving a reasonable distribution of patients, reducing the leapfrog medical treatment in SLHs can enable some patients from TLHs to choose SLHs, thereby relieving the pressure of treatment in TLHs and improving the effective and reasonable utilization of resources.

The increase in the maximum patient capacity of low-level hospitals will also increase the patient capacity of higher-level hospitals. Still, the increase in the maximum patient capacity of higher-level hospitals will not affect the change in the patient capacity of lower-level hospitals. The increase in the maximum patient capacity of SLHs has minimal impact on the overall patient capacity. Therefore, FLHs is the epitome of Chinese hospitals. In other words, with an increase in the comprehensive strength of FLHs, the absolute power of hospitals at all levels will also increase.

Consequently, if the leaders of China's medical system aim to reasonably distribute patients among hospitals at all levels and improve the situation of overcrowding in both large and small hospitals, it is not the best way to control the leapfrog medical treatment rate. Instead, they should improve the comprehensive strength of lower-level hospitals by implementing measures to increase the number of practitioners, enhance their training, and enhance the availability of advanced medical equipment, thereby increasing patients' trust in primary hospitals. Artificial intelligence can be used to improve the service capacity of primary hospitals. For example, in consultation, the system can prompt doctors in primary hospitals to consult patients according to the consultation logic. In the diagnosis process, the system can conduct intelligent analysis and judgment based on the patient's medical record data input by the doctor and assist the doctor in making accurate judgments on the condition. It can also build a new family doctor service model according to the intelligence, understand the health status of residents from time to time, and improve the family doctor compliance rate and residents' satisfaction.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found at: http://www.nhc.gov.cn/mohwsbwstjxxzx/s2906/new_list.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

FUNDING

This study was supported by the National Natural Science Foundation of China nos. 71764035 and 71864021.

REFERENCES

1. Lee SR, Koo BH, Byun GY, Lee SG, Kim MJ, Hong SK, et al. Influence of Internet dissemination on hospital selection for benign surgical disease: a single center retrospective study. *Int J Health Plann Manage.* (2018) 33:502–10. doi: 10.1002/hpm.2545
2. Smith H, Currie C, Chaiwuttisak P, Kyprianou A. Patient choice modelling: how do patients choose their hospitals? *Health Care Manag Sci.* (2018) 21:259–68. doi: 10.1007/s10729-017-9399-1
3. Hanefeld J, Smith R, Horsfall D, Lunt N. What do we know about medical tourism? a review of the literature with discussion of its implications for the UK National Health Service as an example of a public health care system. *J Travel Med.* (2014) 21:410–7. doi: 10.1111/jtm.12147
4. Kessler DP, Summerton N, Graham JR. Effects of the medical liability system in Australia, the UK, and the USA. *Lancet.* (2006) 368:240–6. doi: 10.1016/S0140-6736(06)69045-4
5. Amin SA, McEntee RM, Wagner SC, Schroeder GD, Knightly JJ, Vaccaro AR. Disparities and the American Health Care System. *Clin Spine Surg.* (2019) 32:67–70. doi: 10.1097/BSD.0000000000000608
6. Heidel A, Hagist C. Potential benefits and risks resulting from the introduction of health apps and wearables into the German Statutory Health Care System: scoping review. *JMIR Mhealth Uhealth.* (2020) 23:e16444. doi: 10.2196/16444
7. Zieff G, Kerr ZY, Moore JB, Stoner L. Universal Healthcare in the United States of America: a healthy debate. *Medicina.* (2020) 56:580. doi: 10.3390/medicina56110580
8. Yip W, Fu H, Chen AT, Zhai T, Jian W, Xu R, et al. 10 years of health-care reform in China: progress and gaps in universal health coverage. *Lancet.* (2019) 394:1192–204. doi: 10.1016/S0140-6736(19)32136-1
9. Zhang L, Cheng G, Song S, Yuan B, Zhu W, He L, et al. Efficiency performance of China's health care delivery system. *Int J Health Plan Manage.* (2017) 32:254–63. doi: 10.1002/hpm.2425
10. Li X, Lu J, Hu S, Cheng K, 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
11. Liu XZ, Wang JL. An introduction to China's health care system. *J Public Health Policy.* (1991) 12:104–16. doi: 10.2307/3342782
12. Li L, Fu H. China's health care system reform: Progress and prospects. *Int J Health PlannManage.* (2017) 32:240–53. doi: 10.1002/hpm.2424
13. Wang L, Wang Z, Ma Q, Fang G, Yang J. The development and reform of public health in China from 1949 to 2019. *Global Health.* (2019) 15:45. doi: 10.1186/s12992-019-0486-6
14. Ingrid B de. Groot, Wilma Otten, Harm J Smeets, Perla J Marang-van de Mheen. Is the impact of hospital performance data greater in patients who have compared hospitals? *BMC Health Serv Res.* (2011) 11:214. doi: 10.1186/1472-6963-11-214
15. Gil MR, Choi CG. Factors Affecting the Choice of National and Public Hospitals Among Outpatient Service Users in South Korea. *Inquiry.* (2019) 56:46958019833256. doi: 10.1177/0046958019833256
16. Varkevisser M, van der Geest SA, Schut FT. Do patients choose hospitals with high quality ratings? Empirical evidence from the market for angioplasty in the Netherlands. *Health Econ.* (2012) 31:371–8. doi: 10.1016/j.jhealeco.2012.02.001
17. Roh CY, Lee KH, Fottler MD. Determinants of hospital choice of rural hospital patients: the impact of networks, service scopes, and market competition. *Med Syst.* (2008) 32:343–53. doi: 10.1007/s10916-008-9139-7
18. Victoor A, Friele R, Delnoij D, Rademakers J. Why patients may not exercise their choice when referred for hospital care. An exploratory study based on interviews with patients. *Health Expect.* (2016) 19:667–78. doi: 10.1111/hex.12224
19. Gutacker N. Siciliani L, Moscelli G, Gravelle H. Choice of hospital: which type of quality matters? *Health Econ.* (2016) 50:230–46. doi: 10.1016/j.jhealeco.2016.08.001
20. de Groot IB, Otten W, Dijs-Elsinga J, Smeets HJ, Kievit J, Marang-Van De. Mheen, PJ. Choosing between hospitals: the influence of the experiences of other patients. *Med Decis Making.* (2012) 32:764–78. doi: 10.1177/0272989X12443416
21. Robertson R, Burge P. The impact of patient choice of provider on equity: analysis of a patient survey. *J Health Serv Res Policy.* (2011) 16:22–8. doi: 10.1258/jhsrp.2010.010084
22. de Cruppé W, Geraedts M. Hospital choice in Germany from the patient's perspective: a cross-sectional study. *BMC Health Serv Res.* (2017) 17:720. doi: 10.1186/s12913-017-2712-3
23. Gaynor M, Propper C, Seiler S. Free to choose? Reform, choice, and consideration sets in the English National Health Service. *Am Econ Rev.* (2016) 106:3521–57. doi: 10.1257/aer.20121532
24. Sá L, Siciliani L, Straume OR. Dynamic hospital competition under rationing by waiting times. *J Health Econ.* (2019) 66:260–82. doi: 10.1016/j.jhealeco.2019.06.005
25. Song J, Wen JP. A non-cooperative game with incomplete information to improve patient hospital choice. *Int J Prod Res.* (2015) 53:7360–75. doi: 10.1080/00207543.2015.1077284
26. De la Sen M, Ibeas A. On a sir epidemic model for the COVID-19 pandemic and the logistic equation. *Discrete Dyn Nat Soc.* (2020) 3:1–17. doi: 10.1155/2020/1382870
27. Khatua A, Kar TK, Nandi SK, Jana S, Kang Y. Impact of human mobility on the transmission dynamics of infectious diseases. *Energy Ecol Environ.* (2020) 5:389–406. doi: 10.1007/s40974-020-00164-4
28. Chen YT, Chang DS. Diffusion effect and learning effect: an examination on MSW recycling. *J Cleaner Prod.* (2010) 18:496–503. doi: 10.1016/j.jclepro.2009.12.013
29. Zhou Q, Wang L, Juan L, Zhou S, Li L. The study on credit risk warning of regional listed companies in China based on logistic model. *Discrete Dyn Nat Soc.* (2021) 2022:1–8. doi: 10.1155/2021/6672146
30. Wang C, Rao K, Wu S, Liu Q. Health care in China: improvement, challenges, and reform. *Chest.* (2013) 143:524–31. doi: 10.1378/chest.12-1839
31. Liu Y. China's public health-care system: facing the challenges. *Bull World Health Organ.* (2004) 82:532–8.
32. Shao S, Zhang H, Chen X, Xu X, Zhao Y, Wang M, et al. Health education services utilization and its determinants among migrants: a cross-sectional study in urban-rural fringe areas of Beijing, China. *BMC Fam Pract.* (2021) 22:23. doi: 10.1186/s12875-021-01368-1
33. Zhao D, Zhou Z, Shen C. Nawaz perspective of residents. *BMC Health Serv Res.* (2021) 21:330. doi: 10.1186/s12913-021-06328-0
34. Chen J, Xu S, Gao J. The mixed effect of China's new health care reform on health insurance coverage and the efficiency of health service utilisation: a longitudinal approach. *Int J Environ Res Public.* (2020) 17:1782. doi: 10.3390/ijerph17051782
35. Maignan M, Xiaoyan X, Fiere E. China's health system reform and medical education. *JAMA.* (2009) 302:1270–1. doi: 10.1001/jama.2009.1353
36. Hung LM, Shi LY, Wang HP, Nie XY, Meng QY. Chinese primary care providers and motivating factors on performance. *Fam Pract.* (2013) 30:576–86. doi: 10.1093/fampra/cmt026
37. China National Health Commission. Statistical report on China's health care development in 2019. *Translation.* (2020). Available online at: http://www.nhc.gov.cn/guihuaxxs/s10748/202006/ebfe31f24cc145b198dd730603ec4442.shtml
38. Meng Q, Mills A, Wang L, Han Q. What can we learn from China's health system reform? *BMJ.* (2019) 365:12349. doi: 10.1136/bmj.l2349
39. National Health Commission. *China's health statistics yearbook 2019.* Beijing: Peking Union Medical College Press (2019).
40. Liu J, Yin H, Zheng T, Ilia B, Wang X, Chen R, et al. Primary health institutions preference by hypertensive patients: effect of distance, trust and quality of management in the rural Heilongjiang province of China. *BMC Health Serv Res.* (2019) 19:852. doi: 10.1186/s12913-019-4465-7

