CHRONIC ILLNESS AND AGEING IN CHINA

EDITED BY: Colette Joy Browning, Shane Andrew Thomas, Zeqi Qiu, Anna Chapman and Shuo Liu

PUBLISHED IN: Frontiers in Public Health

frontiers Research Topics

frontiers

ISSN 1664-8714
ISBN 978-2-88963-754-6
DOI 10.3389/978-2-88963-754-6

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CHRONIC ILLNESS AND AGEING IN CHINA

Topic Editors:
Colette Joy Browning*, Federation University, Australia
Shane Andrew Thomas*, Australian National University, Australia
Zeqi Qiu, Peking University, China
Anna Chapman, Deakin University, Australia
Shuo Liu, Peking University, China

* These editors contributed equally and are first co-editors

Citation: Browning, C. J., Thomas, S. A., Qiu, Z., Chapman, A., Liu, S., eds. (2020). Chronic Illness and Ageing in China. Lausanne: Frontiers Media SA.
doi: 10.3389/978-2-88963-754-6

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frontiers in Public Health

EDITORIAL
published: 09 April 2020
doi: 10.3389/fpubh.2020.00104

Editorial: Chronic Illness and Ageing in China

Shane Andrew Thomas[1,2]*, *Zeqi Qiu*[3], *Anna Chapman*[4], *Shuo Liu*[5] and *Colette Joy Browning*[6]

[1] Research School in Population Health, Australian National University, Canberra, BC, Australia, [2] International Primary Health Care Research Institute, Shenzhen, China, [3] Department of Sociology, Peking University, Beijing, China, [4] School of Nursing and Midwifery and Centre for Quality and Patient Safety Research, Deakin University, Burwood, VIC, Australia, [5] Key Laboratory of Carcinogenesis and Translational Research, Beijing Office for Cancer Prevention and Control, Peking University Cancer Hospital & Institute, Beijing, China, [6] School of Nursing and Healthcare Professions, Federation University, Ballarat, VIC, Australia

Keywords: chronic illness, aging, China, behavior change, health, well-being

Editorial on the Research Topic

Chronic Illness and Ageing in China

This Research Topic focussed on chronic illness and aging in China. China's population is aging and chronic illnesses are increasingly prevalent (1–4). China's population life expectancy has increased by 17 years since 1970. From 2010 to 2040, it is predicted that the proportion of people aged 60 years plus in China will increase from 12.4% (168 million) to 28% (402 million) (1). There is a progressive shift in the burden of disease to chronic Non-Communicable Diseases (NCDs). Almost 80% of deaths in China in people aged 60 years are from chronic NCDs (5), the most burdensome being Ischemic Heart Disease, Stroke, Chronic Obstructive Pulmonary Disease (COPD), and Type 2 Diabetes. Behavioral risks including smoking, alcohol consumption, sedentary behavior and poor dietary intake contribute significantly to these conditions.

China has been preparing for the dramatic aging of its population and the health transition from communicable diseases to NCDs. In this Research Topic 40 researchers from throughout China and invited international colleagues, examined a range of topics impacting on the health and well-being of older people living in China. These included nutrition, smoking, cognitive impairment, cardiovascular health, sensory loss and diabetes as well as how to prepare the healthcare workforce to provide effective services for older adults. A range of methodologies and article types comprise the Research Topic: a case study, national surveys, a randomized controlled trial, qualitative interviews, a focussed review and predictive studies using multiple regression. These papers focus on preparing the world's most populous country to deal effectively with the health of its seniors and be positioned to share lessons learned with others.

Two papers in this issue focussed on general practitioner training. Rao et al. reported curriculum development research to prepare Chinese GPs for increased chronic disease prevalence. The curriculum was trialed with 600 GP trainees. Sun et al. analyzed the epidemiology of Chinese chronic illness and their associated risk factors. They argued that upgrading of Chinese General Practitioner skills is necessary to meet contemporary and future health needs of China.

Heine et al.; Heine et al. used the China Health and Retirement Survey (CHARLs) Wave 2, 2013 data for people aged 60 years and over (n = 8,268). The authors concluded that sensory loss especially dual sensory loss was significantly and positively associated with advanced age, having difficulty in any Activities of Daily Living (ADL) or Instrumental Activities of Daily Living (IADL) and experiencing depression and less life satisfaction. They also found that sensory loss is a significant health issue for older Chinese people that strongly affects their social participation that needs to be reflected in practitioner training and services. This is an area that requires increased resources and attention.

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Edited by:
Connie J. Evashwick, George Washington University, United States

Reviewed by:
Donghua Tao, Saint Louis University, United States

***Correspondence:**
Shane Andrew Thomas
shane.thomas@anu.edu.au

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

Received: *30 January 2020*
Accepted: *17 March 2020*
Published: *09 April 2020*

Citation:
Thomas SA, Qiu Z, Chapman A, Liu S and Browning CJ (2020) Editorial: Chronic Illness and Ageing in China. Front. Public Health 8:104. doi: 10.3389/fpubh.2020.00104

Browning et al. reported a qualitative study of older Chinese people concerning their experiences of food and its cultural impacts and importance for health and well-being in China and confirmed the high cultural importance of food for older Chinese. It was found that social and economic lifespan experiences continued to strongly impact on the food and eating attitudes and practices of older Chinese people. These experiences differed markedly from younger Chinese suggesting that health promotion messaging involving food and nutrition must be targeted to maximize its effectiveness amongst older Chinese.

Two studies in this issue examined the association between cardiovascular health and diet and cognitive function in older Chinese. Gildner et al. reported analyses of the WHO Study on global Aging and adult health (SAGE) Wave 1 ($n = 11{,}295$). Seven Cardiovascular Health (CVH) factors were classified as "ideal" or "not ideal" including smoking and drinking frequency, Body Mass Index, physical activity level, blood pressure, diet, and self-reported anxiety. It was found that "ideal" CVH factors predicted higher cognitive performance. This study suggested that early detection and controlling modifiable CVH risks may protect aging individuals in China from cognitive decline, a major benefit.

Xu et al. analyzed a 10-year sequence of participants aged 55+ ($n = 4{,}847$) from the China Health and Nutrition survey. Linear mixed statistical models were used to investigate the association between dietary patterns, hypertension, and cognitive function. Three dietary patterns were identified "Traditional Chinese," "Protein-rich," and "Starch-rich." The Protein-rich dietary pattern was associated with higher cognitive global and verbal memory scores, while the starch-rich dietary pattern (high intake of salted vegetable and legumes) was associated with lower cognitive global and verbal memory scores as was hypertension. The study reinforced the importance of diet and management of hypertension for preventing cognitive decline.

Yiengprugsawan and Browning reported a focussed review of the link between NCDs and Cognitive Impairment and Mild Cognitive Impairment (CI/MCI) through common risk factors. They argued that the identification of risk factors is critical for the effective prevention and management of chronic conditions including cognitive impairment in China and globally. The review also identified the importance of primary health care services in reducing behavioral risk factors. The authors argued that addressing shared determinants and pathways was important in the design of public health and primary health care services in China. The results of these papers paint a clear picture of the potential benefits of evidence-based interventions in maximizing the cognitive health in China.

Hou et al. used data from CHARLs to study the smoking behaviors of Chinese rural-to-urban migrants, urban-to-urban migrants, rural return migrants, and urban return migrants. Smoking is a major chronic illness risk factor in China especially amongst older men. Strong associations between migration status and later-life smoking behaviors in China were discovered and that these associations varied greatly according to different migration status. These findings provide important data to inform smoking cessation programs in China.

Chapman et al. reported a diabetes management Randomized Controlled Trial conducted in Beijing ($n = 726$). "Control" participants received usual care according to the Chinese Guideline for Diabetes Prevention and Management. "Intervention" participants received Motivational Interviewing (MI) health coaching plus usual care. The participants displayed significant within-group HbA1c improvements at 18-months. The findings suggested that there is benefit in training Chinese clinicians in coaching and behavior change techniques.

We consider that to meet the health care needs of China that the outcomes of ongoing and detailed epidemiological analyses and research must be directly reflected in health system design and practitioner training. The papers in this Research Topic provide important guidance. Benchmarking against international standards is useful as well as understanding the unique and changing needs of older people in China. While ongoing research is warranted, the studies reported in this Research Topic inform pragmatic changes to the prevention and treatment of chronic conditions among older Chinese and training of the healthcare workforce.

AUTHOR CONTRIBUTIONS

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

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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.

该研究主题集中于中国的慢性病和老龄化。中国人口老龄化和慢性病日益增长（世界卫生组织，2015年（1）;世界银行，世卫组织，财政部，国家卫生和计划生育委员会，人力资源和社会保障部，2016年（2）;Li, Zeng, Liu, Liu, Liu, Yin等，2017（3）; Tan, Zhang & Shao， 2019（4））。自1970年以来，中国的人口平均预期寿命增长了17岁。从2010年到2040年，预计60岁以上的中国人口比例将从12.4%（1.68亿）增至28%（4.02亿）（世卫组织， 2015（1））。疾病负担逐渐向慢性非传染性疾病（NCD）转移。在60岁的人群中，中国将近80%的死亡病例来自慢性非传染性疾病（Yang，Wang，Zeng等，2013（5）），其中负担最重的是缺血性心脏病，中风，慢性阻塞性肺病（COPD），和2型糖尿病。包括吸烟，饮酒，久坐行为和不良饮食摄入的行为风险因素是造成这些状况的重要原因。

中国一直在为人口的急剧老龄化和从传染病向非传染性疾病的健康过渡做准备。在本研究主题中，来自中国各地的40名研究人员和受邀的国际同行对影响中国老年人健康和福祉的一系列主题进行了研究。其中包括营养，吸烟，认知障碍，心血管健康，感官丧失和糖尿病，以及如何让医务人员做好准备，为老年人提供有效服务。研究主题包括各种方法和文章类型：案例研究，国家调查，随机对照试验，定性访谈，重点回顾和使用多元回归的预测研究。这些论文着重于让世界上人口最多的国家做好准备，以有效应对老年人的健康问题，并与他人分享经验教训。

本专刊的两篇论文关注全科医生培训。
Rao，Lai，Sun，Hua，Li，Xu，Browning＆Thomas，（2020）（6）报告了课程开发研究，通过培训中国全科医生（GP）来减少慢性病患病率。该课程已对600名GP学员进行了试验。 Sun，Li，Hu，Rao，Xu，Browning＆Thomas（2019）（7）分析了中国慢性病的流行病学及其相关的危险因素。他们认为，提高中国全科医生的技能对于满足中国当代和未来的健康需求是必要的。

Heine，Browning＆Gong，（2019）（8）和Heine，Gong，＆Browning（2019）（9）使用2013年中国健康与养老追踪调查（CHARLs）第二波中60岁及以上人口的数据（n = 8,268）。作者得出的结论是，感觉丧失尤其是双重感觉丧失与高龄、难以进行任何日常生活活动（ADL）或工具性日常生活活动（IADL）、患有抑郁症且生活满意度较低显著正相关。他们还发现，感官丧失对于中国老年人来说是一个重要的健康问题，严重影响他们的社会参与，这需要在从业人员的培训和服务中体现出来。这是一个需要更多资源和关注的领域。

Browning，Qiu，Yang，Zhang和Thomas（2019）（10）对中国老年人的饮食经历及其对文化的影响和对健康和福祉的重要性进行了定性研究，并证实了饮食对中国老年人高度的文化重要性。研究发现，社会和经济寿命经验持续对中国老年人的饮食观念和饮食习惯产生强烈影响。这些经验与年轻的中国人明显不同，这表明有关食品和营养的健康宣传信息必须有针对性，以便在中国老年人中最大限度地发挥其效用。
本专刊的两项研究调查了中国老年人心血管健康与饮食和认知功能之间的关系。

Gildner，Ng，Wu，Guo，Snodgrass，＆Kowal（2018）（11）报告了WHO对全球老龄化和成人健康研究（SAGE）第一波的分析（n = 11,295）。七个心血管健康（CVH）因素被归类为“理想”或“不理想”，包括吸烟和饮酒的频率，身体质量指数，身体活动水平，血压，饮食和自我报告的焦虑。发现“理想的”CVH因素预示着

更高的认知能力。这项研究表明，早期发现和控制可改变的CVH风险可以保护中国的老年人免受认知能力下降，这是最大的好处。

Xu，Parker，Shi，Byles，Hall和Hickman（2018）（12）分析了一项来自中国健康与营养调查，参与者年龄在55岁以上（n = 4,847）的十年序列研究。线性混合统计模型被用于研究饮食模式，高血压与认知功能之间的关系。三种饮食模式被确定为“传统中国模式”，“富含蛋白质”和“富含淀粉”。富含蛋白质的饮食方式与较高的整体认知和言语记忆得分相关，而富含淀粉的饮食方式（高盐蔬菜和豆类摄入）与较低的整体认知和言语记忆得分相关，与高血压的关系也是如此。这项研究强调了饮食和高血压管理对预防认知功能下降的重要性。

Yiengprugsawan & Browning（2019）（13）报告了通过常见风险因素对非传染性疾病与认知障碍和轻度认知障碍（CI / MCI）之间的联系的重点回顾。他们认为，识别风险因素对于有效预防和管理中国以及全球范围内的认知障碍在内的慢性疾病至关重要。该综述还确定了初级卫生保健服务在减少行为风险因素方面的重要性。作者认为，解决共同的决定因素和途径对于中国公共卫生和初级卫生保健服务的设计很重要。这些论文的结果清楚地说明了循证干预在最大程度地提高中国的认知健康方面的潜在好处。

Hou，Nazroo，Banks和Marshall（2018）（14）使用CHARLs的数据研究了中国农村到城市流动人口，城市到城市流动人口，农村返乡流动人口和城市返乡流动人口的吸烟行为。吸烟是中国主要的慢性疾病危险因素，尤其是在老年男性中。在中国，人们发现迁移状态与晚年吸烟行为之间存在很强的关联性，并且这些关联因迁移状态的不同而有很大差异。这些发现为中国的戒烟计划提供了重要数据。

Chapman，Browning，Enticott，Yang，Zhang＆Thomas（2018）（15）报告了一项在北京进行的糖尿病管理随机对照试验（n = 726）。根据中国《糖尿病防治管理指南》，“对照组”参与者接受了常规护理。 “干预组”参与者接受了动机性访谈（MI）健康指导以及常规护理。参与者在18个月时显示出组内HbA1c的显著改善。研究结果表明，在知道和行为改变技术方面对中国临床医生进行培训是有益的。

我们认为，为了满足中国的卫生保健需求，正在进行的详细流行病学分析和研究的结果必须直接反映在卫生系统设计和从业人员培训中。该研究主题的论文具有重要的指导意义。参照国际标准进行基准测试对于了解中国老年人的独特和不断变化的需求非常有用。尽管有必要进行持续的研究，但本研究主题所报告的结果为中国老年人慢性病的预防和治疗以及医护人员的培训提供了务实的改进指导。

我们感谢作者们的杰出贡献。

Xu X, Parker D, Shi Z, Byles J, Hall J and Hickman L (2018) Dietary Pattern, Hypertension and Cognitive Function in an Older Population: 10-Year Longitudinal Survey. Front. Public Health 6:201. doi: 10.3389/fpubh.2018.00201

Abstract

背景：很少有研究探讨饮食模式与认知功能之间的关系，以及饮食模式与高血压之间是否存在与老年人的认知功能相关的相互作用。

方法：我们分析了来自中国健康与营养（CHNS）调查的数据。从1991年开始收集饮食数据，在1997年至2006年之间收集认知功能访谈数据。我们分析了10年的数据，包括4,847名参与者和10,658名观察者（年龄_55岁）。探索性因素分析用于确定饮食模式。认知功能量度包括认知整体评分和言语记忆评分。线性混合模型用于研究饮食模式，高血压与认知功能之间的关系。

结果：通过因素分析确定了三种饮食模式，分别为"传统中国模式"，"富含蛋白质"和"富含淀粉"的饮食模式。富含蛋白质的饮食方式（高摄入牛奶，鸡蛋和豆浆）与较高的认知整体得分和言语记忆得分显著相关，而富含淀粉的饮食方式（高摄入盐腌蔬菜和豆类）与较低的认知整体得分和言语记忆分数显著相关。此外，我们发现高血压参与者与低认知功能具有独立的显著关系。

结论：该研究加强了饮食在预防老年人口认知下降中的重要性。在干预研究中应以识别高血压的老年人群为目标，以保持其认知健康。

frontiers in Public Health

ORIGINAL RESEARCH
published: 20 July 2018
doi: 10.3389/fpubh.2018.00201

Dietary Pattern, Hypertension and Cognitive Function in an Older Population: 10-Year Longitudinal Survey

Xiaoyue Xu[1,2]*, *Deborah Parker*[1], *Zumin Shi*[3,4], *Julie Byles*[2], *John Hall*[5] and *Louise Hickman*[1]

[1] Faculty of Health, University of Technology, Sydney, NSW, Australia, [2] Priority Research Centre for Generational, Health and Ageing, School of Medicine and Public Health, Hunter Medical Research Institute, University of Newcastle, Newcastle, NSW, Australia, [3] Human Nutrition Department, Qatar University, Doha, Qatar, [4] School of Medicine, University of Adelaide, Adelaide, SA, Australia, [5] School of Public Health and Community Medicine, University of New South Wales, Sydney, NSW, Australia

Background: There is a paucity of studies that have explored the association between dietary pattern and cognitive function, and whether there is an interaction between dietary pattern and hypertension in relation to older people's cognitive functioning.

Methods: We analyzed data from the China Health and Nutrition (CHNS) survey. Dietary data have been collected since 1991, and cognitive function interview data were collected between 1997 and 2006. We analyzed ten years of data, including 4,847 participants with 10,658 observations (aged ≥55 years). Exploratory factor analysis was used to identify dietary patterns. Cognitive function measures include cognitive global scores and verbal memory scores. Linear mixed models were used to investigate the association between dietary patterns, hypertension and cognitive function.

Results: Three dietary patterns were identified by factor analysis, named "Traditional Chinese," "Protein-rich," and "Starch-rich" dietary pattern. A Protein-rich dietary pattern (high intake of milk, eggs and soymilk) was significantly associated with higher cognitive global scores and verbal memory scores, while the starch-rich dietary pattern (high intake of salted vegetable and legumes) was significantly associated with lower cognitive global and verbal memory scores. In addition, we found that participants with hypertension were independently associated with significant low cognitive function.

Conclusion: The study reinforces the importance of diet in preventing cognitive decline among the older population. Identification of older populations who had hypertension should be targeted in intervention studies to maintain their cognitive health.

Keywords: dietary pattern, cognitive functioning, hypertension, longitudinal data analysis, older people

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Edited by:
Anna Chapman,
Deakin University, Australia

Reviewed by:
Marco Aurelio M. Freire,
University of the State of Rio Grande do Norte, Brazil
Sebastian Huhn,
Max-Planck-Institut für Kognitions- und Neurowissenschaften, Germany

***Correspondence:**
Xiaoyue Xu
xiaoyue.xu@uts.edu.au

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

Received: *08 May 2018*
Accepted: *29 June 2018*
Published: *20 July 2018*

Citation:
Xu X, Parker D, Shi Z, Byles J, Hall J and Hickman L (2018) Dietary Pattern, Hypertension and Cognitive Function in an Older Population: 10-Year Longitudinal Survey. Front. Public Health 6:201. doi: 10.3389/fpubh.2018.00201

INTRODUCTION

China is aging rapidly. It is predicted that the proportion of population aged 60 years and over will increase from 14.3% in 2012 to 25% in 2035, and further increase to 40% in 2040 (1). This change in age structure has an impact on the increasing incidence of age-associated diseases or conditions, such as cardiovascular disease, arthritis, type 2 diabetes, hypertension, cognitive decline, and dementia (2).

Age remains the strongest risk for cognitive decline and dementia (3, 4). Globally, an estimated 47 million people were living with dementia in 2015 (5), with the incidence of dementia doubling with every 5.9 year increase in age, from 3.1/1,000 person yeas at age 60–64, to 175/1,000 person years at age 95 or above (6). In China, the number of dementia cases was 9.19 million (20% of the worldwide total) in 2015, and is predicted to increase to 30 million in 2050 (7, 8). People with Mild Cognitive Impairment (MCI) are more likely to develop dementia. A recent epidemiological study in China showed that 20.1% of people aged 60 or above had MCI, which implies the risk of high prevalence of dementia (9).

The high incidence and prevalence of cognitive impairment and dementia are leading chronic disease contributors to disability (10). People with cognitive impairment and dementia are at greater risk of disease comorbidities, hospital admission and subsequent mortality than their cognitively normal counterparts (10). They also have high needs for both social and health care, which contributes to an increasing economic burden (6). The total estimated worldwide cost of dementia was US $604 billion in 2010 (6).

Major modifiable risk factors for developing cognitive impairment and dementia including smoking, physical activity (8), obesity, and social engagement (5). Diet has been reported as a strong factor associated with chronic diseases among the older Chinese population (11–14). There is growing interest in the association between diet, cognitive functioning, as well as dementia (15–17). The link between single food (nutrient) and cognitive function has been proposed, with the mechanism of lowering oxidative stress, reducing inflammation, preventing vascular comorbidity, and protection against cerebrovascular diseases (18). For example, epidemiological evidence suggests the benefits of fish consumption, monounsaturated fatty acids, polyunsaturated fatty acids, and cognitive activity, in reducing the risk of cognitive decline and dementia (18). Dietary pattern has emerged in nutrition epidemiology studies to examine the impact of diet on health outcomes, as they illustrate the combined effects of diet intake (19). A Mediterranean (Med) diet, which includes high consumption of olive oil, legumes, unrefined cereals, fruits, and vegetables, has generated positive results suggesting its beneficial role for cognitive health (18). A systematic review by Rest et al. (20) found an inverse association between Med dietary pattern and cognitive functioning among four of six cross-sectional studies and six of twelve longitudinal studies. A systematic review from Aridi et al. (21) found Med diet is associated with better cognitive function, and might also decrease the risk of developing Alzheimer's disease. However, epidemiologic evidence of the association between dietary pattern (rather than Med dietary pattern) and cognitive function is mixed (22, 23). There are limited data on diet and cognition in China, mostly due to the complexity of collecting comprehensive data on cognitive functioning.

In addition, cardiovascular risk factors, such as diabetes, hypertension, and mid-life obesity, were associated with an increased risk of cognitive decline and dementia (5, 24). Our research team has previously identified an association between dietary pattern and hypertension (12). It may follow the interaction between dietary pattern and hypertension impacts on people's cognitive health.

Therefore, the purpose of this present study was to evaluate the association between dietary pattern and cognitive function, and to provide the evidence for clinical intervention and public health dietary guidelines in preventing cognitive health among older people. The specific aims were (1) to examine the association between dietary pattern and cognitive function, and identify individual foods, which are associated with cognitive function; and (2) to test whether there is an interaction between dietary pattern and hypertension in relation to cognitive function.

MATERIALS AND METHODS

China and Health Nutrition Survey (CHNS)

The CHNS is an ongoing open cohort longitudinal survey of nine waves (1989–2011). The survey used a multistage random-cluster sampling process to select samples from nine provinces. Details of CHNS sampling is described in our previous studies (11, 13, 14, 25, 26). Briefly, the survey used a multistage random-cluster sampling process to select about 4,400 households with over 19,000 individuals from 9 provinces. Counties in the provinces were stratified by income levels, and a weighted sampling scheme was used to randomly select four counties in each province. Two cities (a provincial capital/or a big city and a lower-income city) were selected. Two urban neighborhoods, two suburban neighborhoods within cities, one county capital town and three villages within counties were randomly selected. Finally, twenty households were randomly selected within each neighborhood. As CHNS is an open cohort study, and the specific number of communities, household and individuals for each wave are presented in the CHNS website (27). Dietary data have been collected since 1991. Cognitive function data have been collected through interview between 1997 and 2006. In the analysis sample, 68% of participants attended the survey at least two times over the 10-year period.

Dietary Assessment and Food Group

Dietary assessment is based on each participant's 24 h-recall, with information collected over three consecutive days. The three consecutive days during which detailed food consumption data have been collected were randomly allocated from Monday to Sunday. Over 99% of the participants provided all of the 3 days dietary data. Details of the dietary data collection are described elsewhere (14, 25).

The food groups included were based on a food system developed specifically for the CHNS and the Chinese Food Composition Table, which has been applied in our previous studies (11, 28). Food categories were collapsed into 35 food groups based on the similar nutrient profiles or culinary use, and average food intake for individuals calculated for each wave, as Liang (Chinese ounce, 1 Liang = 50 g) (28).

Hypertension

After at least a 10 min rest, trained examiners measured the blood pressure on the right arm in the sitting position using a

mercury sphygmomanometer according to a standard protocol (12). Hypertension was defined by combining a systolic blood pressure (SBP) $\geq$ 140 mmHg and/or diastolic blood pressure (DBP) $\geq$ 90 mmHg or if the person was taking anti-hypertensive medication (12).

Cognitive Function

The CHNS adopted the cognitive screening items from part of the Telephone Interview for Cognitive Status-modified, which has been used in the Chinese population (15). The cognitive screening was administered among CHNS participants aged 55 years or over. The cognitive screening included immediate and delay recall of a 10-word list, counting backward from 20, serial 7 subtraction, and orientation (15). The outcomes of interest in the present study were repeated measures of cognitive global scores and include (1) immediate and delayed recall of a 10-word list (ten points each), counting backwards (two points), and serial 7's (five points); and (2) verbal memory scores which combined immediate and delayed 10-word recall (ten points each). High scores reflect better cognitive function.

Covariates

Socio-demographic factors included in the study were age, gender, marital status (married and others), work status (Yes/No), education (low: illiteracy and primary school; medium: junior middle school; and high: high middle school or higher), and urbanization levels (low, medium, and high). Urbanization is defined by a multidimensional twelve-component urbanization index to capture population density and physical, social, cultural, and economic environments (7).

Health behavior factors included smoking, drinking and physical activity levels. Smokers were identified as people who smoke at least one cigarette per day, based on the question "how many cigarettes do you smoke per day?" Alcohol consumption was allocated to two categories (Yes/No), with the question "last year, did you drink beer or any other alcoholic beverage?" We calculated Metabolic Equivalent of Task (MET) to identify physical activity level based on the Compendium of Physical Activities. The details have been described in our previous studies (12–14). We also included doctor-diagnosed diabetes as a covariate given the strong link between diabetes and vascular dementia.

Statistical Analysis

Study participants in each analysis are described in **Figure 1**. Dietary pattern across six waves (1991, 1993, 1997, 2000, 2004, and 2006) were identified by factor analysis, using the standard principal component analysis method (13, 14). The total participants aged 55 years or above, who also have dietary data were included in the factor analysis (N = 5,056, with 11,627 observations). The number of dietary patterns was identified based on the eigenvalue (>1), scree plot, factor interpretability, and the variance explained (>5%). Varimax rotation was applied to improve the interpretability of the factors and minimize the correlation between them. Factor loadings are equivalent to correlation between food items and factors. Higher loadings indicate a higher shared variance with the factor. Factor loadings of $>|0.20|$ represent the foods that most strongly related to the identified factor.

At each wave, participants were assigned pattern-specific factor scores. Scores for each pattern were calculated as the sum of the products of the factor loading coefficients. We chose to use the cumulative mean score as it reflects long-term diet and may reduce dietary measurement error (28). Cumulative scores were added across seven waves (1991–2006), and a cumulative mean score was calculated for each factor.

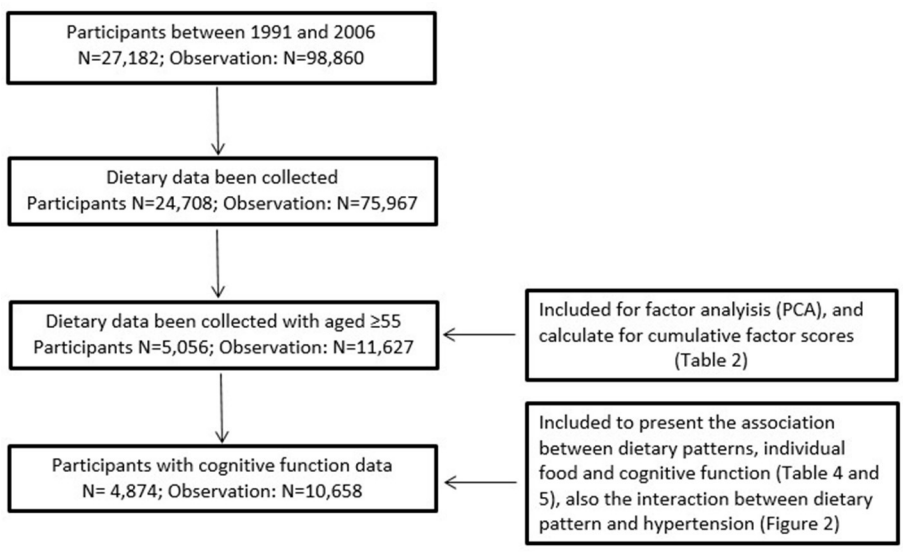

FIGURE 1 | The number of participants in the analysis.

Cumulative mean scores were divided into quartiles based on their distribution in each stratum, implying increased intake from quartile 1 (Q1) to quartile 4 (Q4). Mean and standard deviation across four quartiles were used to present the average global scores and verbal memory scores in each quartile of each dietary pattern.

Linear Mixed Models (LMMs) were used to evaluate associations between dietary patterns and cognitive function (both global scores and verbal memory scores). Model 1 adjusted for sociodemographic factors (age, gender, urbanization index, marital status, work status, and education level); model 2 adjusted for health behavior factors (BMI, alcohol drinking, and smoking

TABLE 1 | Characteristics of study participants in 1997, 2000, 2004, and 2006 ($N = 4,847$ with 10,658 observations).

Factors	1997	2000	2004	2006	*P*-value‡
AGE					
Median (IQR)	64 (59; 70)	64 (59; 71)	64 (59; 71)	64 (59; 71)	<0.001
PHYSICAL ACTIVITY (MET)					
Mean (SD)	88 (97)	77 (98)	76 (95)	73 (96)	<0.001
GENDER					
Men	1,006 (47.3%)	1,064 (47.8%)	1,418 (47.8%)	1,588 (47.5%)	0.93
Women	1,123 (52.8%)	1,160 (52.2%)	1,546 (52.2%)	1,753 (52.5%)	
MARITAL STATUS					
Married	1,530 (72.6%)	1,588 (74.7%)	2,286 (77.6%)	2,621 (78.6%)	<0.001
Other marital status*	577 (27.4%)	538 (25.3%)	660 (22.4%)	741 (21.4%)	
EDUCATION LEVELS					
Low	946 (49.6%)	781 (40.2%)	798 (27.0%)	1,017 (30.6%)	<0.001
Medium	621 (32.6%)	730 (37.7%)	1,295 (43.9%)	1,276 (38.4%)	
High	340 (17.8%)	426 (22.0%)	859 (29.1%)	1,034 (31.1%)	
WORK STATUS					
Yes	833 (39.3%)	826 (37.5%)	952 (32.2%)	1,046 (31.3%)	<0.001
No	1,286 (60.7%)	1,378 (62.5%)	2,005 (67.8%)	2,295 (68.7%)	
URBANIZATION LEVELS					
Low	782 (36.3%)	717 (32.2%)	955 (32.2%)	996 (29.8%)	<0.001
Medium	957 (45.0%)	797 (35.8%)	811 (27.4%)	998 (29.9%)	
High	390 (18.3%)	710 (31.9%)	1,198 (40.4%)	1,347 (40.3%)	
SMOKING STATUS					
Yes	574 (27.0%)	599 (26.9%)	779 (26.3%)	819 (24.5%)	<0.001
No	1,555 (73.0%)	1,625 (73.1%)	2,185 (73.7%)	2,522 (75.5%)	
ALCOHOL DRINKING					
Yes	641 (30.6%)	694 (31.9%)	863 (29.2%)	938 (28.1%)	<0.001
No	1,456 (69.4%)	1,484 (68.1%)	2,097 (70.8%)	2,403 (71.9%)	
BMI					
Underweight	249 (13.1%)	203 (9.4%)	244 (8.8%)	244 (7.8%)	<0.001
Normal	1,062 (56.0%)	1,214 (56.0%)	1,465 (52.5%)	1,656 (52.9%)	
Overweight	423 (22.3%)	563 (26.0%)	797 (28.6%)	934 (29.8%)	
Obese	164 (8.6%)	189 (8.7%)	284 (10.1%)	299 (9.5%)	
HEALTH OUTCOMES					
Hypertension					
No	1,081 (56.6%)	1,294 (59.3%)	1,705 (60.2%)	2,046 (64.2%)	<0.001
Yes	829 (43.4%)	887 (40.7%)	1,129 (39.8%)	1,139 (35.8%)	
COGNITIVE GLOBAL SCORES					
Median (IQR)	12 (7; 17)	13 (7; 18)	13 (8; 18)	12 (7; 17)	<0.001
VERBAL MEMORY SCORES					
Median (IQR)	9 (6; 12)	9 (6; 12)	9 (6; 12)	8 (5; 11)	<0.001

‡*Generalized Estimating Equation was used to examine the association between survey year and gender, marital status, work status, smoking status, alcohol drinking and hypertension. Mixed linear regression as used to examine the association between survey year and age, physical activity, education levels, urbanization level, BMI, cognitive global scores and verbal memory scores.*

**Other marital status includes divorced, widowed, separated, and never married.*

status) and model 1; model 3 adjusted for survey years and model 2; and model 4 adjusted for hypertension, diabetes, and model 3.

LMMs were also used to examine the association between hypertension and both global scores and verbal memory scores. Model 1 adjusted for both dietary patterns; model 2 adjusted for sociodemographic factors and model 1; model 3 adjusted for health behavior factors and model 2; and Model 4 adjusted for diabetes and survey year and model 3.

Ethics

Survey protocols, instruments, and the process for obtaining informed consent for CHNS were approved by the institutional review committees of the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety, China Centre for Disease Control and Prevention. Also, this study has been approved by the University of Newcastle Ethics Committee, Australia (Approval Number: H-2013-0360).

RESULTS

Sample Characteristics

Table 1 shows the characteristics of study participants in 1997, 2000, 2004, and 2006. Significant differences were found between participants for different survey years in their age, physical activity levels, marital status, education level, work status, urbanization levels, alcohol drinking, BMI, smoking status hypertension, and cognitive global and verbal memory scores. No significant difference was found between different survey years and gender.