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.

this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

frontiers | Frontiers in Public Health

ORIGINAL RESEARCH
published: 27 April 2022
doi: 10.3389/fpubh.2022.773668

Mapping the Research on Health Policy and Services in the Last Decade (2009–2018): A Bibliometric Analysis

Linyan Zhao[1], *Yang Zhao*[2,3,4], *Jian Du*[5,6], *Allissa Desloge*[4], *Zhiyong Hu*[1] *and Gaofang Cao*[1]*

[1] School of Public Health and Management, Binzhou Medical University, Yantai, China, [2] The George Institute for Global Health, University of New South Wales, Sydney, NSW, Australia, [3] The George Institute for Global Health at Peking University Health Science Center, Beijing, China, [4] School of Public Health, University of Illinois Chicago, Chicago, IL, United States, [5] National Institute of Health Data Science, Peking University, Beijing, China, [6] Institute of Medical Information, Chinese Academy of Medical Sciences, Beijing, China

OPEN ACCESS

Edited by:
Stefania Salmaso,
Independent Researcher, Rome, Italy

Reviewed by:
Petar Radanliev,
University of Oxford, United Kingdom
Samar ElFeky,
WHO Regional Office for the Eastern Mediterranean, Egypt

***Correspondence:**
Gaofang Cao
Z17862804987@163.com;
caogaofang2003@163.com

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

Received: 10 September 2021
Accepted: 23 March 2022
Published: 27 April 2022

Citation:
Zhao L, Zhao Y, Du J, Desloge A, Hu Z and Cao G (2022) Mapping the Research on Health Policy and Services in the Last Decade (2009–2018): A Bibliometric Analysis. Front. Public Health 10:773668. doi: 10.3389/fpubh.2022.773668

Background: Health policy and services is a continuously evolving field of research that can inform prevention and control efforts for a variety of health conditions. The "Healthy China" strategy reflects the demand to formulate health policy that suits China's national needs and goals. Applying bibliometric analysis to grasp the general situation of health policy and services research globally will be conducive to informing China's designated health plans and initiatives.

Method: A bibliometric analysis of 58,065 articles on "Health Policy and Services" topics was conducted. The document type was restricted to journal articles that were published in the Web of Science database between the time parameter of January 1, 2009 to December 31, 2018. Data was collected on indicators such as the annual number of publications in the field of health policy and services, the country where the publication is issued, the publication organization, the source journal, the frequency of citations, research hotspots, and academic areas.

Results: The overall number of articles published in Web of Science on health policy and services research has increased over time. The United States has the largest number of articles in the field. The institution with the highest number of citations in the field is Harvard University and the journal with the most published articles in the field is Health Affairs. Research hotspots in the health policy and services field include topics such as "HIV Infections," "Primary Health Care," "Delivery of Health Care," and "Health Services Accessibility."

Conclusion: Experts in the field of health policy and services globally are dedicated to researching the most effective ways to improve people's health and living standards. There is a certain gap in the depth of health policy and services research between China and developed countries and regions such as Europe or America. China must

learn from foreign experience to conduct meaningful and informative research that can aid in the formulation of multi-dimensional health policies in specific areas such as environmental infectious diseases, where attention is needed in areas beyond the medical and health system.

Keywords: health policy, health services, research trends, research hotpots, bibliometric analysis

INTRODUCTION

Health policy and services is a broad research field which covers resources on healthcare systems, including healthcare provision and management, financial analysis, healthcare ethics, health policy, and quality of care. It often intersects with other areas to conduct research. The field of health policy and services research continues to play a key role in public health prevention and control efforts and is an important part of the medical and health system framework. In order to understand the scope of health policy and services research around the world, a bibliometric analysis is needed. Through examining the annual number of publications in the field of health policy and services, the country where the publication is issued, the publication organization, the source journal, the frequency of citations, research hotspots, and academic areas in China and abroad will provide sufficient evidence for an objective comparative analysis of the development of the health policy and services field. In general, the application of bibliometric analysis methods to study health policy and services can provide an overview of research in the field and identify research hotspots and research distribution, which is of great significance for the targeted formulation of health policies.

In the process of deepening China's health system reform, the government has promulgated a large number of health policy documents covering the entire medical and health field. In 2016, the State Council of the People's Republic of China (CPC) issued the Healthy China 2030 Planning Outline, proposing a strategy for developing a healthy China (1). In the report at the 19th CPC National Congress, Xi Jinping emphasized that people's health is an essential symbol of national prosperity. It is necessary to improve national health policies and provide comprehensive health services to the general public. These policies and regulations not only reflect the changes in China's health system but also embody the development of public health concepts since 2009. The deepening of health system reform, the Healthy China 2030 strategy and the introduction of a new medical reform program have brought health policy and services research into a new era.

Research on health policy and services in China has progressed greatly due to the enhancement of health reform and the development of medical services. Most studies in the field of health policy and services, however, are either based on descriptive qualitative analysis or employ quantitative analyses on very minimal amounts of data. Furthermore, the results of this quantitative research on health policy are rarely reported from the bibliometric perspective. Bibliometric analyses on academic papers related to health policy have been conducted previously. For example, Ahmed and others (2) employed a bibliometric analysis of multimorbidity to identify and analyze publications on multimorbidity, including those that most influenced this field. Bibliometric analysis provides a method for measuring the academic interest in health policies and estimates the impact of research on health services and policies (3).

Most researchers have focused on disease-specific health policies and the impact of data on relevant health policies, but this study uses bibliometrics to conduct comprehensive analyses with a broad perspective within health policy and services. After summarizing and analyzing existing research, we recognize several problems: (1) Most studies lack holistic and coherent health policy research, focusing on biomedicine, microscopy, and diagnosis, especially on specific diseases or branches of health; (2) there is a big gap between China's health policy research and those of foreign countries in terms of the number of articles published and the scope of coverage. The foreign experience can be used to inform health policies in specific areas such as caring for environmental infectious diseases, but overall, the gaps identified need to be addressed in order to adequately inform medical and health system reform.