Dietary Patterns

Dietary patterns were constructed using factor analysis, with three factors explaining 15.7% of the variance in food intake. Factor 1 ("Traditional Chinese" dietary pattern) was loaded heavily on rice, pork and fish, and inversely on wheat and whole grain. Factor 2 ("Protein-rich" dietary pattern) was characterized by high intake of milk, soy milk and eggs, and inversely on rice and fresh vegetables. Factor 3 ("Starch-rich" dietary pattern) was characterized by high intake of salted vegetables, legumes, whole grain and tubers (**Table 2**).

Table 3 shows the food intake across quartiles of three dietary patterns. For the traditional Chinese dietary pattern, compared with Quartile 1 (Q1), Q4 had significantly higher intakes of rice, pork, fish, dry tofu, poultry, fresh vegetable, offal, and beef; and significantly lower intakes of whole grain and wheat (p for trend <0.001).

For the protein-rich dietary pattern, compared with Q1, Q4 had significantly higher intakes of fruit, soy milk, milk, deep fried products, eggs, fast food, cake, fungus, shrimp, beer, poultry, and nuts; and significantly lower intakes of vegetables and rice (p for trend <0.001). However, relative low intakes across four quartiles were found for milk, deep fried products and fast food. For starch-rich dietary pattern, compared with Q1, Q4 had significantly higher intakes of salted vegetables, legumes, whole grain and tubers (p for trend <0.001).

TABLE 2 | Factor loadings of three dietary patterns.

	Factor loadings		
	Traditional Chinese	**Protein-rich**	**Starch-rich**
Rice	0.72	−0.37	
Fruit		0.47	
Salted vegetables			0.66
Legume			0.55
Whole grain	−0.42		0.54
Tubers			0.47
Soy milk		0.43	
Milk		0.42	
Deep fired product		0.40	
Eggs		0.39	
Pork	0.48		
Fish	0.42		
Fast food		0.39	
Cake		0.31	
Dry tofu	0.31		
Fungus		0.26	
Shrimp		0.25	
Beer		0.23	
Poultry	0.30	0.22	
Nuts		0.21	
Fresh vegetable	0.26	−0.21	
Offal	0.25		
Beef	0.25		
Wheat	−0.70		

Association Between Dietary Patterns and Cognitive Function

Table 4 shows that there were significant positive association between protein dietary pattern and cognitive function for both global scores and verbal memory scores. The significant positive association was also found between traditional Chinese dietary pattern and cognitive global scores, but not for verbal memory scores. The significant negative associations were found between starch-rich dietary pattern and cognitive function for both global scores and verbal memory scores (p for trend <0.001).

In the crude model, compared with Q1, participants in the highest quartile of protein-rich dietary pattern had β (difference in mean) of 4.05 (95% CI: 3.63; 4.48) higher global scores, and 2.33 (95% CI: 2.04; 2.61) higher verbal memory scores. After adjustment for sociodemographic, health behaviors, survey years, diabetes and hypertension (model 4), participants in the highest quartile of protein-rich dietary pattern had β of 2.28 (95% CI: 1.80; 2.76) increases for global scores, and 1.36 (95% CI: 1.01; 1.71) increases for verbal memory scores.

In the crude model for traditional Chinese dietary pattern, compared with Q1, participants in the highest quartile had β of 2.79 (95% CI: 2.36; 3.23) higher global scores, and 1.18 (95% CI: 0.88; 1.47) higher verbal memory scores. After adjustment (model 4), participants in the highest quartile of traditional Chinese dietary pattern had of 1.32 (95% CI: 0.90; 1.73) increases

TABLE 3 | Food intake across quartiles of three dietary patterns.

Food items (Liang per day)	Intake of Traditional Chinese dietary pattern (Q)								*p* for trend
	Q1		Q2		Q3		Q4		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Rice	1.04	1.31	4.56	2.01	6.46	2.03	7.35	2.48	<0.001
Pork	0.50	0.53	0.84	0.67	1.22	0.77	1.73	0.96	<0.001
Fish	0.10	0.23	0.28	0.42	0.51	0.54	1.10	0.89	<0.001
Dry tofu	0.04	0.13	0.13	0.22	0.23	0.32	0.33	0.39	<0.001
Poultry	0.05	0.15	0.10	0.25	0.18	0.29	0.48	0.60	<0.001
Fresh vegetables	5.00	2.06	5.00	2.16	5.82	2.25	6.50	2.28	<0.001
Offal	0.01	0.06	0.03	0.13	0.06	0.13	0.14	0.28	<0.001
Beef	0.02	0.09	0.05	0.15	0.10	0.20	0.19	0.32	<0.001
Whole grain	1.16	1.39	0.33	0.68	0.08	0.28	0.04	0.15	<0.001
Wheat	7.23	3.30	2.59	1.65	1.23	1.01	0.90	0.82	<0.001
INTAKE OF PROTEIN-RICH DIETARY PATTERN (Q)									
Fruit	0.05	0.18	0.13	0.35	0.33	0.60	1.22	1.72	<0.001
Soy milk	0.01	0.05	0.03	0.11	0.08	0.22	0.50	0.83	<0.001
Milk	0.001	0.22	0.005	0.04	0.05	0.20	0.80	1.26	<0.001
Deep fried products	0.01	0.03	0.02	0.07	0.09	0.19	0.34	0.51	<0.001
Eggs	0.17	0.20	0.28	0.26	0.54	0.43	0.99	0.83	<0.001
Fast food	0.003	0.02	0.01	0.08	0.05	0.13	0.19	0.44	<0.001
Cake	0.01	0.07	0.02	0.08	0.06	0.17	0.24	0.55	<0.001
Fungus	0.01	0.05	0.03	0.08	0.08	0.16	0.16	0.27	<0.001
Shrimp	0.003	0.02	0.01	0.05	0.03	0.12	0.14	0.48	<0.001
Beer	0.01	0.10	0.01	0.10	0.04	0.27	0.25	1.30	<0.001
Poultry	0.10	0.21	0.15	0.29	0.25	0.44	0.31	0.55	<0.001
Nuts	0.02	0.06	0.03	0.07	0.05	0.12	0.12	0.25	<0.001
Fresh vegetables	6.98	2.60	5.27	1.86	5.07	1.98	4.98	1.98	<0.001
Rice	7.81	2.34	4.45	2.82	4.03	2.80	3.10	2.33	<0.001
INTAKE OF STARCH-RICH DIETARY PATTERN (Q)									
Salted vegetables	0.04	0.08	0.11	0.14	0.19	0.22	0.49	0.62	<0.001
Legume	0.04	0.09	0.08	0.15	0.14	0.21	0.42	0.72	<0.001
Whole grain	0.16	0.29	0.24	0.49	0.37	0.70	0.85	1.49	<0.001
Tubers	0.36	0.43	0.54	0.56	0.81	0.82	1.53	1.67	<0.001

for global scores (p for trend <0.001). No significant association was found between traditional Chinese dietary pattern and verbal memory scores after adjustment.

In the crude model for starch-rich dietary pattern, no significant association was found between this dietary pattern and global scores; while compared with Q1, participants in the highest quartile had β of 0.04 (95% CI: −0.26; 0.33) indicating higher verbal memory scores. In the adjusted model (model 4), compared with Q1, participants in the highest quartile had β of 0.31 (95% CI: −0.70; 0.08) lower global scores, and 0.43 (95% CI: −0.71; −0.15) lower verbal memory scores (p for trend <0.001).

Although no interactions ($p > 0.05$) were found between hypertension and three dietary patterns in relation to cognitive function (**Figure 2**), we found hypertension to be an independent factor which was significantly associated with both cognitive global and verbal memory scores. After adjustment for dietary pattern, sociodemographic, health behaviors, survey years, and diabetes, participants with hypertension had 0.32 (95% CI: −0.57; −0.07) lower cognitive global scores, and 0.26 (95% CI: −0.44; −0.07) lower verbal memory scores than those with no hypertension.

Association Between Individual Food Intake and Cognitive Function

As the positive link was found between protein-rich dietary pattern and both cognitive global and verbal memory scores, and the negative link was found for starch-rich dietary pattern and both cognitive global and verbal memory scores, we further examined the association between each food component in these two dietary patterns and the cognitive function after adjusting for sociodemographic and health behavior factors. Due to the low intake of fruit, soy milk, milk, deep fired products, fast food, cake, fungus, shrimp, beer, poultry, nuts, salted vegetables, legumes, whole grain, we categorized consumption into two levels: non-consumers and consumers. Eggs and tubers were categorized into four quantiles, which indicates increased intake from Q1 to Q4.

TABLE 4 | The association between dietary patterns and cognitive function*.

Global scores	Quantiles of dietary pattern (Q)							
	Q1	Q2		Q3		Q4		*P* for trend
Traditional Chinese	**Ref**	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**	
Crude model	1	0.90	0.46; 1.33	0.34	−0.10; 0.78	2.79	2.36; 3.23	<0.001
Model 1	1	0.76	0.39; 1.13	0.39	0.01; 0.77	0.95	0.57; 1.33	<0.001
Model 2	1	1.13	0.73; 1.53	0.93	0.51; 1.35	1.39	0.98; 1.80	<0.001
Model 3	1	1.08	0.68; 1.47	0.81	0.39; 1.23	1.31	0.90; 1.72	<0.001
Model 4	1	1.10	0.70; 1.50	0.86	0.43; 1.28	1.32	0.90; 1.73	<0.001
PROTEIN-RICH								
Crude model	1	0.85	0.43; 1.28	2.35	1.93; 2.78	4.05	3.63; 4.48	<0.001
Model 1	1	0.86	0.49; 1.24	1.77	1.37; 2.16	2.47	2.02; 2.91	<0.001
Model 2	1	0.79	0.40; 1.19	1.73	1.31; 2.15	2.41	1.93; 2.89	<0.001
Model 3	1	0.73	0.33; 1.12	1.62	1.20; 2.04	2.27	1.79; 2.75	<0.001
Model 4	1	0.72	0.32; 1.12	1.66	1.24; 2.08	2.28	1.80; 2.76	<0.001
STARCH-RICH								
Crude model	1	−0.13	−0.57; 0.31	0.32	−0.12; 0.76	0.36	−0.08; 0.80	0.16
Model 1	1	−0.27	−0.63; 0.09	−0.32	−0.69; 0.04	−0.45	−0.83; −0.08	<0.001
Model 2	1	−0.27	−0.64; 0.10	−0.21	−0.58; 0.16	−0.47	−0.85; −0.09	<0.001
Model 3	1	−0.24	−0.61; 0.13	−0.14	−0.51; 0.23	−0.34	−0.73; 0.04	<0.001
Model 4	1	−0.20	−0.57; 0.18	−0.12	−0.50; 0.26	−0.31	−0.70; 0.08	0.001
VERBAL MEMORY								
Traditional Chinese								
Crude model	1	0.46	0.17; 0.76	−0.21	−0.51; 0.09	1.18	0.88; 1.47	<0.001
Model 1	1	0.75	0.46; 1.03	0.32	0.02; 0.61	0.54	0.24; 0.83	0.78
Model 2	1	0.76	0.47; 1.05	0.30	-0.01; 0.60	0.54	0.24; 0.84	0.78
Model 3	1	0.72	0.43; 1.01	0.18	-0.13; 0.48	0.46	0.16; 0.76	0.84
Model 4	1	0.73	0.44; 1.02	0.19	-0.11; 0.50	0.44	0.14; 0.74	0.77
PROTEIN-RICH								
Crude model	1	0.52	0.23; 0.82	1.38	1.09; 1.67	2.33	2.04; 2.61	<0.001
Model 1	1	0.53	0.25; 0.81	1.14	0.84; 1.43	1.56	1.23; 1.90	<0.001
Model 2	1	0.45	0.16; 0.74	1.05	0.75; 1.36	1.47	1.12; 1.82	<0.001
Model 3	1	0.39	0.10; 0.68	0.94	0.64; 1.25	1.33	0.98; 1.67	<0.001
Model 4	1	0.41	0.12; 0.70	0.99	0.69; 1.30	1.36	1.01; 1.71	<0.001
STARCH-RICH								
Crude model	1	−0.12	−0.42; 0.18	0.06	−0.24; 0.36	0.04	−0.26; 0.33	0.02
Model 1	1	−0.13	−0.40; 0.13	−0.30	−0.57; −0.04	−0.51	−0.78; −0.24	0.001
Model 2	1	−0.21	−0.48; 0.06	−0.31	−0.58; −0.04	−0.59	−0.87; −0.31	<0.001
Model 3	1	−0.18	−0.45; 0.09	−0.23	−0.50; 0.04	−0.46	−0.74; −0.18	<0.001
Model 4	1	−0.17	−0.44; 0.10	−0.22	−0.49; 0.05	−0.43	−0.71; −0.15	<0.001

**Model 1 adjusted for age, gender, urbanization index, marital status, work status, and education levels; model 2 adjusted for BMI, alcohol drinking, smoking status, and model 1. Model 3 adjusted for survey year and model 2, model 4 adjusted for hypertension, diabetes, and model 3.*

Compared with fruit non-consumers, fruit consumers had 0.43 higher cognitive global scores ($p < 0.001$) and 0.03 higher verbal memory scores ($p = 0.03$); compared with soy milk non-consumers, soy milk consumers had 0.28 higher cognitive global scores ($p = 0.01$) and 0.30 higher verbal memory scores ($p < 0.001$); compared with milk non-consumers, milk consumers had 1.16 higher cognitive global scores ($p < 0.001$), and 0.77 higher verbal memory scores ($p < 0.001$); compared with Q1 for egg consumers, participants in the highest quantiles had 1.06 higher cognitive global scores ($p < 0.001$), and 0.75 for verbal memory scores ($p = 0.002$). Similar pictures were also found for fungus and poultry: compared with fungus and poultry non-consumers, fungus, and poultry consumers had significant higher cognitive global and verbal memory scores ($p < 0.05$) (**Table 5A**).

For the starch-rich dietary pattern, compared with salted vegetables non-consumers, salted vegetable consumers had 0.24 lower cognitive global scores ($p = 0.01$) and 0.44 lower verbal memory scores ($p < 0.001$); Compared with legumes consumers, legumes non-consumers had 0.37 lower cognitive global scores

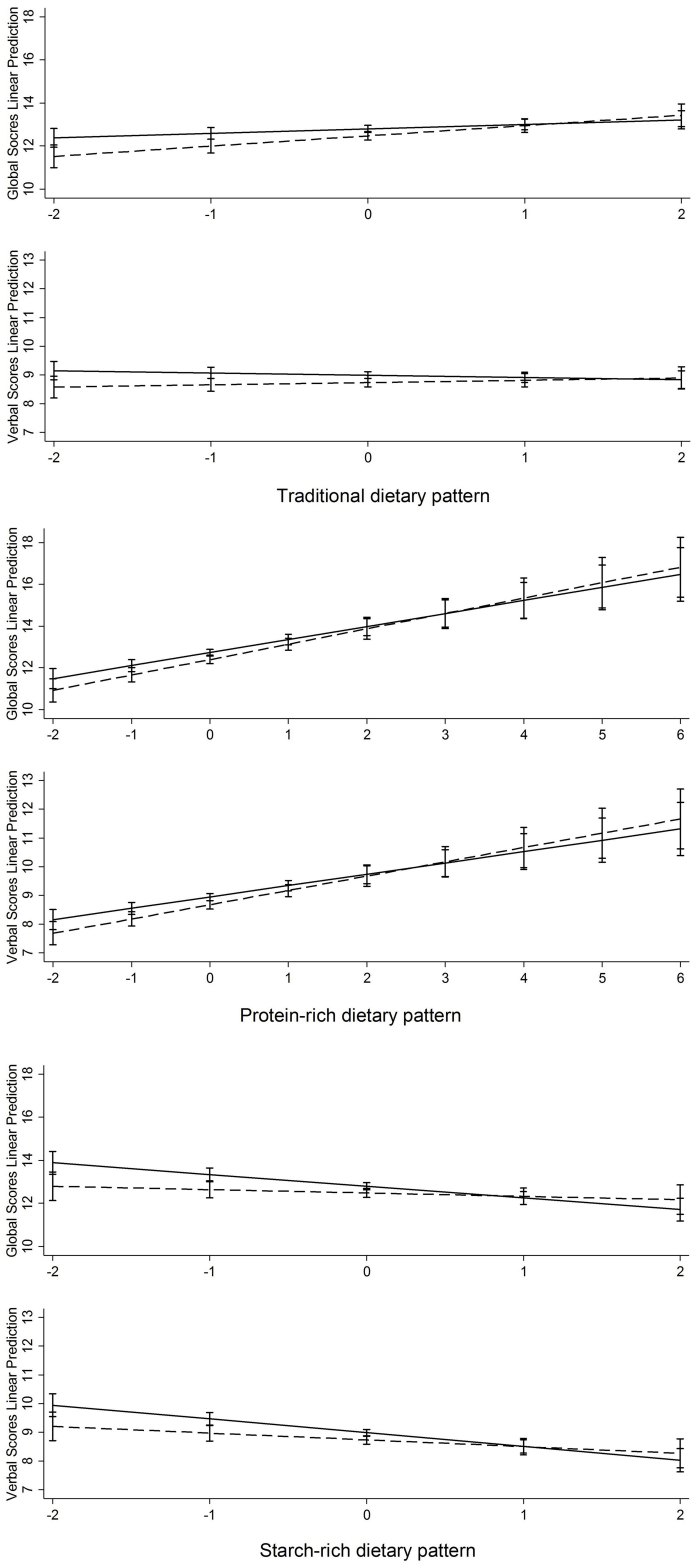

FIGURE 2 | Interaction between dietary pattern and hypertension in relation to cognitive function. After adjusted for age, gender, urbanization index, marital status, work status, education levels, BMI, alcohol drinking, smoking status, diabetes and survey year. *P*-value for interaction: (1) Traditional Chinese dietary pattern: $p = 0.07$ for global cognitive scores, $p = 0.15$ for verbal memory scores; (2) Protein-rich dietary pattern: $p = 0.43$ for global cognitive scores, $p = 0.32$ for verbal memory scores; (3) Starch-rich dietary pattern: $p = 0.05$ for global cognitive scores, $p = 0.10$ for verbal memory scores.

($p < 0.001$) and 0.28 lower verbal memory scores ($p < 0.001$). No significant associations were found between whole grain, tubers and cognition scores (**Table 5B**).

Sensitivity Analysis

As there was a chance that participants who had low cognitive function would not provide valid dietary information, we further conducted sensitivity analysis by excluding participants who had low cognitive global scores less than 5 ($N = 1{,}398$, 13% of total participants), and participants who had low verbal memory scores less than 3 ($N = 835$, 8% of total participants), respectively. In addition, as there was a potential association between heart disease and low cognitive functioning, and the association between diabetes and low cognitive functioning, we also excluded the participants who had heart disease ($N = 294$, 2.7% of total participants), and the participants who had diabetes ($N = 358$, 3.4% of total participants). However, the results were consistent with the full analysis.

DISCUSSION

The study identified three dietary patterns: a protein-rich dietary pattern was inversely associated with cognitive decline, while starch-rich dietary pattern was positively associated with cognitive decline for both cognitive global scores and verbal memory scores. No interaction was found between hypertension and dietary pattern impacting on cognitive health, but we found hypertension to be an independent factor which is significantly associated with cognitive function among older Chinese population.

Advancing age in China is associated with the high prevalence of cognitive decline and an increase in neurodegenerative disorders, such as dementia (8). Despite the proportionally large older population and massive demand for aged care, very little is known of effective measures for maintaining cognitive function among this population (29). A better understanding of the role of diet in maintaining cognitive function would benefit older people's quality of life, and further reduce the cost of dementia care among the older population.

Our study shows the significant decrease in verbal memory scores (include immediate and delayed recall words) among all participants between1997 and 2006. Although there is no consensus about the specific memory test that should be used to diagnose MCI or the prodromal phase of dementia, previous studies showed that delayed recall of the word list was the most successful discriminator to classify correctly 96% of normal subjects (30). An immediate and delayed recall of a 10-word list is a variation of Rey's Auditory Verbal Learning Test (31), and the study showed that delayed recall of words test is a sensitive measure for diagnosis of amnestic mild cognitive impairment and early dementia regardless of short or long-term recall (32).

Protein-rich dietary pattern was inversely associated with cognitive decline, with the milk, soy milk, egg and fungus the most influential diet factors in our results. Compared with people who did not consume milk, people who consumed milk had higher cognitive functioning. Relatively little attention has been paid to milk (33), and studies on the association between milk consumption and cognitive function were inconsistent. The results from US National Health and Nutrition Examination Survey show that compared with non-consumers, the people who consumed dairy foods had higher cognitive functioning. However, the significant association was only observed with cheese consumers, not for milk consumers (34). A recent meta-analysis among 10,940 participants shows that the higher consumption of milk was significantly associated with cognitive disorders. Compared with people with lowest level of milk consumption, people at the highest level of milk consumption had a decrease in cognitive disorders of 28% (35). The benefit of consuming milk in slowing the cognitive decline may be attributed to its protein, minerals, vitamins, and essential amino acids (35, 36). Although Chinese dietary guidelines present the benefit of consuming milk, our previous study showed that milk was consumed by an extremely small proportion of older people, with only 0.5% of them meeting the recommended intake of dairy (26). The small proportion of people consuming milk limits this study in drawing conclusions on the relationship between milk consumption and improvement in cognitive function.

Our results indicate that egg is the main dietary factor in the protein-rich dietary pattern for cognitive function among older people in China. Numerous studies have shown the association between high egg consumption and increased risk of coronary heart diseases, stroke (37) and incidence of Type 2 diabetes (38). However, eggs have been reported to be a highly bioavailable source of lutein and zeaxanthin, which may be important in cognitive function. Lutein can help maintain brain structure by lowering chronic oxidative stress; and both Lutein and Zeaxanthin are known to be potent anti-inflammatories as the brain is susceptible to damage due to chronic inflammation (39). A recent Finnish study that followed 2,497 adults for 22 years, found moderate egg intake was associated better with performance in neuropsychological tests, include executive functioning, and frontal lobe performance (40).

Our results show that compared with non-consumers, soy milk consumers had higher cognitive functioning, including both global and verbal memory scores. Previous studies suggested the beneficial role of soy consumption to health, for example, the link has been found between increased soy consumption and lower risk of incidence and prognosis of osteoporosis, coronary heart diseases (41), breast cancer (42), and diabetes (43). However, studies exploring the benefit of consuming soy products in cognitive functioning were inconsistent (44, 45). For example, 78 elderly individuals with mild cognitive deficits who were given 300 mg soy supplementation (Soybean-derived phosphatidylserine made from soybean lecithin) per day for six months showed a significant improvement in memory function compared with the placebo group (45); while the six months trials of 100mg/day soy isoflavone among 65 older people who were aged 60 years or over did not benefit people with Alzheimer's disease (46). No association between soy isoflavone and cognitive functioning was found among healthy, postmenopausal women during a 16 week intervention (47). The mechanism of these different effects need to be further explored.

Edible fungus (mushrooms and fungi) is often considered as an alternative medicine for treating age-related disease,

TABLE 5 | Coefficients (95% CI) for cognitive function by quartiles of individual food intake for potential-rich and salted-vegetable dietary pattern*.

Global scores	Quantiles of food components (Q)				
	β (95% CI)				
Food groups	**Q1**	**Q2**	**Q3**	**Q4**	***P* for trend**
(A) PROTEIN-RICH DIETARY PATTERN					
Fruit	0	0.43 (0.14; 0.71)	–	–	<0.001
Soy milk	0	0.28 (-0.05; 0.62)	–	–	0.01
Milk	0	1.16 (0.76; 1.55)	–	–	<0.001
Deep fired product	0	−0.04 (-0.35; 0.27)	–	–	0.12
Eggs	0	0.32 (-0.06; 0.69)	0.88 (0.49; 1.26)	1.06 (0.66; 1.46)	0.001
Fast food	0	0.31 (-0.06; 0.69)	–	–	0.59
Cake	0	0.29 (-0.05; 0.64)	–	–	0.32
Fungus	0	0.53 (0.23; 0.83)	–	–	<0.001
Shrimp	0	0.37 (−0.01; 0.74)	–	–	0.05
Beer	0	0.71 (0.04; 1.38)	–	–	0.47
Poultry	0	0.67 (0.40; 0.94)	–	–	<0.001
Nuts	0	0.47 (0.17; 0.77)	–	–	0.002
Verbal memory scores					
Fruit	0	0.03 (−0.17; 0.24)	–	–	0.03
Soy milk	0	0.30 (0.05; 0.54)	–	–	<0.001
Milk	0	0.77 (0.48; 1.05)	–	–	<0.001
Deep fired product	0	0.15 (−0.07; 0.38)	–	–	0.61
Eggs	0	0.14 (−0.13; 0.42)	0.44 (0.16; 0.72)	0.75 (0.46; 1.04)	0.002
Fast food	0	0.07 (−0.20; 0.34)	–	–	0.73
Cake	0	0.15 (−0.10; 0.39)	–	–	0.25
Fungus	0	0.33 (0.12; 0.55)			<0.001
Shrimp	0	0.04 (−0.24; 0.31)	–	–	0.19
Beer	0	0.11 (−0.37; 0.59)	–	–	0.99
Poultry	0	0.19 (−0.01; 0.39)	–	–	0.03
Nuts	0	0.08 (−0.14; 0.30)	–	–	0.42
(B) STARCH-RICH DIETARY PATTERN*					
Salted vegetables	0	−0.24 (−0.51; 0.03)	–	–	0.01
Legumes	0	−0.37 (−0.63; −0.11)	–	–	<0.001
Whole grain	0	0.09 (−0.18; 0.36)	–	–	0.09
Tubers	0	0.14 (−0.23; 0.50)	−0.14 (−0.51; 0.24)	0.14 (−0.23; 0.51)	0.47
Verbal memory scores					
Salted vegetables	0	−0.44 (−0.63; −0.25)	–	–	<0.001
Legumes	0	−0.28 (−0.47; −0.10)	–	–	<0.001
Whole grain	0	1.11 (−0.09; 0.30)	–	–	0.17
Tubers	0	0.16 (−0.10; 0.43)	0.07 (−0.20; 0.35)	0.22 (−0.05; 0.49)	0.07

**Adjusted for age, gender, urbanization index, marital status, work status, education levels, BMI, alcohol drinking, smoking status, survey year, hypertension and diabetes.*

include type 2 diabetes, cardiovascular disease and cancer (48). The medicinal effects attributed to fungus mainly include immunomodulatory, antioxidant, anti-inflammatory, and antidiabetic effects (48). Our result showed the significant benefit of consuming fungus in improving the verbal memory scores. Although fungus is often seen in Chinese cuisine, the lack of studies exploring the role of fungus in the cognitive function indicates the need for further studies.

In our results the starch-rich dietary pattern, in particular salted vegetable and legumes, were positively associated with cognitive decline. Salted vegetables often called "pickled vegetables," are an integral part of the diet in many families in China. It is often prepared by keeping tightly packed vegetable in a jar packing for a few weeks, allowing fermentation and growth of fungi and yeasts that can generate potentially carcinogenic N-nitroso compounds and mycotoxins (49). Studies showed the beneficial role of fresh brassica species (broccoli) in reducing the risk of cancers (50). However, there were positive links between pickled vegetable and increased risk of cancer, including esophageal (49) and gastric cancer (51), but studies of exploring

the association between pickled vegetable and cognitive function were scarce. Pickled vegetable is often studied in a specific dietary pattern, which used to examine the association between that specific dietary pattern and cognitive function for older people. However, the study results were inconsistent. For example, a cross-sectional study in Japan showed that pickled vegetable was included in the "Plant food and fish" dietary pattern, which was significantly associated with high cognitive function (23); but our study indicated that the pickled vegetable was the key component which may the most influential diet factors for cognitive decline. Further research is needed, particularly to explore the mechanism of this association.

Legumes are often studied as part of a specific dietary pattern when assessing association between diet and cognition among older people, however, the research results were inconsistent. The results from a study conducted among participants who lived in the Mediterranean area showed the positive link between legumes pattern and cognitive function (52); but a 10 years follow-up study conducted in UK indicated that high legumes consumption included in the inflammatory dietary pattern was associated with high circulating serum interleukin-6 levels and accelerated cognitive decline at older ages (53), which was similar with our study results. Our results supported that compared with legumes non-consumers, legumes consumers had lower global cognitive scores and verbal memory scores.

The association between hypertension and cognitive function was consistent with previous studies. Moreover, cross-sectional and longitudinal studies implicate hypertension may be a possible contributor to late-life dementia. This aligns with cardiovascular disease as a major risk factor for stroke and dementia, and the strong association between hypertension and cardiovascular disease, thus far, hypertension is recognized as the most consistent risk factor for stroke and dementia (54). Due to the association between dietary pattern and hypertension (12), our hypothesis was that there may have been an interaction between hypertension and dietary pattern, with this interaction impacting on cognitive functioning. However, our results did not indicate this interaction, but does support the significant association between hypertension and cognitive functioning.

The strengths of the present study include using cumulative mean factor scores to capture the long-term diet pattern which may reduce dietary measurement error. In addition, the longitudinal study assists in making an etiological link between dietary pattern and cognitive function. However, some limitations may apply. The components in the global cognitive score of "orientation," including asking participants current date and naming the tool were not asked in 2006. Therefore we were unable to use the entire global cognitive function score. The benefit of consuming milk and soy milk has been highlighted in the present study. However, due to the low amount of consumption and relative small proportion of people consuming milk and soy milk, it was difficult to draw the conclusion of the beneficial role of consuming milk and soy milk in maintaining cognitive function among older Chinese population. Lastly, the self-reported data of comorbidities (e.g., diabetes and hypertension) may have response bias in the study.

CONCLUSION

We found a protein-rich dietary pattern was significantly negatively associated with cognitive decline, while starch-rich dietary pattern was positively associated with cognitive decline among a Chinese older population. Hypertension impacts on older people's cognitive functioning. The present study provides important evidence that can inform dietitians, other health professionals and educators to design dietary interventions for older people (such as encouraging older people to eat more protein-rich food, but less pickled food) aimed at improving and maintaining their cognitive function.

AUTHOR CONTRIBUTIONS

XX and DP designed the study. XX conducted the analyses and wrote the manuscript. ZS guide the data analysis procedure. ZS, DP, JB, JH, and LH review the manuscript. All authors approved the final version of the manuscript.

ACKNOWLEDGMENTS

The authors thank the National Institute of Nutrition and Food Safety, the Chinese Center for Disease Control and Prevention, the Carolina Population Center (5 R24 HD050924), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700), and the Fogarty International Center, NIH, for providing financial support for collecting CHNS data and analysis files from 1989 to 2011 and conducting future surveys and the China–Japan Friendship Hospital, Ministry of Health, for providing support for conducting the CHNS 2009.

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Conflict of Interest Statement: 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.

Chapman A, Browning CJ, Enticott JC, Yang H, Liu S, Zhang T and Thomas SA (2018) Effect of a Health Coach Intervention for the Management of Individuals With Type 2 Diabetes Mellitus in China: A Pragmatic Cluster Randomized Controlled Trial. Front. Public Health 6:252. doi: 10.3389/fpubh.2018.00252

Abstract

目的：确定与常规治疗相比，健康教练干预对2型糖尿病（T2DM）患者的血糖控制以及生理，心理和自我管理的效果。

方法：本研究于2011年8月至2013年12月在北京丰台区进行了实用的集群随机对照试验研究。对41个社区卫生站（CHS）进行集群随机化（按地理分层，比例为1：1），并按顺序随机抽取符合条件的2型糖尿病患者。对照参与者按照《中国糖尿病预防与管理指南》接受常规治疗。干预的参与者根据动机访谈（MI）加上常规诊疗的原则接受了为期18个月的健康指导。两组均免收医疗和病理学费用。在基线，第6、12和18个月进行结果评估。主要结局是糖化血红蛋白（HbA1c）。次要结局包括一系列生理，心理和自我保健措施。

结果：HbA1c在18个月时未发现差异治疗效果（差异-0.07，95％CI -0.53至0.39，p = 0.769）或任何指定的次要结果。有趣的是，两组在HbA1c的18个月时均显示出统计学和临床上显著的组内改善，幅度均相同（干预：平均变化-3.65，95％CI -3.92至-3.37；对照组：平均变化-3.38，95％ CI -3.67至-3.08）。

结论：缺乏观察到的差异性治疗效果表明，在中国推荐基于MI原则的常规健康教练干预措施为时过早。但是，组内平均HbA1c水平的较大且可比的改善，促进了针对中国T2DM个体建立免费的，定期的临床健康评估。

frontiers in Public Health

CLINICAL TRIAL
published: 19 September 2018
doi: 10.3389/fpubh.2018.00252

Effect of a Health Coach Intervention for the Management of Individuals With Type 2 Diabetes Mellitus in China: A Pragmatic Cluster Randomized Controlled Trial

Anna Chapman[1,2,3], Colette J. Browning[3,4], Joanne C. Enticott[5,6], Hui Yang[3,5], Shuo Liu[7], Tuohong Zhang[8] and Shane A. Thomas[3,4]*

[1] School of Nursing and Midwifery and Centre for Quality and Patient Safety Research, Deakin University, Geelong, VIC, Australia, [2] Monash Health, Clayton, VIC, Australia, [3] International Institute for Primary Health Care Research, Shenzhen, China, [4] Research School of Population Health, Australian National University, Acton, ACT, Australia, [5] School of Primary and Allied Health Care, Monash University, Notting Hill, VIC, Australia, [6] School of Clinical Sciences, Monash University, Dandenong, VIC, Australia, [7] Key Laboratory of Carcinogenesis and Translational Research, Beijing Office for Cancer Prevention and Control, Peking University Cancer Hospital and Institute, Beijing, China, [8] School of Public Health, Peking University Health Science Centre, Beijing, China

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Edited by:
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***Correspondence:**
Anna Chapman
a.chapman@deakin.edu.au

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

Received: *20 June 2018*
Accepted: *15 August 2018*
Published: *19 September 2018*

Citation:
Chapman A, Browning CJ, Enticott JC, Yang H, Liu S, Zhang T and Thomas SA (2018) Effect of a Health Coach Intervention for the Management of Individuals With Type 2 Diabetes Mellitus in China: A Pragmatic Cluster Randomized Controlled Trial. Front. Public Health 6:252. doi: 10.3389/fpubh.2018.00252

Aim: To determine the effect of a health coach intervention for the management of glycemic control, as well as physiological, psychological and self-care outcomes of patients with type 2 diabetes mellitus (T2DM), compared with usual care.