Based on the research gap between China and foreign countries, this article conducts a quantitative analysis of domestic and foreign health policy and services literature. We aim to analyze research hotpots by using indicators such as the annual number of publications, the country where the publication is issued, the publication organization, the source journal, the frequency of citations, research hotspots, and academic areas to increase the quality of health policy and services research in China, broaden the coverage of health policies, and ensure that a comprehensive, multi-level health policy that meets China's need can be formulated. This would, in turn, provide basic compliance and guidance for China's medical and health services.

METHODS

Bibliometric methods, which are often used in information and library science as scientometrics, were utilized to analyze the data for this study. Bibliometric methods have previously been applied to analyze the descriptive characteristics of various journals, including the trend in the number of publications, document type, publication year, number of pages and impact factor. Through this method, we can more intuitively conduct a thematic analysis, hotspot analysis and research trend analysis of the past 10 years of health policy and services literature.

Database and Literature Research

We collected data from Web of Science, the largest database available with about 50% more publications than PubMed (4). First, we searched the database for articles published in INCites using the Category Name: "Health Policy & Services." This Category Name was determined according to the subject category of the core collection of Web of Science. The INCites database gathers data from the seven major index databases in the core collection of Web of Science within the past 30 years, with diversified indicators and rich visualization effects, which can assist scientific research managers in making strategic decisions more efficiently. Concerning the document type, only published journal articles were included in the analysis. Then, a time parameter from January 1, 2009, to December 31, 2018 was applied. December 31, 2018 was selected as the end date of our search timeframe because in 2019, research related to COVID-19 appeared in the Web of Science database for the first time. This worldwide pandemic has caused a surge in related research. This may affect our discovery of other more valuable studies when conducting bibliometric analysis. A10-year research time span can help us better understand the research progress of health policy and services and identify trends in a relatively moderate time. With this in mind, working backwards from the desired end date, the start time of our search timeframe was set to January 1, 2009. Utilizing the above search parameters, 58,065 articles were retrieved and included in the study. In this paper, the bibliometric method is used to conduct a statistical analysis of the literature in the field of health policy and services research in Web of Science from 2009 to 2018. Academic areas, publication year, citation impact, and periodical influencing factors of the retrieval results were analyzed, and bibliometric analysis was performed in the units of the number of papers.

Bibliometric Analysis

Bibliometric analysis is a quantitative analysis used to examine the production of academic literature over time (5), it has previously been applied to analyze the descriptive characteristics of various journals, including the trend in the number of publications, document type, publication year, number of pages, and impact factor (IF) (6, 7). A prominent advantage of bibliometrics is that it allows researchers to study specific research areas by analyzing citations, co-citations, geographical distribution, and word frequency.

After comparing the advantages and disadvantages of the BibExcle, Statistical Analysis Toolkit for Infometrics (SATI), CiteSpace and VOSviewer software programs, CiteSpace software was finally selected as the best fit given the features of the data set of this study. CiteSpace has the following advantages: (1) it can directly de-duplicate the data on the Web of science platform and can also directly preprocess the data on platforms such as Scopus and Derwent. (2) the Chinese data can also be preprocessed through deduplication and format conversion. (3) the layout and visualization of clustering networks are more intuitive and easier to interpret. (4) From a micro point of view, both co-occurrence network analysis and literature coupling analysis can be performed to help researchers obtain classic literature in related fields, and to assist users in acquiring research topics, inflection points, and future development trends. It also supports hybrid networks. We used literature metrological analysis software CiteSpace to analyze these research papers for indicators including the annual number of publications, the country where the publication is issued, the publication organization, the source journal, the frequency of citations, research hotspots, and academic areas in order to describe the characteristics of research results in the field of health policy and services.

RESULTS

Annual Publication Trends

The annual number of papers published over the past decade reports an overall growth trend, which fluctuated slightly from 2015 to 2018, with a decline between 2015 to 2016 and 2017 to 2018. The growth rate of published literature from 2009 to 2015 is relatively fast, while that from 2016 to 2018 is relatively slow. The year with the highest annual growth rate is from 2012 to 2013, during which the total number of papers increased by 808.

As is shown in **Figures 1**, **2**, the number of research papers published in the field of health policy and services from 2009 to 2018 shows an overall increasing trend. The United States (US) and the United Kingdom (UK) have always been the top two countries, maintaining a high level of papers. Published papers from Mainland China have also grown rapidly, ranking 6th in 2018.

The research papers we collected data on are mainly from the US, Australia, Sweden, Spain, Norway, the UK, New Zealand, France, Italy, China, Canada, Germany, Switzerland, North Africa, and 14 other countries and regions. The US has the most extensive collection of literature in this field, but its growth has been slow since 2009. Before 2012, there had been relatively little research on health policy and services in mainland China, but it has been slowly increasing since then.

Top 10 Research Institutions According to Citation Frequency

Table 1 lists the statistical data of scientific research institutions that published papers on health policy and services from 2009 to 2018 and their rankings in descending order of citation frequency. The total number of related literature published by scientific research institutions in various regions is extremely uneven. Among them, institutions in the US have the largest number of papers. Of the top 10 scientific and technological institutions, 8 are from the US, followed by one from the UK and one from Canada.

The top 10 institutions cited have published 15,782 papers, accounting for 27.2% of the total. Harvard University, the University of California System, and the University of London topped the list, with 2,632, 2,895, and 2,176 articles, respectively. Most remaining institutions in the top 10 have published around 1,000 articles each. University of Pennsylvania published <1,000.

The citation frequency ranking of published articles by the top 10 scientific research institutions is the same as that of the articles published. Among the institutions, Harvard University has been cited the most, with 43,578 citations. Literature published by

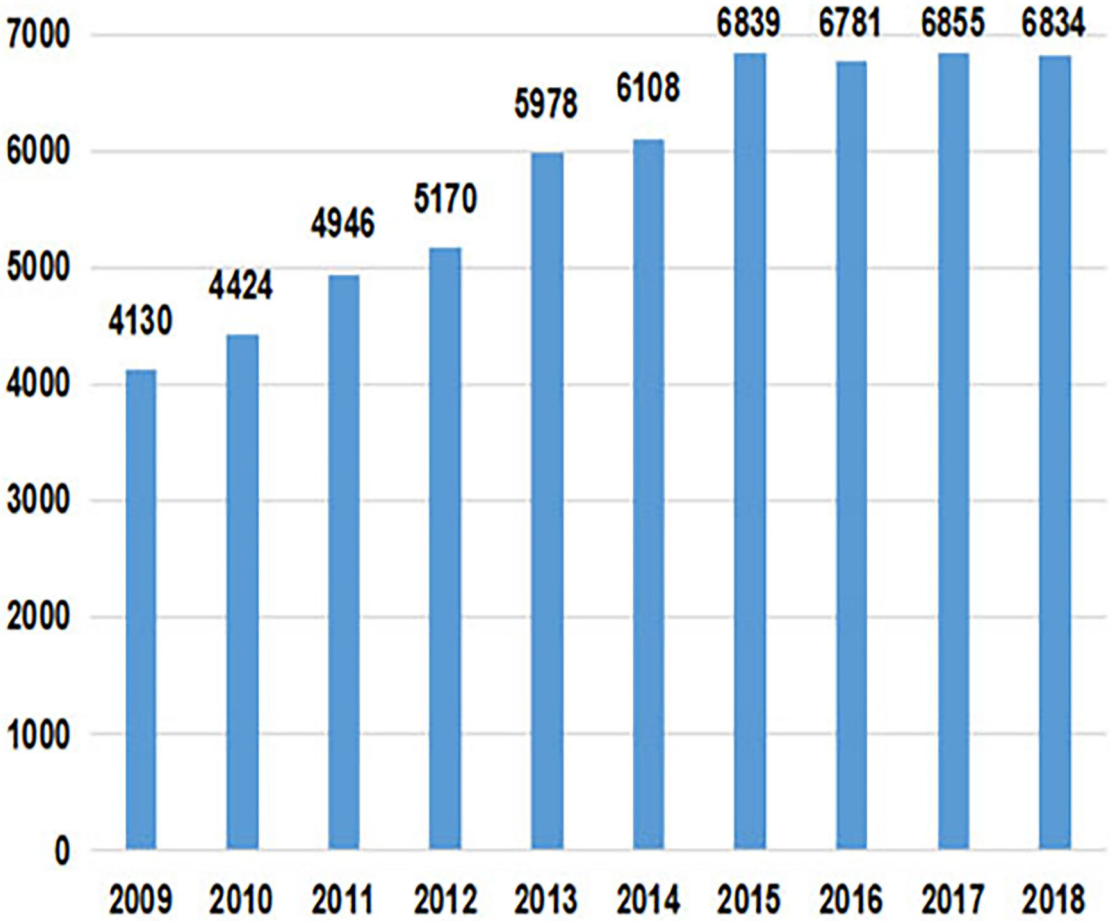


FIGURE 1 | Total number of publications of health policy and services from 2009 to 2018.