Methods: This pragmatic cluster RCT was conducted in the Fengtai district of Beijing from August 2011 to December 2013. Forty-one community health stations (CHSs) were cluster randomized (stratified geographically, 1:1 ratio) and eligible, randomly selected T2DM patients were sequentially contacted by CHSs. Control participants received usual care according to the Chinese Guideline for Diabetes Prevention and Management. Intervention participants received 18-months of health coaching based on principles of Motivational Interviewing (MI) plus usual care. Medical and pathology fees were waived for both groups. Outcome assessment was performed at baseline, 6, 12, and 18-months. The primary outcome was glycated hemoglobin (HbA1c); secondary outcomes encompassed a suite of physiological, psychological and self-care measures.

Results: No differential treatment effect was found at 18-months for HbA1c (*adj. difference −0.07, 95% CI −0.53 to 0.39, p = 0.769*) or any specified secondary outcomes. Interestingly, both groups displayed a statistically and clinically significant within-group improvement of the same magnitude at 18-months for HbA1c (*intervention: mean change −3.65, 95% CI −3.92 to −3.37; control: mean change −3.38, 95% CI −3.67 to −3.08*).

Conclusions: The lack of differential treatment effects observed indicate that it may be premature to recommend the routine delivery of health coach interventions based on MI principles for the management of T2DM in China. However, the large, comparable

within-group improvement in mean HbA1c promotes the establishment of free, regular clinical health assessments for individuals with T2DM in China.
Trial Registration: ISRCTN registry - ISRCTN01010526 (https://doi.org/10.1186/ISRCTN01010526)

Keywords: type 2 diabetes, China, health coaching, motivational interviewing, cluster randomized controlled trial, pragmatic trial

INTRODUCTION

Diabetes Mellitus (DM) has emerged as a global health concern affecting ≥425 million adults worldwide (1), and an astonishing 25% of these are individuals in China. Recent estimates indicate that 114.4 million adults in China had DM in 2017, and this is projected to reach 119.8 million by 2045 (1). Such large and increasing numbers of DM pose significant challenges to the Chinese health care system, with direct annual costs recently estimated to be Int$170 billion (2). Effective DM management approaches are therefore key goals for China.

Type 2 diabetes mellitus (T2DM), the most prevalent form of DM, "is a complex, chronic condition that requires effective long-term medical management to prevent or postpone chronic complications" (3). To ensure individuals with T2DM receive the wide range of support that is required to manage the physical, psychological and social impacts of their condition, the combination of high-quality clinical care, and self-management support are fundamental (4). However, in China, T2DM management approaches are generally not patient-centered. Alternatively, doctors in China predominantly focus on the pharmaceutical management of T2DM, and generally disregard the facilitation of behavior change to control T2DM-related outcomes (5).

China is currently in the process of major health system reform, and the delivery of health care to individuals with T2DM is in transition. A key focus of these reforms is the establishment of a community-based primary health care system that is affordable, accessible and of high-quality (6). The most recent version of the Chinese Guideline for Diabetes Prevention and Management supports these reform goals by prioritizing the long-term management of T2DM, shifting away from an acute-centered care model that has traditionally been delivered by Chinese hospitals (7). The guideline further recommends the delivery of psychological care to assist individuals in adjusting to a new-diagnosis, and to support adherence to lifestyle changes (7).

A number of T2DM management approaches have been implemented internationally to support individuals in the self-management of their condition. The utilization of peer support programs (8), web-based interventions (9), diabetes self-management education programs (10), and psychological interventions (11) have all been found to have direct benefits for individuals with T2DM. A recent meta-analyses of randomized controlled trials (RCTs) in China similarly supported the use of psychological therapies, namely cognitive behavioral therapy, client-centered therapy, and motivational interviewing (MI) for the improvement of glycemic and psychological outcomes of T2DM (12). However, only three studies were included in the meta-analysis for MI (13–15); validity, as assessed through risk of bias (16), was unclear for the majority of included studies; and only two studies utilizing MI were conducted within the community health setting (14, 17).

Given the lack of methodologically robust studies utilizing MI within the community health sector in China, and the Chinese governments' strong commitment to primary care reform, this study aimed to assess the effectiveness of a T2DM management intervention that utilized health coaches trained in MI within an urban community health setting in China. Based on findings observed in previous meta-analyses (11, 12), it was hypothesized that compared to usual care, the structured health coach intervention would lead to improved physiological, psychological, and self-care T2DM-related outcomes. This paper will report on the final outcome assessment of the trial at 18-months; results of both the pilot study (18) and 12-month pre-results (19) are available elsewhere.

METHODS

Trial Design and Participants

A pragmatic, cluster RCT design was implemented from August 2011 to December 2013 within Community Health Stations (CHSs) in the Fengtai district of Beijing, China. This district lies to the southwest of central Beijing and covers an area of approximately 305 km^2 (20). The utilization of a cluster design was primarily selected to minimize experimental contamination between individuals in the control and intervention groups (health professionals & participants). The study protocol was approved by the Monash University Human Research Ethics Committee (CF11/2657 - 2011001550). All participants gave written informed consent in accordance with the Declaration of Helsinki.

All government-owned and administered CHSs in Fengtai district were identified as eligible clusters, resulting in an overall cluster sample size of 42 CHSs. Prior to randomization, consent for CHS participation was obtained from the Fengtai Health Bureau, the body which governs all eligible CHSs.

To reduce risk of recruitment bias, eligible participants were identified and recruited prior to cluster randomization. A blinded, independent person at each of the 42 CHSs identified eligible participants from medical records. Patients with an established T2DM diagnosis were eligible if they were receiving care at a participating CHS; aged ≥50 years; and lived in Fengtai. Exclusion criteria included a medical condition that precluded adherence to recommendations (e.g., terminal cancer),

or the inability to provide informed consent. No additional exclusion criteria were applied due to the pragmatic nature of the trial.

Sample Size

Sample size calculations have previously been reported (19). In brief, sample estimates assumed 42 clusters, a participant attrition rate of 20%, intracluster correlation coefficient of 0.05, power at 80%, alpha of 0.05, and an expected standardized effect of 0.32 for the primary outcome (HbA1c) measured on a continuous scale. This estimated a total of 726 participants were required. Small CHSs aimed to recruit 15 participants, while large stations aimed to recruit 25 participants per station. Consequently, the overall number of participants targeted for recruitment was 780 (control: 395: intervention: 385).

Stratification and Randomization

Eligible participants from each CHS were firstly stratified by gender to achieve a balance of men and women. This was performed as gender-specific health disparities have previously been observed among individuals of Chinese descent with regard to DM management and DM-related outcomes (21). Participants were then randomly sampled by computerized random allocation software, resulting in an ordered list of participants (for each CHS; by gender) to be contacted for consent. Because the socio-demographic profile of individuals residing in Fengtai varies according to locality, CHSs were then stratified by geographic location to achieve a balance of groups. Prior to cluster randomization, one CHS permanently shut down; resulting in a total of 41 CHSs available for randomization. Clusters were randomized into control ($n = 20$) or intervention ($n = 21$) groups using block randomization by computerized random allocation software. This procedure was performed at a central location by an independent person, and all clusters were coded to ensure the block randomization was blinded.

Participant Recruitment

To ensure the required participant sample size was met after the closure of one CHS, one neighboring CHS was required to recruit double the participant numbers (i.e., 30 instead of 15). A recruitment officer at each CHS sequentially contacted and invited individuals to participate in the study. If an individual declined, the reason provided was to be recorded.

All interested participants were provided with a consent form and explanatory statement. Once consent forms were received, participants were allocated an identification number and were instructed to return to their CHS for the baseline clinical health assessment at a specified date and time.

Participants were notified that payment would not provided for participation in the study, but medical fees (consultation and pathology fees) associated with the study would be waived. Despite China having near-universal health insurance coverage, individuals commonly experience out-of-pocket expenses for both pharmaceutical and medical care (22).

Outcome Assessment

Patient level outcomes were assessed at baseline, 6, 12, and 18-months via a clinical health assessment and an interviewer-administered questionnaire. An interviewer-administered mode was chosen in preference to a self-administered mode due to potential literacy problems within the participant group. In 2010, 26.09% of Chinese adults aged >65 were estimated to be illiterate (23).

The primary outcome measure was glycated hemoglobin (HbA1c). Secondary physiological outcomes included weight, body mass index (BMI), systolic and diastolic blood pressure (BP), waist and hip circumference, and fasting blood samples [fasting plasma glucose (FPG), triglycerides, and total, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) cholesterol]. The suite of psychological and self-care secondary outcome measures comprised psychological distress [Kessler 10 (K10)], quality of life (WHOQoL-BREF), diabetes self-care activities (SDSCA), and diabetes management self-efficacy (C-DMSES). All outcomes were assessed by CHS doctors and nurses specifically trained in data collection for the trial, according to the study protocol (24) (except LDL cholesterol, which utilized a direct method). The classification of elevated physiological outcomes was based on specified information within the Chinese diabetes guidelines (7). Participants in both treatment groups were informed of their physiological results following each assessment.

Participants were asked to fast overnight prior to each clinical health assessment for $\geq$8 h. Due to the pragmatic nature of this trial, data collectors were unblinded to group allocation; however, laboratory technicians were blinded. Analysis of all blood samples was performed at the Fengtai Center for Disease Control and Prevention Laboratory, which has certification from the National Center for Clinical Laboratories of China.

Intervention

Control Group

Participants in the control group received usual care only from their CHS. Usual care referred to the standard care as specified in the Chinese Guideline for Diabetes Prevention and Management (7). Although usual care is naturally expected to vary in pragmatic trials between providers and patients, and according to institutional policies, the recommended schedule outlined within the Chinese guideline involves quarterly doctor consultations and biannual physical examinations that include the assessment of HbA1c. The guideline also includes referral to health professionals from multiple disciplines. In order to meet the data collection requirements for this trial, an increase in monitoring was necessary (in addition to that outlined in the guidelines).

Intervention Group

Participants in the intervention group received a combination of face-to-face and telephone health coaching, plus usual care from their CHS. The health coaching was delivered by experienced clinicians (community nurses, doctors, and psychologists) from each CHS. Before commencing the intervention, health coaches completed a Monash University certified training

program in coach-assisted chronic disease management. This entailed a pre-workshop learning phase which included the study of key concepts in patient-centered communications, health psychology, epidemiology of key targeted illnesses and conditions, MI and behavior change, program evaluation, clinical outcome measurement, and the intervention protocol (24). This was followed by a 2-day intensive MI workshop that introduced health coaches to the rationale and framework of MI, and involved the application of core MI skills throughout the behavior change process. This workshop was conducted by a member of the Motivational Interviewing Network of Trainers (25). The workshop was delivered face-to-face in English and an interpreter was used to communicate the content in Mandarin. To ensure health coaches were supported in their MI skill development, refresher workshops were also conducted throughout the 18-month intervention phase. One month after the intervention commenced, health coaches received an additional half-day advanced workshop and were contacted on a quarterly basis for feedback and debriefing.

Health coaches aimed to support participants in achieving the management targets as specified within the Chinese diabetes guidelines (7), with the management of HbA1c <7% being of primary focus. An intervention manual was used to guide health coaches in utilizing existing local recommendations and guidelines. Variation in intervention delivery was expected due to the pragmatic nature of the trial and the need for health coaches to adapt the manual to local contexts.

The first requirement of each health coaching session involved setting the agenda with participants. This was accomplished by asking the participant to determine the most productive place to start the discussion. Once a key issue was identified, health coaches guided the discussion with the fundamental aim of enhancing the participants internal motivation and commitment for change. Initially, participants received two telephone and two face-to-face coaching sessions per month. Session frequency decreased over the 18-month trial period, as depicted in **Figure 1**.

Statistical Analysis

Statistical analysis was performed using Stata software (v12.0) and a significance level of $p < 0.05$ was used to evaluate statistical significance for both primary and secondary outcomes. Descriptive statistics were used to summarize characteristics (baseline and patterns of mean change over time) of both CHSs and participants. Differences between control and intervention conditions, on all outcomes, were evaluated using multilevel modeling analysis. Specifically, multilevel mixed effects models with robust standard errors were used to assess all continuous outcomes, implemented with the *xtmixed* command. Random effects accounted for within-patient correlation and within-site clustering. Fixed effects included intervention group and time. Primary analysis assessed 6, 12, and 18-month changes in HbA1c. Secondary analyses included all pre-specified continuous outcomes. Model fit was evaluated by comparing AIC values.

Models were adjusted for an *a priori* set of baseline variables, consisting of gender, highest education level, chronic comorbidity category, age group, time since diabetes diagnosis, and residential address socioeconomic status (specific categories provided below **Tables 2**, **3**). Between-group effects were then calculated for all outcomes using the *lincom* command. This procedure estimates an adjusted difference in mean scores between the two treatment groups and its 95% confidence interval. One-way analysis of variance tests were used to estimate ICCs. A missing data analysis was done for each outcome, which consisted of Little's MCAR test to examine patterns of missingness in variables of baseline characteristics and group allocation (**Table 1**).

RESULTS

Between August 22, 2011, and November 15, 2011, 753 participants were recruited into the trial. The trial flow for CHSs and participants is depicted in **Figure 2**. Of the 20 CHSs randomized to the control condition, two CHSs did not recruit participants according the study protocol. This led to inaccurate ID allocation of participants, and these clusters were subsequently removed from the study prior to baseline data collection (23 participants). Therefore, 39 CHSs [*18 control CHSs (345 participants) and 21 intervention CHSs (385 participants)*] were included in the study. No additional CHSs were lost to follow-up throughout the 18-month trial.

Prior to baseline data collection, 19 participants (*intervention: $n = 13$; control: $n = 6$*) withdrew and did not commence the study. Of the 711 participants (*intervention: $n = 372$; control: $n = 339$*) who participated in baseline data collection, 588 (*intervention: $n = 322$; control: $n = 266$*) were included in the analysis at 18-months. The participant attrition from baseline was 17.3% (*intervention: 13.4%; control: 21.5%).* Analysis of missing data showed that dropouts were missing completely at random (*Little's MCAR test: Chi-Square = 19.4, df = 18, p = 0.4*).

Baseline data were obtained from 39 CHSs (*21 intervention; 18 control*) and 711 participants (*372 intervention; 339 control*) (**Table 1**). The two trial arms were balanced for all variables at both the cluster and participant level.

With regard to the characteristics of CHSs, the mean population of CHS zone in the intervention and control group was 19,025 ± 10,553 and 23,884 ± 29,994, respectively. The mean number of annual CHS visits was 18,198 ± 16,572 for intervention CHSs and 30,862 ± 42,075 for control CHSs. The doctor to nurse ratio was approximately 1:1 (*intervention: 2.9 ± 2.0:3.1 ± 1.8; control: 3.2 ± 2.3: 2.9 ± 1.2*) and the mean number of years since CHS establishment was >10 years for both groups (*intervention: 13.5 ± 6.0; control: 11.4 ± 4.9*).

At the participant level, mean age for both groups was approximately 64 years (*intervention: 63.7 ± 7.6; control: 64.0 ± 9.0*); and there were slightly more women in the sample (*intervention: 51.3%, 191/372; control: 54.3%, 184/339*) than men. The majority of participants in both groups were married (*intervention: 91.1%, 338/371; control 88.5%, 299/338*), had received secondary school education (*intervention: 71.5%, 266/372; control: 65.7%, 222/338*), and were retired (*intervention: 92.7%, 343/370; control: 91.4%, 309/338*). Mean T2DM duration

Timeline	MI Health Coaching + Usual Care (Intervention)	Usual Care (Control)
Randomisation		
Baseline	Measurement of outcomes	
0-3 month (per month)	a c b a b	c
3-6 month (per month)	a c b b	c
6 month	Measurement of outcomes	
6-12 month (per month)	a c b	c
12 month	Measurement of outcomes	
12-18 month (per month)	a c b	c
18 month	Measurement of outcomes	

a	Telephone call made by health coach trained in MI NB: Between 12-18 months telephone calls were performed three-monthly
b	Face-to-face session with health coach trained in MI
c	Usual care from community health station (medical fees waived) NB: Measurement of outcomes deviated from usual care recommendations.

FIGURE 1 | Graphical representation of interventions for each treatment condition.

for both groups was approximately 10 years (*intervention: 10.0 ± 6.5; control: 9.6 ± 6.6*) and roughly one third of participants were prescribed insulin at baseline (*intervention: 33.4%, 124/371; control: 29.4%, 99/337).* Additionally, the majority of participants in both groups had chronic co-morbid conditions present at baseline (*intervention: 84.9%, 316/372; control: 79.1%, 268/339*) and approximately one-fifth of participants were categorized as current smokers (*intervention: 18.5%, 68/367; control: 20.2%, 65/321*).

Table 2 shows the primary and secondary physiological outcomes; **Table 3** the secondary psychological and self-care outcomes. At 18-months, no significant between-group differences were found for the primary outcome measure, HbA1c (*adj. difference −0.07, 95% CI −0.53 to 0.39, p = 0.769*), with both intervention and control groups displaying statistically significant improvements (*intervention: mean change −3.65, 95% CI −3.92 to −3.37; control: mean change −3.38, 95% CI −3.67 to −3.08*). Similarly, no differential treatment effects were found at 18-months for any of the secondary physiological, psychological or self-care outcome measures. However, both groups displayed statistically significant within-group improvements at 18-months in FPG (*intervention: mean change −0.83, 95% CI −1.19 to −0.47; control: mean change −0.98, 95% CI −1.37 to −0.59*), triglycerides (*intervention: mean change −0.34, 95% CI −0.50 to −0.17; control: mean change −0.20, 95% CI −0.37 to −0.03*), total cholesterol (*intervention: mean change −0.58, 95% CI −0.72 to −0.44; control: mean change −0.61, 95% CI −0.77 to −0.45*), HDL cholesterol (*men—intervention: mean change +0.18, 95% CI 0.13 to 0.23; control: mean change +0.16, 95% CI 0.10 to 0.22: women—intervention: mean change +0.09, 95% CI 0.04 to 0.14; control: mean change +0.11, 95% CI 0.05 to 0.16*), LDL cholesterol (*intervention: mean change −0.53, 95% CI −0.67 to −0.39; control: mean change −0.55, 95% CI −0.70 to −0.40*), and SDSCA-Blood Glucose Monitoring (*intervention: mean change*

TABLE 1 | Baseline characteristics of CHSs and participants by study group.

Baseline characteristics	Intervention group	Control group
Community Health Stations, *n* (%):	21 (53.8%)	18 (46.2%)[a]
Population of CHS zone, mean ± *SD*	19,025 ± 10,553	23,884 ± 28,994
Number of annual CHS visits, mean ± *SD* (median)	18,198 ± 16,572 (19,631)	30,862 ± 42,075 (18,730)
Number of CHS doctors, mean ± *SD*	2.9 ± 2.0	3.2 ± 2.3
Number of CHS nurses, mean ± *SD*	3.1 ± 1.8	2.9 ± 1.2
Years since CHS establishment, mean ± *SD*	13.5 ± 6.0	11.4 ± 4.9
Participants, *n* (%):	372 (52.3%)	339 (47.7%)
Age in years, mean ± *SD* (median)	63.7 ± 7.6 (62.2)	64.0 ± 9.0 (63.7)
Female, *n* (%):	191/372 (51.3%)	184/339 (54.3%)
Married (including de facto), *n* (%):	338/371 (91.1%)	299/338 (88.5%)
Retired, *n* (%):	343/370 (92.7%)	309/338 (91.4%)
Secondary/high school education, *n* (%):	266/372 (71.5%)	222/338 (65.7%)
Duration of T2DM in years, mean ± *SD*	10.0 ± 6.5	9.6 ± 6.6
Currently prescribed insulin, *n* (%):	124/371 (33.4%)	99/337 (29.4%)
Co-morbid conditions present, *n* (%):	316/372 (84.9%)	268/339 (79.1%)
Current Smoker, *n* (%):	68/367 (18.5%)	65/321 (20.2%)

Differences in the participant n denominator for some baseline variables are a consequence of missing data.

[a]*Means and SDs for control CHSs based on n = 17. One CHS was an extreme outlier for all variables and subsequently removed for analysis. Baseline characteristics of the excluded CHS are as follows: Population of CHS zone −120,567; Number of annual CHS visits −420,827; Number of CHS doctors −46; Number of CHS nurses −32; Years of CHS establishment −56.*

+0.78, 95% CI 0.50 to 1.06; control: mean change +0.73, 95% CI 0.42 to 1.03).

Additional within-group significant changes were observed between baseline and 18-months that were not consistent among both treatment groups. With regard to physiological outcomes at 18-months, only intervention participants displayed small yet statistically significant improvements in systolic BP (*mean change +0.84, 95% CI 0.46 to 1.22*); while statistically significant improvements in weight (*mean change −1.99, 95% CI −3.74 to −0.24*), BMI (*mean change −0.27, 95% CI −0.48 to −0.05*), and hip circumference for women (*mean change −1.79, 95% CI −3.19 to −0.40*) were only observed within participants in the control group.

Significant within-group deteriorations in the mean between baseline and 18-months were observed among intervention participants only for a considerable number of psychological outcomes, namely psychological distress (*mean change +1.72, 95% CI 0.80 to 2.63*), C-DMSES (*mean change −4.90, 95% CI −9.32 to −0.48*), and the WHOQoL-BREF domains of physical (*mean change −3.09, 95% CI −4.75 to −1.43*), psychological (*mean change −7.69, 95% CI −9.94 to −5.44*), and environment (*mean change −5.72, 95% CI −7.99 to −3.45*). In contrast, a statistically significant within-group improvement in the SDSCA-Foot Care subscale at 18-months was observed among participants in the control group only (*mean change +0.84, 95% CI 0.46 to 1.22*).

DISCUSSION

This study is the first pragmatic cluster RCT to examine the effectiveness of a health coach intervention for the management of physiological, psychological and self-care outcomes of T2DM within the community health sector in China, relative to usual care. The findings obtained found no differential treatment effect for HbA1c or for a series of physiological, psychological or self-care secondary outcomes. As such, the study hypothesis was not supported.

Chief among the key findings observed were the significant within-group improvements in mean HbA1c between baseline and 18-months for participants from both treatment groups. In addition to being statistically significant, the comparable change in mean HbA1c from approximately 10% at baseline to within the optimal range of <7.0% at 18-months, is of clinical significance. Glycemic control is central to T2DM management, and evidence from various landmark studies indicate that lower HbA1c levels are associated with delayed onset or progression of microvascular complications (26). Epidemiological analyses have further revealed a curvilinear relationship between HbA1c and microvascular complications (27). This relationship indicates that the greatest number of complications will be prevented, at a population level, by shifting individuals from very poor glycemic control to fair/good glycemic control. The improvements observed for HbA1c in the present study, if sustained, therefore have the potential for reductions to be noted in microvascular complications.

Although significant within-group changes were noted for numerous secondary outcomes at 18-months, it is unlikely that any of the observed changes will translate into clinical significance. The magnitude of mean change was relatively small for all secondary outcomes; mean values for the majority of statistically significant physiological outcomes remained outside of optimal range at 18-months (except triglycerides and HDL

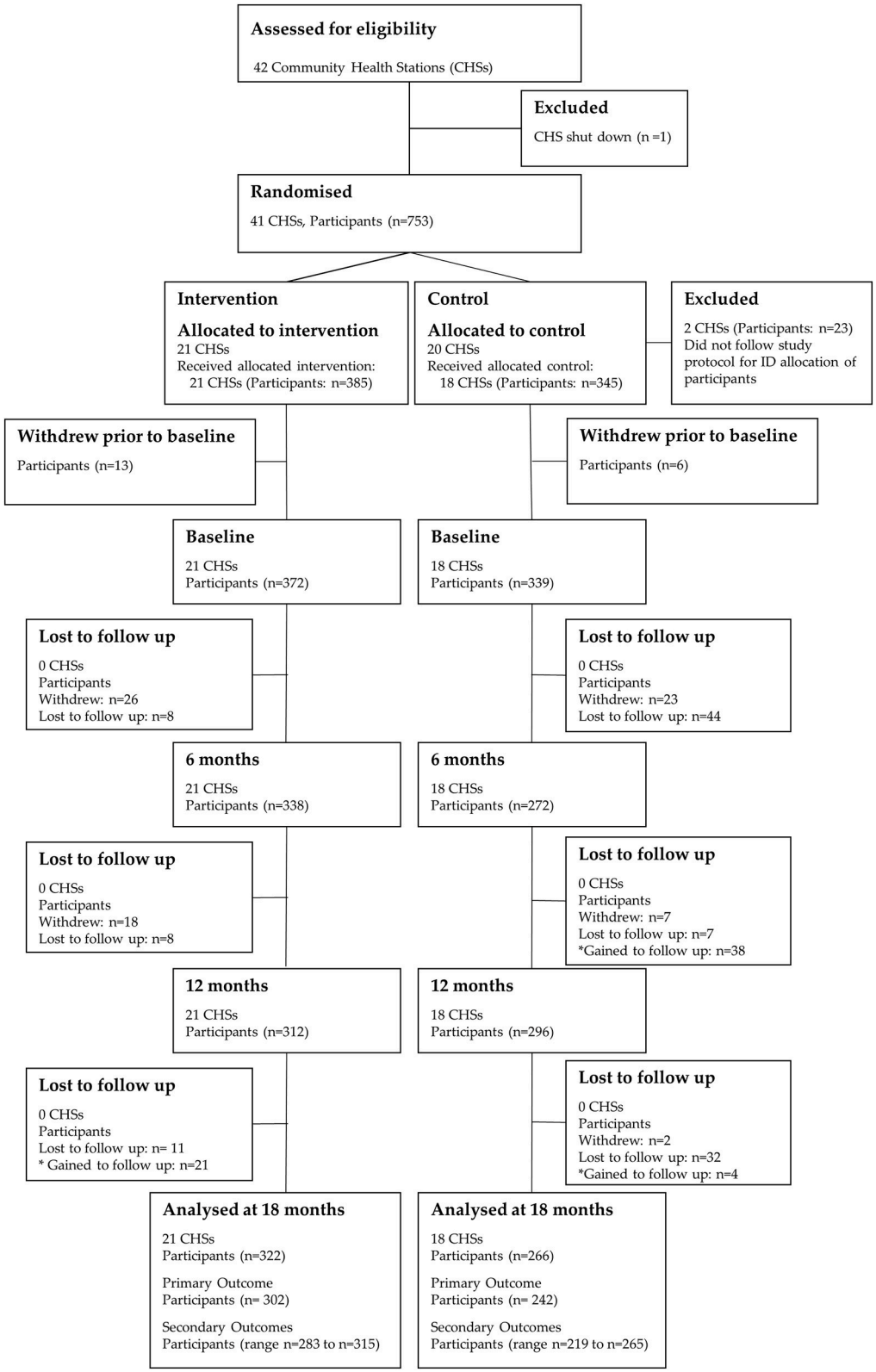

FIGURE 2 | CONSORT flow diagram of community health stations and participants through the 18-month trial. Differences in the participant *n* values for the primary and secondary outcomes at 18-months are due to missing/invalid data.

TABLE 2 | Physiological outcomes at baseline and 18 months by study group.

Outcomes	Intervention group		Control group			Available cases analysis	
	N	Mean ± *SD*	*N*	Mean ± *SD*	ICC[a]	Adjusted difference between change scores (95% CI)[b]	*P*-value
PRIMARY OUTCOME							
HbA1c (%)							
Target: <7.0%							
Baseline	359	10.60 ± 2.09	323	10.29 ± 1.71			
18 months	302	6.94 ± 1.65	242	6.99 ± 1.70			
Mean change from baseline to 18 months (95% CI)		−3.65 (−3.92 to −3.37)		−3.38 (−3.67 to −3.08)	0.33	−0.07 (−0.53 to 0.39)	0.769
SECONDARY OUTCOMES							
Weight (kg)							
Baseline	359	70.13 ± 11.71	333	69.68 ± 10.27			
18 months	283	69.14 ± 11.13	236	67.82 ± 9.77			
Mean change from baseline to 18 months (95% CI)		−0.39 (−0.85 to 0.06)		−0.74 (−1.29 to −0.18)	0.06	0.34 (−0.58 to 1.26)	0.469
BMI (kg/m^2)							
Target: <24 kg/m^2							
Baseline	359	26.23 ± 3.69	333	26.03 ± 3.42			
18 months	283	25.90 ± 3.42	236	25.64 ± 3.37			
Mean change from baseline to 18 months (95% CI)		−0.15 (−0.32 to 0.02)		−0.27 (−0.48 to −0.05)	0.06	0.12 (−0.23 to 0.46)	0.505
Waist (cm) Men							
Target: <90 cm							
Baseline	176	93.75 ± 9.29	153	92.82 ± 8.49			
18 months	139	93.72 ± 8.85	97	90.73 ± 8.11			
Mean change from baseline to 18 months (95% CI)		+0.11 (−0.75 to 0.98)		−0.89 (−2.07 to 0.29)	0.20	1.31 (−0.57 to 3.20)	0.172
Waist (cm) Women							
Target: <80 cm							
Baseline	186	88.57 ± 9.57	176	90.68 ± 10.02			
18 months	150	88.67 ± 9.37	122	88.38 ± 8.92			
Mean change from baseline to 18 months (95% CI)		+1.01 (−0.02 to 2.04)		−0.90 (−2.28 to 0.48)	0.25	1.38 (−0.74 to 3.49)	0.202
Hip (cm) Men							
Baseline	176	102.37 ± 8.69	153	100.23 ± 7.71			
18 months	136	101.62 ± 7.68	101	98.51 ± 6.43			
Mean change from baseline to 18 months (95% CI)		−0.43 (−1.42 to 0.56)		−0.68 (−1.93 to 0.58)	0.23	1.22 (−0.44 to 2.90)	0.150
Hip (cm) Women							
Baseline	186	99.95 ± 8.23	179	102.06 ± 8.81			
18 months	155	99.55 ± 7.71	114	98.79 ± 7.99			
Mean change from baseline to 18 months (95% CI)		−0.64 (−1.52 to 0.23)		−1.79 (−3.19 to −0.40)	0.21	1.13 (−0.80 to 3.05)	0.252
Systolic BP (mmHg)							
Target: <140 mmHg							
Baseline	363	129.03 ± 15.14	334	128.46 ± 14.82			
18 months	314	127.50 ± 9.95	262	126.86 ± 11.72			
Mean change from baseline to 18 months (95% CI)		−1.99 (−3.74 to −0.24)		−1.38 (−3.29 to 0.52)	0.07	−0.16 (−2.96 to 2.65)	0.912

(Continued)

TABLE 2 | Continued

Outcomes	Intervention group		Control group			Available cases analysis	
	N	Mean ± *SD*	*N*	Mean ± *SD*	ICC[a]	Adjusted difference between change scores (95% CI)[b]	*P*-value
Diastolic BP (mmHg)							
Target: <80 mmHg							
Baseline	363	76.91 ± 9.10	334	76.00 ± 8.64			
18 months	315	77.20 ± 6.37	265	74.70 ± 8.06			
Mean change from baseline to 18 months (95% CI)		−0.25 (−1.34 to 0.84)		−0.51 (−1.79 to 0.76)	0.07	1.01 (−1.36 to 3.39)	0.404
Fasting Plasma Glucose (mmol/L)							
Target: 4.4–7.0 mmol/L							
Baseline	367	8.27 ± 2.70	330	8.13 ± 2.74			
18 months	314	7.47 ± 2.88	260	7.31 ± 2.69			
Mean change from baseline to 18 months (95% CI)		−0.83 (−1.19 to −0.47)		−0.98 (−1.37 to −0.59)	0.09	0.30 (−0.36 to 0.96)	0.370
Total Cholesterol (mmol/L)							
Target: <4.5 mmol/L							
Baseline	363	5.46 ± 1.12	326	5.40 ± 1.19			
18 months	314	4.86 ± 1.17	259	4.83 ± 1.07			
Mean change from baseline to 18 months (95% CI)		−0.58 (−0.72 to −0.44)		−0.61 (−0.77 to −0.45)	0.02	0.03 (−0.16 to 0.22)	0.748
Triglycerides (mmol/L)							
Target: <1.7 mmol/L							
Baseline	363	1.91 ± 1.53	326	1.82 ± 1.43			
18 months	314	1.59 ± 1.05	259	1.69 ± 1.62			
Mean change from baseline to 18 months (95% CI)		−0.34 (−0.50 to −0.17)		−0.20 (−0.37 to −0.03)	–	−0.06 (−0.23 to 0.11)	0.509
LDL Cholesterol (mmol/L)							
Target: <2.6 mmol/L							
Baseline	367	3.70 ± 1.21	329	3.56 ± 1.13			
18 months	314	3.18 ± 1.05	259	3.07 ± 0.90			
Mean change from baseline to 18 months (95% CI)		−0.53 (−0.67 to −0.39)		−0.55 (−0.70 to −0.40)	0.20	−0.00 (−0.18 to 0.17)	0.979
HDL Cholesterol (mmol/L) Men							
Target: >1.0 mmol/L							
Baseline	178	1.04 ± 0.31	151	1.08 ± 0.27			
18 months	146	1.20 ± 0.30	117	1.23 ± 0.27			
Mean change from baseline to 18 months (95% CI)		+0.18 (0.13 to 0.23)		+0.16 (0.10 to 0.22)	0.24	0.01 (−0.06 to 0.08)	0.706
HDL Cholesterol (mmol/L) Women							
Target: >1.3 mmol/L							
Baseline	189	1.17 ± 0.35	179	1.17 ± 0.32			
18 months	168	1.25 ± 0.30	142	1.27 ± 0.27			
Mean change from baseline to 18 months (95% CI)		+0.09 (0.04 to 0.14)		+0.11 (0.05 to 0.16)	0.33	0.02 (−0.06 to 0.10)	0.569

Where relevant, treatment targets for each outcome are provided to assist the interpretation of values. With the exception of HDL cholesterol, lower scores indicate improvement.

[a] *ICC, intracluster correlations indicated with a "–" were truncated at zero.*

[b] *Differences between groups were estimated by multilevel regression, adjusting for clustering and baseline covariates of age group (<60 years/≥60 years), gender (male/female), chronic comorbidity category (diabetes only/diabetes plus other/s), time since diabetes diagnosis (<5 years/5–9 years/10–14 years/≥15 years), education level (primary school or less/secondary or high school/tertiary education), and residential address socioeconomic status (Developed areas/Developing areas/Less developed areas).*

TABLE 3 | Psychological and self-care outcomes at baseline and 18 months by study group.