University of Pennsylvania is the least cited, with a total of 15,810 citations. Both Harvard University and the University of California have been cited more than 40,000 times. It is reasonable to assume that these two institutions have the largest literature base with the highest quality in this field.

Top 20 International Journals of Publications in Health Policy and Services

We rank journals based on Web of Science publications. According to **Table 2**, the top 20 journals of publications in health policy and services have included 28,941 papers, accounting for 49.8% of the total. The Journal Citation Report (JCR) published by Institute for Scientific Information (ISI) every year counts and calculates the citations and cited data between journals, and determines the journal's impact factor based on the average number of citations of the journal in 2 years. When the journal's impact factor is higher, the citation rate of its literature is also higher. To reflect the quality of a journal, all journals in a certain discipline are arranged in descending order according to the impact factor value of the previous year, and then divided into four quartiles: Q1, Q2, Q3, and Q4. According to JCR, and as seen in **Table 2**, when looking at journals covering health policy and services research, there were seven journals in Q1, seven in Q2, five in Q3, and one in Q4. The distribution indicates that the selected literature has a high impact factor and is at the leading level in the research field, which is of great significance for citation. The highest Web of Science publications is Health Affairs (2,523 articles) in Q1. AIDS Care-psychological and Socio-medical Aspects of AIDS/HIV in Q2 ranks the second with 2,288 articles. However, the citation frequency of AIDS Care-psychological and Socio-medical Aspects of AIDS/HIV (23,116 times) is significantly lower than that of Health Affairs (63,667 times).

Research Publications Across 10 Specific Academic Areas of Health Policy and Services

Research in the field of health policy and services covers a total of 92 specific disciplines, and the 10 specific disciplines with the largest number of papers (**Table 3**) are Health Policy & Services, Health Care Sciences & Services, Public, Environmental & Health, Economics, Social Sciences,

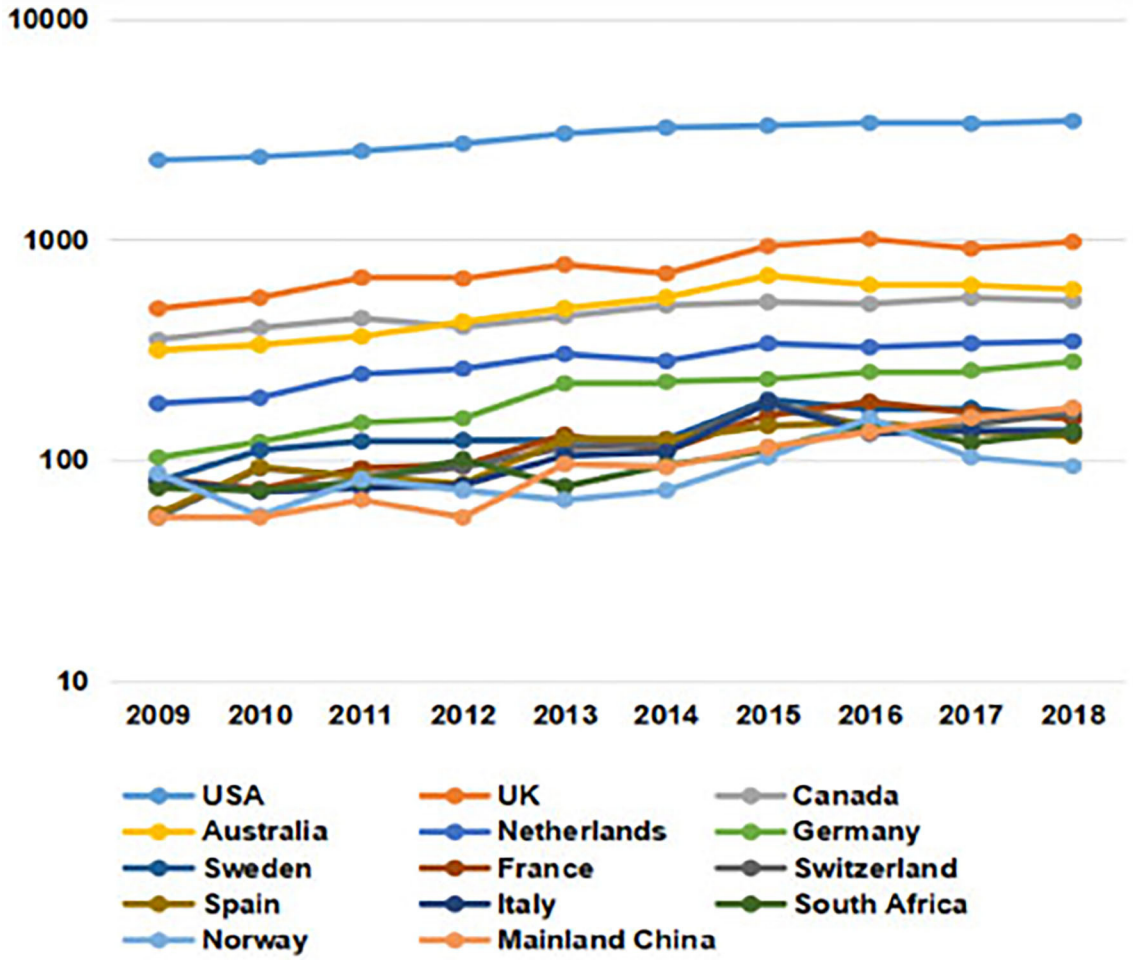


FIGURE 2 | Number of papers of health policy and services from 2009 to 2018 by country.

Biomedical, Psychiatry, Psychology, unapproved, Respiratory System, Rehabilitation, Communication.

As shown in **Figure 3**, through the co-journal approach, computing disciplines and structures related to health policy science form a skeleton diagram of disciplines related to health policy science. Co-journal refers to the division of the same journal based on the subject of the content. A journal may involve multiple subject categories, so a subject will have the same journal. Each node in the figure represents a discipline. The larger the node, the more papers published in the discipline. It can be seen that "Health Policy & Services," "Health Care Science & Services," "Public, Environmental & Occupational Health" are three major fields of health policy and services research. The connection between nodes indicates the correlation between disciplines. When there are more journals in common between disciplines, it is easier to form a closer relationship, and the discipline group formed between these disciplines is stronger. In **Figure 3**, the subject category "Health Policy & Services" is related to multiple subject categories in the circle. Among them, "Health Care Sciences & Services," "Public, Environmental & Occupational Health," "Economics," "Social Science, Biomedical," and "Psychiatry" are more closely related to it, which shows that they have more joint journals.

Main Diseases, Research Targets, and Methods

As shown in **Supplementary Table 1**, most papers in the field of health policy and services focus on humans, such as "female," "male," "adult," and "middle-aged." They mainly use surveys and questionnaires, cross-sectional studies, qualitative research, interviews, and retrospective studies. Selecting the top 100 MeSH terms from these papers in the last 10 years can provide a good overview of the main diseases, research targets, and methods. According to the classification of the MeSH terms, common research targets include humans, female, male, adult, middle aged, aged, and the United States. Common research methods include surveys and questionnaires, cross-sectional studies, retrospective studies, and longitudinal studies. Common diseases include HIV infections, mental disorders, depression, physicians, and neoplasms.

Among the MeSH terms classified as research targets, "Human" has the largest number of records, reaching 17,194, followed by "Female" appearing 10,556 times. The MeSH term "surveys and questionnaires" is the most frequently used research method, with 3,581 records. Among the diseases, "HIV Infections" is the studied most often, with 1,067 records. Based on the number of MeSH terms recorded, the hotpots in the field of health policy and services from 2009 to 2018 are main factors related to disease or health in different age and gender groups, and the research on HIV infection. From the perspective of research content, literature on health assessment methods, health assessment research tools and standards of health assessment status have received the most attention. These studies include information on indicators for assessing health-related quality of life, innovations in the pharmaceutical industry, upgrading of direct measures, and the assessment of annual medical expenditures on obesity, all of which provide methodological support for health policy research.