Outcomes	Intervention group		Control group			Available cases analysis	
	N	Mean ± SD	*N*	Mean ± SD	ICC	Adjusted difference between change scores (95% CI)[a]	*P*-value
PSYCHOLOGICAL DISTRESS (SCORE RANGE 10–50; RISK CATEGORIES <20 NO/LOW; 20–24 MILD; 25–29 MODERATE; 30–50 SEVERE)							
Baseline	362	15.31 ± 6.85	328	14.97 ± 6.24			
18 months	310	16.98 ± 5.92	263	15.10 ± 5.59			
Mean change from baseline to 18 months (95% CI)		+1.72 (0.80 to 2.63)		+0.30 (−0.66 to 1.26)	0.20	0.56 (−2.19 to 3.31)	0.688
DIABETES MANAGEMENT SELF-EFFICACY (SCORE RANGE 0–200)							
Baseline	366	159.32 ± 32.99	334	158.96 ± 34.85			
18 months	311	155.69 ± 31.68	261	158.46 ± 28.05			
Mean change from baseline to 18 months (95% CI)		−4.90 (−9.32 to −0.48)		−2.74 (−7.42 to 1.95)	0.16	8.28 (−7.42 to 23.98)	0.301
SUMMARY OF DIABETES SELF-CARE ACTIVITIES (SCORE RANGES 0–7; REPRESENTING NUMBER OF DAYS ACTIVITY IS PERFORMED)							
General Diet							
Baseline	368	5.37 ± 1.80	337	5.44 ± 1.85			
18 months	314	5.33 ± 1.37	263	5.50 ± 1.31			
Mean change from baseline to 18 months (95% CI)		−0.07 (−0.30 to 0.16)		−0.08 (−0.35 to 0.18)	0.16	0.21 (−0.31 to 0.73)	0.432
Specific Diet							
Baseline	368	4.10 ± 1.51	337	4.37 ± 1.62			
18 months	314	4.10 ± 1.12	263	4.29 ± 1.22			
Mean change from baseline to 18 months (95% CI)		−0.01 (−0.22 to 0.20)		−0.12 (−0.36 to 0.13)	0.11	−0.22 (−0.61 to 0.18)	0.276
Exercise							
Baseline	369	5.27 ± 2.07	337	5.01 ± 2.13			
18 months	314	5.11 ± 1.74	263	5.07 ± 1.86			
Mean change from baseline to 18 months (95% CI)		−0.21 (−0.47 to 0.05)		−0.11 (−0.41 to 0.19)	0.08	−0.06 (−0.57 to 0.46)	0.830
Blood Glucose Monitoring							
Baseline	366	1.46 ± 1.75	336	1.85 ± 1.83			
18 months	313	2.34 ± 1.90	263	2.56 ± 1.97			
Mean change from baseline to 18 months (95% CI)		+0.78 (0.50 to 1.06)		+0.73 (0.42 to 1.03)	0.09	0.03 (−0.62 to 0.69)	0.920
Foot Care							
Baseline	368	4.50 ± 2.79	337	4.46 ± 2.62			
18 months	313	4.80 ± 2.42	263	5.30 ± 2.11			
Mean change from baseline to 18 months (95% CI)		+0.25 (−0.09 to 0.60)		+0.84 (0.46 to 1.22)	0.10	0.19 (−0.78 to 1.15)	0.706
QUALITY OF LIFE (SCORE RANGE FOR EACH DOMAIN 0–100)							
Physical Domain							
Baseline	368	62.62 ± 12.92	338	63.31 ± 13.99			
18 months	314	59.55 ± 11.30	263	62.65 ± 13.21			
Mean change from baseline to 18 months (95% CI)		−3.09 (−4.75 to −1.43)		−1.56 (−3.46 to 0.34)	0.08	−0.36 (−4.79 to 4.08)	0.875
Psychological Domain							
Baseline	368	68.87 ± 14.45	336	67.90 ± 16.18			
18 months	313	61.48 ± 15.71	263	67.16 ± 14.64			
Mean change from baseline to 18 months (95% CI)		−7.69 (−9.94 to −5.44)		−1.88 (−4.31 to 0.55)	0.21	−4.16 (−10.98 to 2.66)	0.232

(Continued)

TABLE 3 | Continued

Outcomes	Intervention group		Control group			Available cases analysis	
	N	Mean ± SD	*N*	Mean ± SD	ICC	Adjusted difference between change scores (95% CI)[a]	*P*-value
Social Relationship Domain							
Baseline	368	64.18 ± 13.95	338	64.82 ± 14.23			
18 months	313	62.55 ± 13.63	263	65.49 ± 13.24			
Mean change from baseline to 18 months (95% CI)		−1.67 (−3.88 to 0.54)		+0.90 (−1.31 to 3.12)	0.12	−0.52 (−4.96 to 3.92)	0.818
Environment Domain							
Baseline	368	65.41 ± 14.53	338	63.72 ± 15.95			
18 months	314	59.80 ± 16.40	263	63.81 ± 14.27			
Mean change from baseline to 18 months (95% CI)		−5.72 (−7.99 to −3.45)		−0.48 (−2.79 to 1.83)	0.18	−3.55 (−9.43 to 2.33)	0.237

Score ranges for each outcome are provided to assist the interpretation of values. With the exception of psychological distress (K10), higher scores indicate improvement in outcome.
[a]Differences between groups were estimated by multilevel regression, adjusting for clustering and baseline covariates of age group (<60 years/≥60 years), gender (male/female), chronic comorbidity category (diabetes only/diabetes plus other/s), time since diabetes diagnosis (<5 years/5–9 years/10–14 years/≥15 years), education level (primary school or less/secondary or high school/tertiary education), and residential address socioeconomic status (Developed areas/Developing areas/Less developed areas).

cholesterol for men); and the within-group deteriorations in mean values for psychological and self-care outcomes for participants in the control group (i.e., psychological distress) were not representative of a clinical shift in risk categories. Clinical significance could be argued for the improvements observed in systolic BP among intervention group participants and improvements in triglycerides among participants in both treatment groups. However, the objectivity of triglyceride levels as a clinically relevant outcome is debatable (28); and the clinical significance of systolic BP improvements <140 mmHg is unclear (29).

The clinically significant improvement in HbA1c among both treatment groups may partially be explained by the regular clinical monitoring and resultant feedback to participants following each clinical health assessment. Most individuals with T2DM in China do not regularly attend specific appointments to manage their condition. The Diabcare-Asia (China) study determined that only 50% of patients with diagnosed DM had a HbA1c test in the preceding 12-months (30), despite Chinese diabetes guidelines prescribing biannual HbA1c assessments (7). Precise health service utilization records were unable to be retrieved for the time-period before the present study, but the numerous physiological outcomes with mean values outside optimal ranges at baseline (in particular HbA1c >10%) indicates that both groups of participants were either not accessing CHSs for T2DM management; were not fully adherent to the T2DM self-care regimen; or were experiencing suboptimal T2DM care prior to participation in this study. Participation in this trial required individuals to undergo health checks at more regular intervals than that outlined in the usual care recommendations. By informing participants of their T2DM health status on a more regular basis, it may have motivated individuals and their healthcare professionals to be more attentive to their health than otherwise expected, thus modifying "usual care."

Furthermore, to maximize participation, medical fees associated with participation in the present study were waived for both treatment groups, further modifying the "usual care" condition. Out-of-pocket healthcare costs are a well-documented barrier to the accessibility and satisfaction of healthcare services in China (31). Out-of-pocket costs are also higher for older (>60 years), retired individuals who are not eligible for the Urban Employee Basic Medical Insurance scheme (22). As >90% of participants in the present study were retired at baseline, the majority of study participants would usually have been required to incur significant out-of-pocket costs to manage their T2DM. Possible consequences of the adjustments to usual care may have been improvement in adherence to the T2DM self-care regimen; increased CHS attendance; as well as the initiation of medication to manage uncontrolled variables.

A further explanation for the comparable improvement in HbA1c within both treatment groups is the possible contamination between clusters. Although every effort was made to prevent contamination, the trial received considerable media attention during the intervention phase, which might have contributed to participants and health coaches altering their usual behavior. Furthermore, all participating CHSs are administered and managed by the Fengtai Health Bureau. This was an unavoidable circumstance of the study setting but is one that may have affected and blurred the delivery of the intervention and control procedures. Lastly, the "Hawthorne Effect," typically described as the human tendency to improve performance because of the awareness of being studied (32), may also have contributed to the improvements noted in both treatment groups.

The lack of clinical relevance for the statistically significant findings were primarily due to the small magnitude of changes for each of the secondary outcomes. The small extent of

improvements observed in the present trial may be related to the pragmatic nature of the trial. The broad eligibility criteria that was utilized resulted in a diverse population of individuals with T2DM that more closely represents typical clinical practice in China. The resulting heterogeneity of participants could have diluted the observed treatment effects which can occur in pragmatic trials (33). Additionally, the potential variability of intervention delivery between each CHS, and the abovementioned considerations of possible contamination between intervention and control CHSs may have further contributed to a dilution of treatment effect. If this study utilized a traditional RCT design under heightened experimental conditions, observed treatment effects may have potentially been larger.

To date, no cluster RCTs in China have examined the effect of health coaching based on MI principles for the management of individuals with T2DM. A recent systematic review and meta-analyses identified five studies that utilized MI, all of which adopted a traditional RCT design (12). As previously noted, the effects of these studies provide some evidence to support the use of MI for the improvement of glycemic control in patients with T2DM; however studies primarily assessed outcomes at 6 months; validity, as assessed through the risk of bias was unclear for the majority of studies; and baseline HbA1c values were lower (7–8%) than that observed in the present study (>10%). Additionally, only two (14, 17) of the five studies were conducted within a community health setting [one of which assessed HbA1c (14)]. These clinical and methodological variations consequently impede the ability for meaningful comparisons to be drawn between the present study and those previously conducted in China.

Internationally, three cluster RCTs have assessed the effectiveness of MI for the improvement of T2DM-related outcomes (34–36). The between-group findings observed in all three trials are largely consistent with that observed in the present study, with no differential treatment effects observed. Despite the limited number of international cluster RCTs published, several traditional RCTs have been conducted in international settings that have assessed the effectiveness of MI for the management of T2DM-related outcomes. Some of these studies have observed a differential treatment effect favoring the intervention with regard to glycaemic control (37), fat intake (38, 39), physical activity (38), weight (40), waist circumference (38), systolic BP (41), DM self-care activities (42), and DM-related knowledge (43). However, for the majority of outcomes in the majority of studies, differential treatment effects have not been found (36, 37, 43, 44); a result similar to that observed in the present trial.

A key strength of the present study was that it was implemented as a pragmatic trial, specifically tailored to be delivered in real world CHSs in urban China, hence maximizing external validity. The cluster design minimized contamination between CHSs, and stratification and randomization procedures for both participants and CHSs minimized selection bias and increased generalizability of the results to other populations of patients with T2DM in urban China.

A limitation of the present study is that intervention fidelity has not been adequately assessed as yet; hence, we have not been able to distinguish between participants with respect to quality of MI received. In the current trial, it is possible that health coaches had not reached an appropriate standard to be effective MI health coaches, despite increasing their skills. All coaching sessions were audio-recorded throughout the 18-month trial and future research is planned for the analysis of treatment integrity. Until this piece of work is performed, it would be unjustified to conclude that MI is ineffective in the management of T2DM in China.

The pragmatic design also caused data collection to be performed by multiple data collectors from all CHSs. While all data collectors were received extensive training on the study protocol, quality of data varied, resulting in higher levels of missing data than expected. Additionally, outcome assessors were not blinded in the present study. While the lack of blinding in pragmatic trials can lead to reduced internal validity; the external validity is enhanced, and consequently improves the generalizability of findings to clinical settings in which they would be applied (33).

Despite the noted limitations, and the lack of differential treatment effects observed, important implications can be drawn from the findings of the present study. The comparable shift in mean HbA1c among both groups from >10% at baseline to within the optimal range of <7% at 18-months is a clinically relevant outcome that promotes the establishment of free, regular clinical health assessments for individuals with T2DM in China. The establishment of such a monitoring program would also fit within the current healthcare reform, which aims to address inequitable access to healthcare services. Existing evidence indicates that healthcare insurance can improve the health outcomes of some population subgroups in China, including those of older people (45). Given that older people are associated with the highest burden of T2DM cases in China, and are more likely to be retired with limited finances, this population group would particularly benefit from regular monitoring that is free of cost.

In all countries, we are struggling with the effective management of chronic disease. To date, there is little evidence globally for the long-term success of large-scale interventions applying behavioral management of diabetes. However, we must keep researching this important area in order to alleviate the large burden of disease resulting from sub-optimal diabetes management. This study represents a foundational step toward the implementation of rigorously designed psychological interventions in China, specifically targeting T2DM. Given the combination of China's increasing burden of T2DM and the governments' strong commitment to healthcare reform, the opportunities for meaningful contributions in the field of chronic disease management in China are manifest. The Chinese government and Chinese Medical Association are striving to adopt best practice medical management and the continued examination of the effectiveness of psychological interventions in T2DM management is a worthy and important element.

DATA SHARING

All available data is presented within this manuscript.

AUTHOR CONTRIBUTIONS

CB and ST led the conception of the study. CB, ST, and TZ obtained research and operational funding, and HY participated. AC, CB, and HY led the design of the study protocol. AC drafted the article and all the authors contributed to critical revision. SL, AC, HY, and TZ coordinated the data collection and data cleaning. JE led the statistical analysis of the data and AC contributed. All the authors participated in the interpretation of the trial data. All the authors, internal and external, had full access to the study data, and take responsibility for the integrity of the data and the accuracy of the data analysis. All the authors have approved the final version of the manuscript.

FUNDING

This trial was funded by the Fengtai Health Bureau, Beijing, China and in kind support was provided by Monash University, Australia and Peking University, China. The funders of the study had no role in study design, data collection, data analysis, data interpretation, writing of the report, or decision to submit for publication.

ACKNOWLEDGMENTS

We thank Professor Liang Wannian, executive director of Beijing Health Bureau; Dr. Zhang Yang and Dr. Xiao Lixin of the Health Bureau of Fengtai Government; Dr. Yang Zhiyun and Dr. Zhou Wei of Fengtai Community Health Management Centre; and all directors, health coaches, and patients from the participating Community Health Stations in the Fengtai district.

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Conflict of Interest Statement: AC, CB, ST, and SL are Editors of the research topic: Chronic Illness and Ageing in China; they had no involvement in the review of this manuscript.

The remaining 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.

Hou B, Nazroo J, Banks J and Marshall A (2018) Migration Status and Smoking Behaviors in Later-Life in China—Evidence From the China Health and Retirement Longitudinal Study (CHARLS). Front. Public Health 6:346. doi: 10.3389/fpubh.2018.00346

Abstract

背景：中国是世界上最大的烟草消费国，吸烟率很高，尤其是在男性中。随着中国人口的快速变化，归因于健康行为的疾病负担，尤其是吸烟正在稳步增加。因此，吸烟已成为中国死亡的主要危险因素。吸烟行为可能与迁移过程有关，这是由于谁迁移以及迁移后的经历与社会经济地位、压力和文化适应有关。现有的研究调查了中国的吸烟和移民现象，但是仅针对临时的从农村到城市的移民和相对年轻的移民。本文研究了吸烟行为与中国晚年移民状况的综合评估之间的关系。

方法：使用全国有代表性的数据集《中国健康与养老追踪调查》（CHARLS），研究农村到城市移民，城市到城市移民，农村返乡移民和城市返乡移民的吸烟行为。我们将它们与中国农村和城市地区相应的非移民群体进行比较。使用控制人口统计学因素，早期生活状况，社会经济因素以及与移民有关的因素的模型，我们研究了开始吸烟和戒烟的决定。此外，我们还在分析中介绍了迁移前的选择。

结果：结果显示，与农村非移民相比，农村到城市的移民不太可能开始吸烟，但他们更可能戒烟。尽管与城市非移民相比，城市到城市的移民更有可能开始吸烟，但我们在完整模型中包括的因素可以解释这种影响。但是，城市到城市的移民戒烟的可能性较小。此外，与非移民群体相比，农村返乡移民和城市返乡移民似乎更可能开始吸烟，而戒烟的可能性较小。

frontiers in Public Health

ORIGINAL RESEARCH
published: 23 November 2018
doi: 10.3389/fpubh.2018.00346

Migration Status and Smoking Behaviors in Later-Life in China—Evidence From the China Health and Retirement Longitudinal Study (CHARLS)

Bo Hou[1]*, *James Nazroo*[2,3,4], *James Banks*[5,6] and *Alan Marshall*[7]

[1] National School of Development, Peking University, Beijing, China, [2] Sociology, School of Social Sciences, The University of Manchester, Manchester, United Kingdom, [3] Manchester Institute for Collaborative Research on Ageing, School of Social Sciences, The University of Manchester, Manchester, United Kingdom, [4] Cathie Marsh Institute for Social Research, School of Social Sciences, The University of Manchester, Manchester, United Kingdom, [5] Economics, School of Social Sciences, The University of Manchester, Manchester, United Kingdom, [6] The Institute for Fiscal Studies, London, United Kingdom, [7] School of Social and Political Science, University of Edinburgh, Edinburgh, United Kingdom

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Anna Chapman,
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University of Turku, Finland

***Correspondence:**
Bo Hou
bo.hou.07@gmail.com

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

Received: 14 August 2018
Accepted: 07 November 2018
Published: 23 November 2018

Citation:
Hou B, Nazroo J, Banks J and Marshall A (2018) Migration Status and Smoking Behaviors in Later-Life in China—Evidence From the China Health and Retirement Longitudinal Study (CHARLS). Front. Public Health 6:346. doi: 10.3389/fpubh.2018.00346

Background: China is the biggest consumer of tobacco in the world, with a high prevalence of smoking especially among men. Along with the rapid demographic change in China, the burden of diseases attributable to health behaviors, particularly smoking is steadily increasing. So, smoking has become a major risk factor for mortality in China. Smoking behaviors may be related to migration processes, as a result of both who migrates and post-migration experiences related to socioeconomic position, stress and acculturation. Existing studies that have examined smoking and migration in China have, however, only focused on temporary rural-to-urban migrants and focused on relatively younger migrants. This paper examines the association between smoking behaviors and a comprehensive assessment of migration status in later-life in China.