Recent Research Topics

This paper describes the research hotspots of health policy and services in the decade through the centrality of vocabulary. The clustering diagram of the co-occurrence

TABLE 1 | Scientific research institutions in the field of health policy and services.

Rank	Research institution	Citation frequency	Web of science publications
1	Harvard University	43,578	2,632
2	University of California System	41,546	2,895
3	University of London	27816	2,176
4	Johns Hopkins University	20,699	1,444
5	University of Michigan	19,503	1,124
6	University of Washington	16,901	1,096
7	University of Washington Seattle	16,685	1,075
8	University of Toronto	16,316	1216
9	VA Boston Healthcare System	15,984	1,131
10	University of Pennsylvania	15,810	993

The ranking is in descending order of citation frequency.

TABLE 3 | Academic areas of health policy and services.

Rank	Academic area	Number of publications
1	Health Policy & Services	58,065
2	Health Care Sciences & Services	32,676
3	Public, Environmental & Occupational Health	19,921
4	Economics	5,874
5	Social Sciences, Biomedical	4,446
6	Psychiatry	3,343
7	Psychology, Multidisciplinary	2,660
8	Respiratory System	2,288
9	Rehabilitation	1,253
10	Communication	1,166

TABLE 2 | Journals of publications in health policy and services.

Rank	Journal	Web of science publications	Citation frequency	Quartile
1	Health Affairs	2,523	63,667	Q1
2	AIDS Care-psychological and Socio-medical Aspects of AIDS/HIV	2,288	23,116	Q2
3	Quality of Life Research	2,284	30,509	Q2
4	Psychiatric Services	1982	26,826	Q2
5	Health and Quality of Life Outcomes	1,690	20,132	Q2
6	Medical Care	1,689	30,552	Q1
7	Health Policy	1,506	14,808	Q2
8	American Journal of Managed Care	1,503	13,423	Q3
9	Value in Health	1,398	23,948	Q1
10	Journal of Community Health	1,327	9,196	Q3
11	Health Services Research	1,277	17,195	Q1
12	Health Economics	1,218	14,263	Q2
13	Implementation Science	1,216	27,309	Q1
14	Journal of Health Care for the Poor and Underserved	1,205	7,325	Q4
15	Health Communication	1,097	8,051	Q3
16	Community Mental Health Journal	1,067	6,812	Q3
17	Journal of Interprofessional Care	954	6,761	Q3
18	Health Policy and Planning	952	10,595	Q1
19	Journal of Genetic Counseling	898	6,651	Q2
20	Journal of Health Economics	867	15,514	Q1

The ranking is in descending order of Web of Science publications.

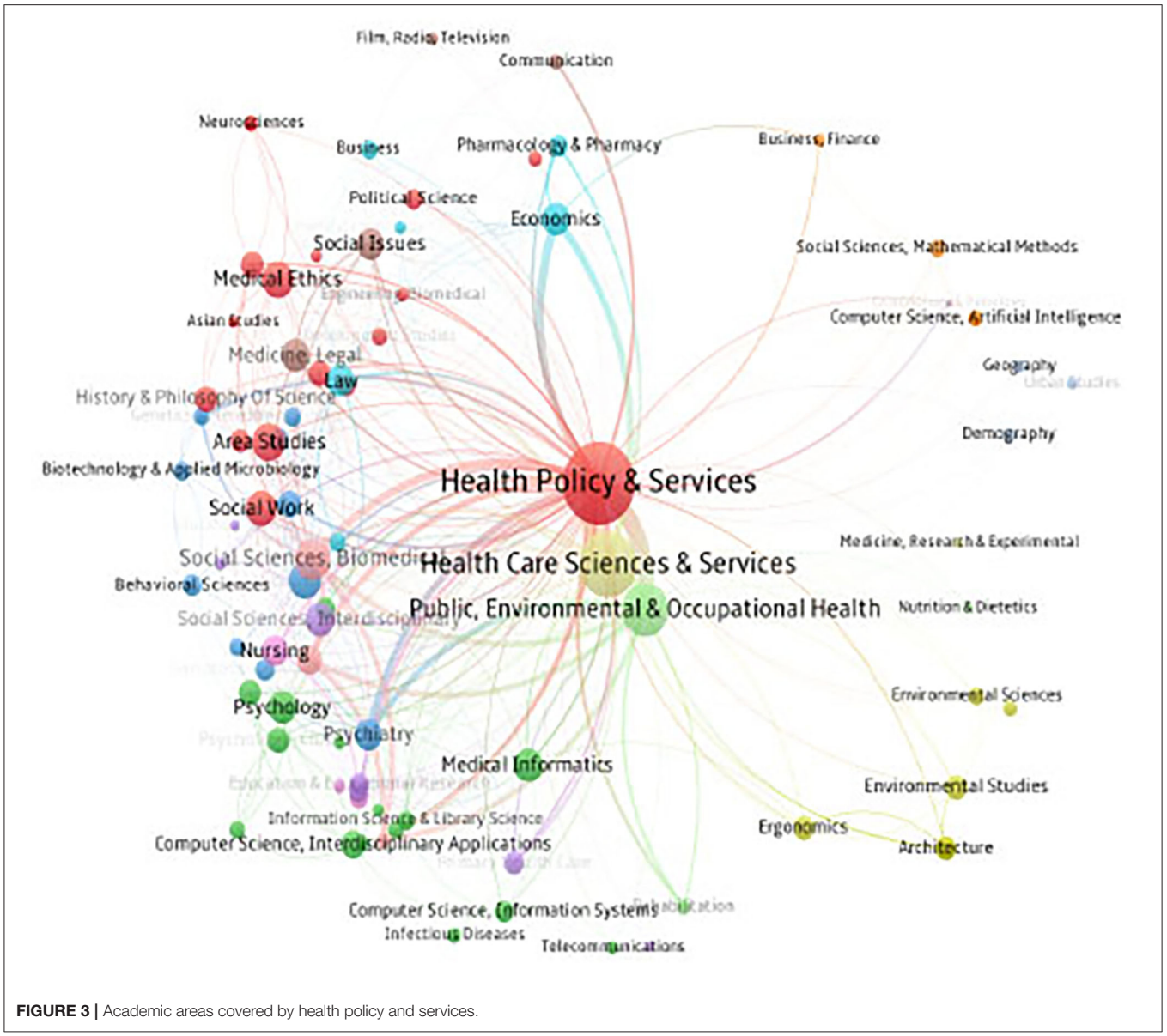


FIGURE 3 | Academic areas covered by health policy and services.

of main keywords (**Figure 4**) shows the word frequency and centrality. The larger the dots, the higher the word frequency. The hot topics in the last 3 years are calculated based on 5,871 articles from 2016, 5,950 from 2017, and 6,329 from 2018.

In 2016–2018, keywords with the highest word frequency are "HIV Infections," "Primary Health Care," "Delivery of Health Care," and "Health Services Accessibility." Cluster analysis was conducted on 135 high-frequency keywords divided into 6 categories was shown in **Figure 5**.

Highly-Cited Papers on Health Policy and Services

As shown in **Supplementary Table 2**, highly-cited papers are another important aspect reflecting research hotspots. The research papers published in the field of health policy and services from 2009 to 2018 were ranked according to the Category Normalized Citation Impact (CNCI). The top 20 papers in terms of CNCI are shown in **Supplementary Table 2**. The paper with the highest CNCI is "Valuing health-related quality of life: An EQ-5D-5L value set for England" from Health Economics, cited 167 times by September 19, 2019 (CNCI = 142.0383). The top 20 papers are mainly from journals such as Health Economics and Implementation Science, of which 18 have been cited more than 200 times. The most cited paper is "Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science" from Implementation Science, which has been cited 2,088 times and ranks second by CNCI (CNCI = 93.8544).

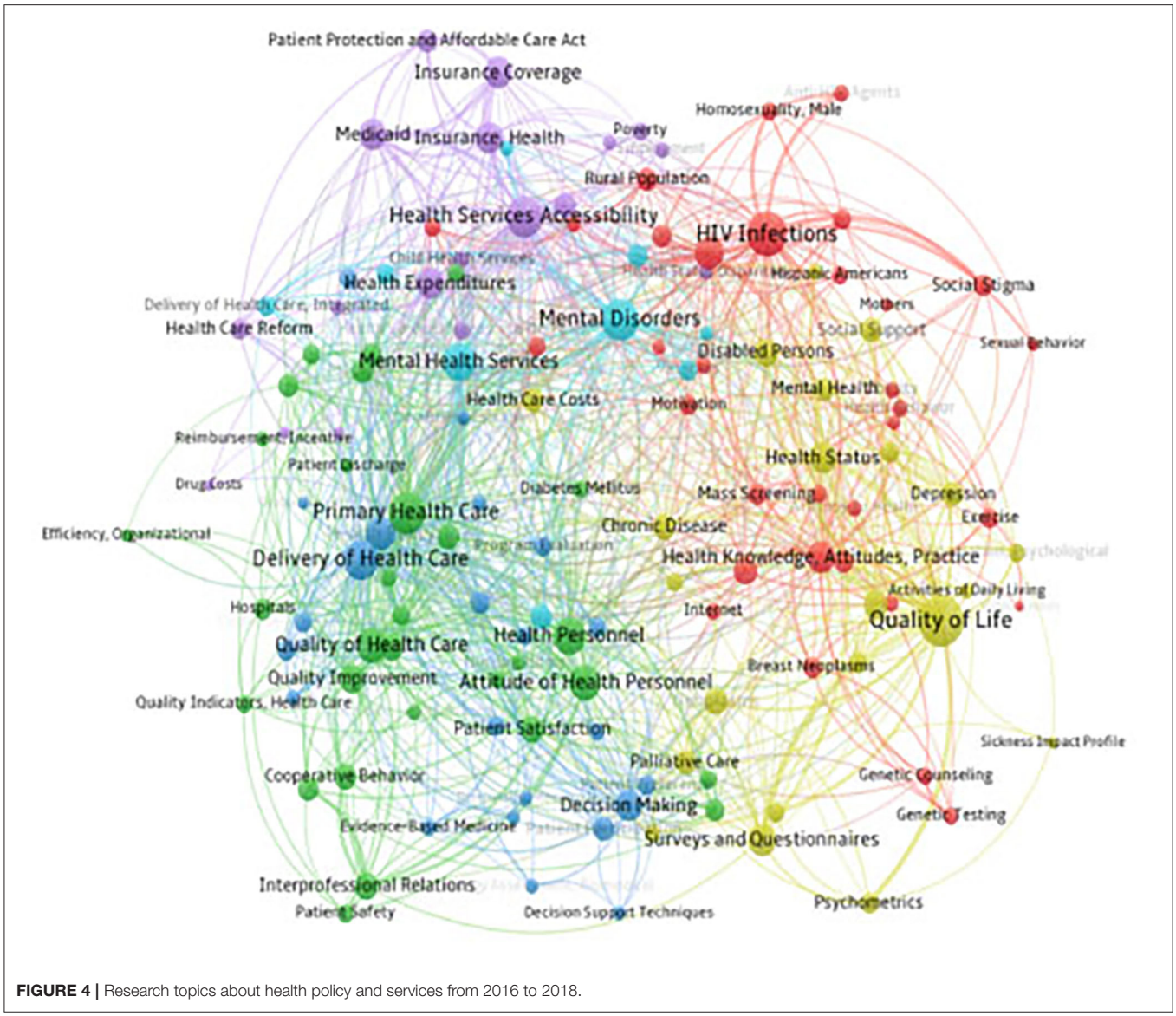


FIGURE 4 | Research topics about health policy and services from 2016 to 2018.

DISCUSSION

This bibliometric analysis provides an overview of the trends within health policy and services research from 2009 to 2018. For a long time, substantial effort has been devoted to catalyzing health policy and services research, but due to funding and resource limitations, some low and middle-income countries still have insufficient participation in this area (8). The article applies the bibliometric method to interpret the focus of health policy and service research in different countries and regions (especially China and the United States), the correlation between discipline categories, and the focus on diseases and research frontiers.

This article offers a unique contribution and builds upon the existing research on health policy and services using bibliometric analysis methods, in the following ways:

In terms of research scope, previous research in this area has been focused on a specific country or region. For example, Zyoud and colleagues used Microsoft Excel software to analyze the research productivity of toxicology in Middle Eastern Arab countries (9), and Sharma analyzed the published road traffic injury research in India (10). Comparatively, this article analyzes research productivity in the field of health policy and services based on a global perspective, so as to find research differences and changing trends between countries, and better grasp the frontiers of world research.

In terms of analysis indicators, previous studies utilize the basic indicators of bibliometric analysis. For example, Sweileh used basic indicators such as number and types of retrieved documents, author keywords, research domains, preferred journals, most active countries and journals to show the results of a bibliometric analysis of the global immigration health research in the peer-reviewed literature (11). In addition to the above basic indicators, this article also shows the main subject areas of the research, the cooperation of each subject area, and the results

FIGURE 5 | Clustering analysis results of health policy and services.

of cluster analysis of keywords. This helps to grasp the research hotspots and trends in the field of health policy and services.

At different times, different countries have different priorities for health policy and services. In last decade, the focus of this field has gradually shifted from public environmental occupational health (12–16), health policy services (17–21), and health science services (22–26) to specific diseases such as psychiatric (27–29) and pediatric diseases as well as environmental science ecology (30), biomedical social sciences and other fields. It has undergone a transformation from macro to micro. Generally, research on public environmental health, health policy services, and health science services are relatively mature. Developed countries are the main contributors to the research results in the field of health policy and services, and their research is more forward-looking, such as the research on the combination of pharmacology and health policy services. In addition to researching medical and health services and health care, the research on health policy and services also involves the fairness and accessibility of medical and health services, the reform of the medical and health system, traditional Chinese medicine, and infectious diseases like tuberculosis. However, in comparison, China's policy research on health care services is not as mature. All countries have strengths and weaknesses in their research, but have the opportunity to learn from one another. For example, learnings from the United States on pharmacology research can enhance traditional Chinese medicine. Additionally, China can learn from research in other countries on health services for pregnant women, newborns, and patients with mental health conditions.

Health Policy and Services research scientific policy has the characteristics of multi-disciplinary, prone to problem-solving, and obvious standardization. **Figure 3** calculated by the method of co-journalism reflects the multidisciplinary nature of health

policy and services research. Although the relationship between "health policy & services" and "economics," "health care sciences & services," "public," "environmental & occupational health," "social science," "biomedical," "psychiatry" and other disciplines is relatively close, there are still "geography," "nutrition & dietetics," "information science & library science" and other disciplines that are marginalized. It shows that health policy and service research should strengthen the correlation between economics, library science, information technology and science, journalism and communication, and enrich the research results in this field, and seek new breakthroughs. In the new post COVID 19 era, the rapid development of big data and artificial intelligence will lead to more precise, comprehensive, and rapid research. This will allow for improved conduction of empirical research on factors affecting population health, exploration of ways to formulate health policies in line with social development trends, and discovery of health policy and services breakthroughs in medical and health system quality improvement.

In terms of the diseases that are of major concern, in addition to the highly valued research on HIV/AIDS, mental disorders, chronic diseases, depression, and tumors have become the most concerning diseases in the health policy and services field during this period. According to a report released by The Joint United Nations Programme on HIV/AIDS(UNAIDS), as of 2018, the number of people living with HIV worldwide has reached 1.7 million, a decrease of 16% compared to 2010, which is mainly due to the progress made in combating HIV in southern and eastern African countries (31). This is consistent with the results of the literature measurement. Africa ranks third in the output of AIDS research in the field of health policy and services, after the United States and the United Kingdom. In China, according to the "China Health Statistics Yearbook" from 2009 to 2018, AIDS ranks first in the number of deaths from statutory infectious diseases reported in categories A and B, and its incidence has increased year by year. However, China's research results on fighting AIDS are very few, which points out a key area for China to pursue breakthrough research in. Additionally, in the past 10 years, the mortality rate of malignant tumors and the prevalence of chronic diseases have gradually increased in China. Similarly, China, Europe and the United States and other developed countries and regions on the relevant research for the prevention and treatment of cancer and chronic disease control obviously living in disadvantaged. Based on the high prevalence and high fatality rate of domestic infectious diseases, chronic diseases, malignant tumors, and depression, future research should focus on tackling these key diseases (32–41).

The co-occurrence cluster map of the main themes from 2016 to 2018 is further evidence of the above discussion. In the past 3 years, the focus of global attention in the field of health policy and services has alluded to the importance of fighting AIDS, enhancing the accessibility of medical and health services, the provision of medical and health services, and the importance of mental health services. These are the first issues that should be addressed in this field. China's focus is more on the reform of medical insurance (42, 43), the development and application of intelligent medical systems (44), and primary medical and health services. Western countries pay more attention to the application of mathematical-statistical analysis and other methods to verify or evaluate influencing factors. However, the application of this aspect is not limited to clinical disease causative factors, and environmental indicators are also taken into consideration.

It is found that although the total number of publications in the field of health policy and services in the US far exceeds that of China, the proportion of publications detailed in each research direction is different. For example, the proportion of publications in the research direction of Public Environmental Occupational Health in the US is 39.472%, while the proportion of publications in this research direction in China is 44.182%, which is nearly 5% higher than that in the US. Therefore, the US has an opportunity to learn from China. On the basis of maintaining extensive research on health policy and services, the US should strengthen its research in the following areas which currently represent less than half of the total amount of health policy and services research published to make up for the weaker aspects such as Public Environmental Occupational Health (accounting for 39.472%), Biomedical Social Sciences (accounting for 8.928%), Business Economics (accounting for 8.141%), Psychology (accounting for 5.755%), Respiratory System (accounting for 4.961%), Pharmacology Pharmacy (accounting for 1.078%), Government Law (accounting for 0.844%) and International Relations (accounting for 0.05%).

Similarly, compared with the US, China's research in the field of health policy and services needs to be strengthened. China has only 18 research directions, while the US has 21 research directions. In addition, China should also learn from the excellent research results of the US, and enhance the depth of research, especially for Psychiatry (accounting for 4.353%), Geriatrics Gerontology (accounting for 1.897%), Rehabilitation (accounting for 1.786%), Medical Informatics (accounting for 1.451%), to improve academic influence in the field. In general, while drawing on the experience of other regions and countries, China's health policy research should also incorporate the development status and characteristics of its own health system. Through a bibliometric analysis of global health policy and services research, this article shows the research trends in various countries and regions and highlights the areas that need to be further strengthened. The research directions of various countries and regions are basically the same for diseases that are showing a pandemic trend on a global scale. In addition, the focus of each country and region is different according to its own context. For example, the research focus of China tends to the goal of medical and health system reform.

Strengths and Limitations

Using bibliometrics methods to analyze research in the field of health policy and services, we can directly understand, the scientific research contributions made by countries and regions to the development of the field, the scientific research institutions and journals, research hotspots and main research directions. Through this research method, you can quickly see the research progress of different countries and regions in the field of health policy and services, find research gaps, and help to formulate health policies and provide health services in a targeted manner.

Despite these strengths, there are some limitations to be acknowledged. This study is just based on the Web of Science database, although we believe it fully depicts the research results of the past 10 years. However, our findings may not necessarily represent the overall development of the health policy and services field beyond this what is provided in this database and the specified timeframe. In addition, as mentioned previously in this article, COVID-19 related articles were not included in the study. The inclusion of these articles had the potential of skewing our findings and masking identified trends, but we are considering conducting a comprehensive and in-depth review and analysis on COVID-19 in the future.

CONCLUSION

Studying journal articles on health policy and services in the Web of Science database over the past decade, we have found that scholars and experts in this field are working on the most effective ways to improve people's health and living standards. The methods and indicators of health evaluation have become the focus of research, which is also the general trend of China's health policy research. Highly cited papers have important reference value for discussion on research methods, standards, and models. Statistical analysis of the Web of Science database indicates that most papers are from developed regions and countries such as Europe and the US, and the most influential research institutions and journals are also mainly from the UK and the US. In terms of the number of publications in the field of health policy and services, China should learn from developed countries to improve research productivity.

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/s.

AUTHOR CONTRIBUTIONS

GC conceived and designed the study. LZ, JD, and GC did the initial analysis and supervised data analysis. LZ and YZ wrote the first draft of the paper. YZ, AD, ZH, and GC critically revised the first draft. All authors reviewed and approved the final version of the paper submitted for publication.

FUNDING

The National Social Science Fund of China (81602869) was funded by National Office of Philosophy and Social Science.

ACKNOWLEDGMENTS

We thank the teacher who provided data processing support for this study to JD and also thank the National Social Science Foundation of China for its financial support for this research. Finally thank the authors for their hard work on this article.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.773668/full#supplementary-material

REFERENCES

1. *The CPC Central Committee and the State Council Issued the Outline of the Healthy China 2030 Plan*. Available online at: http://www.gov.cn/zhengce/2016-10/25/content_5124174.htm (accessed October 2016).
2. Ahmed MAA, Almirall J, Ngangue P, Poitras ME, Fortin M. A bibliometric analysis of multimorbidity from 2005 to 2019. *J Comorb.* (2020) 10:1–7. doi: 10.1177/2235042X20965283
3. Sun GH. Bibliometric analysis of health services research in otolaryngology journals. *Otolaryngology Head Neck Surgery.* (2012) 147:841–47. doi: 10.1177/0194599812454405
4. *Clarivate Analytics*. (2017). Available online at: http://wokinfo.com (accessed March 29, 2017).
5. Bach XT, Frank YW, Kiet THP, Carl AL, Giang HH, Giang TV, et al. Evolution of interdisciplinary landscapes of HIV acquired immune deficiency syndromes studies from 1983 to 2017: results from the global analysis for policy in research (GAPRESEARCH). *AIDS Rev*. (2019) 21:184–94. doi: 10.24875/AIDSRev.19000083
6. Elster AD, Chen MY. The internationalization of the American journal of roentgenology: 1980-1992. *Am J Roentgenology.* (1994) 162:519–22. doi: 10.2214/ajr.162.3.8109488
7. Wang MH, Yu TC, Ho YS. A bibliometric analysis of the performance of water research. *Scientometrics*. (2010) 84:813–20. doi: 10.1007/s11192-009-0112-0
8. English KM, Pourbohloul B. Increasing health policy and systems research capacity in low- and middle-income countries: results from a bibliometric analysis. *Health Res Policy Syst.* (2017) 15:64. doi: 10.1186/s12961-017-0229-1
9. Zyoud SH, Al-Jabi SW, Sweileh WM, Awang R. A bibliometric analysis of toxicology research productivity in Middle Eastern Arab countries during a 10-year period (2003-2012). *Health Res Policy Syst*. (2014) 12:1–13. doi: 10.1186/1478-4505-12-4
10. Sharma N, Bairwa M, Gowthamghosh B, Gupta SD, Mangal DK. A bibliometric analysis of the published road traffic injuries research in India, post-1990. *Health Res Policy Syst.* (2018) 16:18. doi: 10.1186/s12961-018-0298-9
11. Sweileh WM, Wickramage K, Pottie K, Hui C, Roberts B, Sawalha AF, et al. Bibliometric analysis of global migration health research in peer-reviewed literature (2000-2016). *BMC Public Health.* (2018) 18:777. doi: 10.1186/s12889-018-5689-x
12. Nalukwago J, Alaii J, Van den Borne B, Bukuluki PM, Crutzen R. Application of core processes for understanding multiple concurrent sexual partnerships among adolescents in Uganda. *Front Public Health*. (2018) 6:371. doi: 10.3389/fpubh.2018.00371
13. Behzadifar M, Beyranvand T, Jafari M, Behzadifar M, Taheri MM, Martini M, et al. A description of the temporal pattern of out-of-pocket expenditure related to iranian healthcare services during 1995-2014. *Iran J Public Health.* (2018) 47:1552–7. doi: 10.1016/.jaac.2010.10.006
14. Angel HYL, Zoey K, Carrie HKY, Shereen A, Eng-Kiong Y. Vouchers for primary healthcare services in an ageing world? The perspectives of elderly voucher recipients in Hong Kong. *Health Soc Care Community.* (2018) 26:374–82. doi: 10.1111/hsc.12523
15. Beaussier AL, Demeritt D, Griffiths A, Rothstein H. Accounting for failure:risk-based regulation and the problems of ensuring

healthcare quality in the NHS. *Health Risk Soc.* (2016) 18:205–24. doi: 10.1080/13698575.2016.1192585
16. Letcher AS, Perlow KM. Community-based participatory research shows how a community initiative creates networks to improve well-being. *Am J Prev Med.* (2009) 37:S292–9. doi: 10.1016/j.amepre.2009.08.008
17. Maniatopoulos G, Le Couteur A, Vale L, Colver A. Falling through the gaps: exploring the role of integrated commissioning in improving transition from children's to adults' services for young people with long-term health conditions in England. *J Health Serv Res Policy.* (2018) 23:107–15. doi: 10.1177/1355819617752744
18. Scheffler RM, Arnold DR. Insurer market power lowers prices in numerous concentrated provider markets. *Health Aff.* (2017) 36:1539–46. doi: 10.1377/hlthaff.2017.0552
19. Calciolari S, Ilinca S. Unraveling care integration: Assessing its dimensions and antecedents in the Italian Health System. *Health Policy.* (2016) 120:129–38. doi: 10.1016/j.healthpol.2015.12.002
20. Bojke C, Castelli A, Street A, Ward P, Laudicella M. regional variation in the productivity of the english national health service. *Health Econ.* (2013) 22:194–211. doi: 10.1002/hec.2794
21. Stringhini S, Thomas S, Bidwell P, Mtui T, Mwisongo A. Understanding informal payments in health care: motivation of health workers in Tanzania. *Hum Resour Health.* (2009) 7:53. doi: 10.1186/1478-4491-7-53
22. Rotondo F, Giovanelli L, Fadda N, Ezza A. A methodology to design a performance management system in preventive care. *BMC Health Serv Res.* (2018) 18:1002. doi: 10.1186/s12913-018-3837-8
23. Topp SM, Moonga CN, Luo N, Kaingu M, Chileshe C, Magwende G, et al. Exploring the drivers of health and healthcare access in Zambian prisons: a health systems approach. *Health Policy Plan.* (2016) 31:1250–261. doi: 10.1093/heapol/czw059
24. Kassa H, Murugan R, Zewdu F, Hailu M, Woldeyohannes D. Assessment of knowledge, attitude and practice and associated factors towards palliative care among nurses working in selected hospitals, Addis Ababa, Ethiopia. *BMC Palliat Care.* (2014) 13:6. doi: 10.1186/1472-684X-13-6
25. Bradley CJ, Penberthy L, Devers KJ, Holden DJ. Health services research and data linkages: issues, methods, and directions for the future. *Health Serv Res.* (2010) 45:1468–88. doi: 10.1111/j.1475-6773.2010.01142.x
26. Dall TM, Chen YJ, Seifert RF, Maddox PI, Hogan PF. The economic value of professional nursing. *Med Care.* (2009) 47:97–104. doi: 10.1097/MLR.0b013e3181844da8
27. Merikangas KR, He JP, Burstein M, Swendsen J, Avenevoli S, Case B, et al. Service utilization for lifetime mental disorders in US adolescents: results of the national comorbidity survey-adolescent supplement (NCS-A). *J Am Acad Child Adolesc Psychiatry.* (2011) 50:32–45. doi: 10.1016/j.jaac.2010.10.006
28. Pescosolido BA, Martin JK, Long JS, Medina TR, Phelan JC, Link BG. "A disease like any other"? a decade of change in public reactions to schizophrenia, depression, and alcohol dependence. *Am J Psychiatry.* (2010) 167:1321–30. doi: 10.1176/appi.ajp.2010.09121743
29. Baxter AJ, Brugha TS, Erskine HE, Scheurer RW, Vos T, Scott JG. The epidemiology and global burden of autism spectrum disorders. *Psychol Med.* (2015) 45:601–13. doi: 10.1017/S003329171400172X
30. Barton J, Pretty J. What is the best dose of nature and green exercise for improving mental health? a multi-study analysis. *Environ Sci Technol.* (2010) 44:3947–55. doi: 10.1021/es903183r
31. The Joint United Nations Programme on HIV/AIDS. *New HIV Infectio-NS-All Ages.* Available online at: https://www.unaids.org/en/global-aidsmonitoring (accessed March 20, 2019).
32. Ministry of Health of the People's Republic of China. *2010 China Health Statistical Yearbook*. Available online at: http://www.nhc.gov.cn/htmlfiles/zwgkzt/ptjnj/year2010/index2010.html (accessed October 16, 2011).
33. Ministry of Health of the People's Republic of China. *2011 China Health Statistical Yearbook.* Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/s7967/201301/f34860a7bdb64aad9029eb860a6cf4d2.shtml (accessed January 16, 2013).
34. Ministry of Health of the People's Republic of China. *2012 China Health Statistical Yearbook.* Available online at: http://www.nhc.gov.cn/htmlfiles/zwgkzt/ptjnj/year2012/index2012.html (accessed June 10, 2013).
35. State Family Planning Commission of the People's Republic of China. *2013 China Health and Family Planning Statistical Yearbook*. Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/61cd8c0fb4a24f51bd1b80533e25c004.shtml (accessed June 05, 2014).
36. State Family Planning Commission of the People's Republic of China. *2014 China Health and Family Planning Statistical Yearbook*. Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/e09dc97f4721446eafc4305b81284bee.shtml (accessed June 10, 2015).
37. State Family Planning Commission of the People's Republic of China. *2015 China Health and Family Planning Statistical Yearbook*. Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/e4fc0eab50484509a9c64f481fc322b1.shtml (accessed June 13, 2016).
38. State Family Planning Commission of the People's Republic of China. *2016 China Health and Family Planning Statistical Yearbook*. Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/41c5f4fff9f448868bc03a1e2f4c28a9.shtml (accessed June 13, 2017).
39. State Family Planning Commission of the People's Republic of China. *2017 China Health and Family Planning Statistical Yearbook.* Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/bb81a4c32259405189689e6f7cfe5b8f.shtml (accessed June 13, 2018).
40. National Health Commission of the People's Republic of China. *2018 China Health Statistical Yearbook.* Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/ff9efb87ead24385b83ddb9eb0e3df5f.shtml (accessed June 13, 2019).
41. National Health Commission of the People's Republic of China. *2019 China Health Statistical Yearbook.* Available online at: http://www.nhc.gov.cn/mohwsbwstjxxzx/tjtjnj/202106/04bd2ba9592f4a70b78d80ea50bfe96e.shtml (accessed June 16, 2020).
42. Shi J, Yao Y, Liu G. Modeling individual health care expenditures in China: evidence to assist payment reform in public insurance. *Health Econ.* (2018) 27:1945–62. doi: 10.1002/hec.3812
43. Zhang Y, Su AN, Liu XX, Zhang Y. Social health insurance vs private health insurance in China: revisit crowd-out effect based on a multiple mediation analysis. *Int J Health Plann Manage.* (2018) 33:996–1012. doi: 10.1002/hpm.2554
44. Wei XJ, Wu H, Ge CY, Liu XY, Jia HY, Wang L, et al. Impact of an intelligent chronic disease management system on patients with type 2 diabetes mellitusin a Beijing community. *BMC Health Serv Res.* (2018) 18:821. doi: 10.1186/s12913-018-3610-z

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.

Advantages of publishing in Frontiers

OPEN ACCESS
Articles are free to read for greatest visibility and readership

FAST PUBLICATION
Around 90 days from submission to decision

HIGH QUALITY PEER-REVIEW
Rigorous, collaborative, and constructive peer-review

TRANSPARENT PEER-REVIEW
Editors and reviewers acknowledged by name on published articles

Frontiers
Avenue du Tribunal-Fédéral 34
1005 Lausanne | Switzerland

Visit us: www.frontiersin.org
Contact us: frontiersin.org/about/contact

REPRODUCIBILITY OF RESEARCH
Support open data and methods to enhance research reproducibility

DIGITAL PUBLISHING
Articles designed for optimal readership across devices

FOLLOW US
@frontiersin

IMPACT METRICS
Advanced article metrics track visibility across digital media

EXTENSIVE PROMOTION
Marketing and promotion of impactful research

LOOP RESEARCH NETWORK
Our network increases your article's readership