Methods: Using the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative dataset, this paper studies smoking behaviors of rural-to-urban migrants, urban-to-urban migrants, rural return migrants, and urban return migrants. We compare them with corresponding non-migrant groups in both rural and urban locations in China. Using a model that controls for demographic factors, early-life circumstances, socioeconomic factors, and factors related to migration, we examine both the decision to start smoking and the decision to quit smoking. In addition, we also address pre-migration selection in our analyses.

Results: The results show rural-to-urban migrants are no more likely to start smoking compared with rural non-migrants, but they are more likely to quit smoking. While urban-to-urban migrants are more likely to start smoking compared with urban non-migrants, this effect is explained by the factors we include in the full model. Urban-to-urban migrants are, however, less likely to quit smoking. Moreover, both rural return migrants and urban return migrants seem to be more likely to start smoking and less likely to quit smoking compared with non-migrant groups.

Conclusion: There are strong associations between migration status and later-life smoking behaviors in China; these associations vary greatly according to different migration status and point to populations and factors that public health activities should focus on.

Keywords: smoking behaviors, smoking cessation, internal migration, return migration, rural-to-urban migration, China

INTRODUCTION

It is estimated that there were over 300 million current smokers in China in 2010, making China the biggest consumer of tobacco in the world (1). Studies on tobacco use in China have found a high prevalence of smoking among men and a low prevalence among women (2, 3). According to a recent survey, 53% of Chinese men, and 2% of the women, and 28% of the total population smoke tobacco products (1). Smoking is a major risk factor for mortality in China (4, 5) and for many chronic diseases, such as stroke (6, 7). Treatment of smoking related diseases in China makes up about 6% of total medical expenditure (8). Therefore, smoking is a particularly important public health issue in China.

The urban population in China grew by 440 million from 1978 to 2011, with rural-to-urban migration accounting for roughly half of this growth, and the other half of this growth due to urban expansion into rural areas (9). This trend is projected to grow further under the current government policy (10). Smoking may relate to migration processes as a result of selection processes occurring before migration and of post-migration circumstances in a more westernized urban environment. Studies have shown that migration is selective in terms of health and levels of education in many countries (11–13). Migration processes may also be selective of particular types of personalities (14), thus it may be related to risky health behaviors, such as smoking (15, 16). In China, rural-to-urban migrants often have better socioeconomic status compared with rural natives and worse socioeconomic status compared with urban natives (17). It is common that these migrants work in jobs such as manufacturing and construction; they often have lower incomes, no social benefits, work very long hours and have very basic living standards (14). Studies have shown that material and cultural disadvantages, and stress, are positively associated with smoking (18–21). As a result of these disadvantages, migrants might have worse smoking behaviors. In addition, features of migration, such as the length of migration are also associated with smoking (19, 20). This might be linked to acculturation after migration.

Few studies have examined smoking cessation in the context of migration. Those that have explored the reasons given by migrants to stop smoking, and have given typical responses such as: prevent future illness, current illness, family pressures and financial considerations (8, 22). Given the range of factors related to smoking among migrants, described above, it is valuable from a public health perspective to also study factors related to smoking cessation.

Also, few studies have looked at smoking behaviors among different types of migrants in China, and those that have provided inconclusive results. Some studies find that rural-to-urban migrants have higher smoking rates (19, 23). While other studies find lower smoking rates among rural-to-urban migrants (16, 20, 22). For instance, using a cross-sectional sample from Beijing, Chen et al. find a similar smoking prevalence for male rural-to-urban migrants compared with their non-migrant counterparts, but a much higher smoking prevalence for female migrants (19). Whereas, Mou et al. report a lower smoking prevalence for migrant workers in Shenzhen compared with national rates and they go on to argue this difference may partly be due to the healthy migrant effect (16).

In addition, return migration is also an integral part of migration processes, many migrants return to the area that they originated from Wang and Fan (24), Zhao et al. (25), and Koser (26). The factors that can influence the migrants' decision to return or move closer to home include: poor health, difficulties in finding jobs, constraints in affording and utilizing health care services in their new locations, and various sources of work-related stress (17, 24, 27). Return migration may also be selective in relation to health, sometimes referred to as salmon bias (28), a hypothesis developed in the US context that states that unhealthy immigrants living in the US tend to return home to die. Return migration may also relate to smoking behaviors (15), because of factors related to the causes of returning.

In this paper, we investigate smoking behaviors and their associations with different types of migration processes in China, examining both the decision to smoke and the decision to stop smoking. In addition, to more thoroughly explore the association with migration, rather than just studying rural-to-urban migrants, we also look at urban-to-urban migrants, rural return migrants and urban return migrants in China. In order to study these processes, we focus on those aged 45 or older, who consequently have more complete histories of migration and of starting and quitting smoking.

METHODS

This paper uses the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative, multi-disciplinary and public dataset that aims to capture the health and well-being of the Chinese population aged 45 and over (29). The CHARLS contains detailed information of respondents' social, economic, and health conditions. Further details on the sample are provided elsewhere (30). This paper uses the CHARLS national baseline survey which was conducted between June 2011 and March 2012. The national baseline survey comprises information on about 17,000 individuals and 10,000 households. Our reasons for choosing the CHARLS baseline survey are: first, the CHARLS

sample of older adults contains sufficient people who have been through different types of migration processes, which younger cohorts may not have; second, it includes detailed information on individuals' socioeconomic circumstances and health including early-life circumstances.

Classifying migrants is problematic, this is due to the definition of migrants not being standardized and sometimes unclear; for example, economic migrants can at the same time be illegal migrants and refugees (26). In migration studies in China, a migrant is typically defined as: someone who comes from rural areas and works in an urban area, this person does not have an urban Hukou, and this person is an adult and not a student; for an example, see (31). The Hukou system is a unique feature of migration in China that is loosely similar to an internal passport system, which restricts people's mobility and is linked to access to local welfare and resources (32, 33). There are two types of Hukou, an agricultural type and a non-agricultural type; this classification is based on the rural/urban classification of a person's birthplace. Clearly, these definitions only apply to one type of migration in China, the temporary rural-to-urban migration, i.e., rural-to-urban migrants who have a rural Hukou.

To study wider migration processes in China, this paper classifies migrants according to geographical mobility, with distinctions drawn between movements between and within rural and urban communities in China. This is because of existing inequalities between rural and urban areas in China, and migration is partially driven by inequality in development (26, 34) In particular, we classify the sample into six types: rural non-migrants, urban non-migrants, rural-to-urban migrants, urban-to-urban migrants, rural return migrants, and urban return migrants. The CHARLS uses the classification of an urban area from the National Bureau of Statistics in China, which states a community is urban if it is located in a city, suburb of a city, a town, or other special areas, where non-farming employment constitutes at least 70% of the work force.

The respondents in CHARLS were asked "where were you born?" The answer to this question has five options to choose from, "this village," "neighborhood in this county or city," "another county or city in this province," "another province," and "abroad." Using this information, a migrant here is defined as a person whose current place of residence is different from his or her birthplace and not in the surrounding town or city of her birthplace. According to the rural/urban classification of migrants' birthplaces, current places of residences and their Hukou information. Migrants can be further divided into rural-to-urban migrants with a rural Hukou and urban-to-urban migrants. Moreover, for those whose current places of residence are the same or in the neighborhood of their birthplaces, they were asked "Have you ever lived outside this county or city for more than 6 months?" Based on this, return migrants are defined as people who have been outside of their birthplace for more than 6 months, but they were living at their birthplace when they were interviewed. Thus, this definition also includes historical return migrants. Unfortunately, however, the data is not detailed enough to be able to build in information about how many times they have left for more than 6 months. Non-migrants are defined as people whose current places of residence are the same or in the neighborhood of their birthplaces, and they have never had any migration experience that is longer than 6 months. In addition, using information on the timing of the initial migration, we exclude migrants and return migrants who migrated in their childhood, because our focus is on adult migration effects.

We use the question "have you ever chewed tobacco, smoked a pipe, smoked self-rolled cigarettes, or smoked cigarettes/cigars?" to identify those who have ever smoked. This question further defines smoking as having smoked at least 100 cigarettes or equivalent in a respondent's lifetime. To cover the decision to quit smoking the questionnaire includes the question "do you still have the habit or have you totally quit?" These behaviors are modeled in two stages: in the first stage, we examine predictors of starting smoking for everyone; the second stage examines predictors of quitting smoking for those who have ever smoked. These outcome variables are binary and were modeled using logistic regressions.

In the empirical model, we control for factors related to demography, early-life selection, current socioeconomic circumstances, and migration. Demographic factors include age, gender and marital status. Early-life factors include lower leg length (knee height), education and first job. The relationship between educational attainments and smoking is debated. Generally, there is a negative relationship between smoking rates and levels of education; but evidence also shows that smoking rates for people with relatively high levels of education could also be high (2, 8) This might be because smoking symbolizes greater social status in China (16). As migrants' smoking behaviors may relate to the healthy migrant effect, we also account for factors related to the selective features of migration. We deal with the selection of migrants and the selection of returnee's initial migration by controlling for pre-migration markers of health and economic selection, e.g., lower leg length, a proxy for youth health, and childhood socioeconomic circumstances (35). For socioeconomic factors, this model includes measures of current job status, annualized expenditure, households' consumer durables and house ownership. Factors related to migration processes are the time since migration to the place of destination and participation in local social activities post-migration. Participation in local social activity is an indicator for levels of acculturation at the place of destination as it may capture some level of social integration and the presence of a social network (36). For models of stopping smoking, we also additionally include current self-reported health status, as poor health may be a predictor of quitting smoking (8).

This paper uses a progression of regressions to analyse the relationship between smoking behaviors and migration status in China, adding in each cluster of factors sequentially into the empirical model. As there are many different migrant statuses, and there is an existing inequality between the rural and urban China (34), our models are stratified according to rural and urban for clarity. Effectively, the different migrant groups will be operated as two treatment variables: one includes rural groups (rural non-migrants, rural-to-urban migrants, and rural return migrants) and the other includes urban groups (urban non-migrants, urban-to-urban migrants and urban return migrants). To provide information on differences in

smoking behaviors between rural and urban non-migrants, we also run the same models on these two groups. These results are presented in the **Supplementary Material**. To account for potential heteroscedasticity, robust standard errors are used in all regressions. Sampling weights were incorporated into these analyses. Analyses were conducted using STATA 14 (StataCorp, College Station, TX, USA). Full results are in the **Supplementary Material**. In addition, we have truncated the sample at 80; about 3% of the CHARLS sample is over this age.

RESULTS

Selection

Table 1 shows the distribution of variables in this empirical model stratified by migration status. This table shows that the majority of return migrants are male, i.e., 75%. There are slightly more females in both migrant groups compared with the non-migrant groups. In terms of the objective measure for youth nutrition, return migrants have higher lower leg length compared with both the migrant and non-migrant groups. Migrants to urban areas have higher lower leg length compared with the urban non-migrant group. For instance, the mean of lower leg length for urban return migrants is 48.85 cm, while it is 48.68 cm for urban-to-urban migrants and is 48.33 cm for urban non-migrants. This figure for rural-to-urban migrants is 47.72, 47.75 cm for rural non-migrants and is 48.93 cm for rural return migrants. Moreover, return migrants seem to have better education than non-migrants, but they have worse education compared with migrants, except for rural-to-urban migrants with a rural Hukou. For instance, 17.6% of rural return migrants have no formal education, which compares with 36.45% of rural non-migrants, and 24.5% of rural-to-urban migrants.

Current Socioeconomic Circumstances

Table 1 also shows that migrants have much higher values of household durable wealth compared with the other two groups. Return migrants have similar household durable wealth compared with non-migrant groups. For example, the average of household durables wealth is 11,460 yuan for urban non-migrants, 11,970 yuan for urban return migrants and 22,740 yuan for urban-to-urban migrants. For annualized spending on things other than food, return migrants have higher spending compared with non-migrant groups, but lower spending compared with migrant groups. The annualized non-food expenditure for rural non-migrants is 13,270 yuan, 15,330 yuan for rural return migrants, and 24,520 yuan for rural-to-urban migrants.

Features Related to Migration

For the variables related to features of migration, the average length of migration is 22.84 years for rural-to-urban migrants and 6.31 years for rural return migrants. For urban groups it is 31.65 years for urban-to-urban migrants and 8.02 years for urban return migrants. For current social activities, return migrants seem to be more socially active compared with their non-migrant and migrant counterparts.

Self-rated Health Status

Migrants report the best scores of self-reported health status. Rural return migrants have slightly better self-reported health compared with rural non-migrants. But urban return migrants have slightly worse self-reported health status compared with urban non-migrants. For instance, 27.24% of rural-to-urban migrants reported poor and very poor health status, compared with 29.63% of rural return migrants and 34.66% of rural non-migrants. In the urban area, 21.31% of urban non-migrants reported poor and very poor health status, compared with 16.43% of urban-to-urban migrants and 21.91% of urban return migrants.

Association Between Smoking Behaviors and Migration Status

From **Table 1**, 40% of rural non-migrants have smoked, while 34% of urban migrants have smoked. compared with migrants, return migrants have the greatest proportion of people that have ever smoked and migrants have the lowest proportion of people who have ever smoked. For instance, 63% of rural return migrants have smoked, compared with 40% of rural non-migrants, and 33% of rural-to-urban migrants. In urban areas, 58% of urban return migrants have ever smoked before, the figures for urban-to-urban migrants and urban non-migrants are 28 and 34%, respectively. In terms of quitting smoking, compared with non-migrant groups, migrant groups have the highest proportion of people that have stopped smoking and return migrants have the lowest proportion of people that have stopped smoking. In rural areas, 28% of rural-to-urban migrants who have ever smoked have stopped, compared with 19% of rural non-migrants, and 18% rural return migrants. In urban areas, 33% of ever smokers in urban to urban migrant group have stopped smoking, compared with 24% of urban non-migrants and 23% of urban return migrants.

Table 2 presents models for ever smoking for those from rural areas. This shows that there are no statistically significant differences between rural-to-urban migrants and rural non-migrants across all models. Rural return migrants seem to be more likely to start smoking compared with rural non-migrants. Although this difference is explained after adjusting for sex, it becomes statistically significant again after adjusting for differences in current socioeconomic factors. But this difference is explained in the final model after adjusting for factors related to migration. The odds ratio for rural return migrants is 2.654 ($p < 0.001$) after adjusting for age. It reduces dramatically and becomes 1.207 ($p > 0.05$) after controlling for sex. This is because the majority of returnees are men and smoking is more common among men (almost 90% of smokers are men). This odds ratio changes slightly to 1.22 ($p > 0.05$) after adjusting for early-life selective factors. But after adjusting for current socioeconomic factors this odds ratio becomes 1.246 ($p < 0.05$) in model 4. In the final model which additionally accounts for factors related to migration and levels of social activity, the odds ratio for this group is 1.098 ($p > 0.05$).

Findings for the urban groups are shown in **Table 3**. Urban return migrants are more likely to start smoking compared with

TABLE 1 | Variable distribution and migration status.

Variables list	Rural non-migrants	Rural-to-urban	Rural Return migrants	Urban non-migrants	Urban to urban	Urban return migrants	Sample Sizes
Decision to smoke (%)	40%	33%	63%	34%	28%	58%	12,736
Decision to stop smoking (%)	19%	28%	18%	24%	33%	23%	5,301
Age	58.56	56.76	57.29	57.11	62.75	58.15	12,806
Male (%)	47%	34%	78%	46%	40%	75%	12,818
MARITAL STATUS (%)							
Married with spouse present	80%	77%	71%	84%	79%	80%	10,212
Married not living with spouse temporarily	6%	10%	18%	4%	2%	11%	937
Separated, divorced, widowed and	14%	13%	11%	12%	19%	9%	1,673
NEVER MARRIED							
Knee height	47.75	47.72	48.93	48.33	48.69	48.85	9,847
EDUCATION (%)							
No formal education	36%	25%	18%	10%	7%	7%	3,558
Primary education	41%	45%	47%	27%	21%	35%	4,937
Secondary education	22%	29%	34%	49%	44%	41%	3,696
Tertiary education	1%	2%	2%	14%	28%	17%	615
FIRST JOB (%)							
Government	1%	1%	2%	5%	9%	8%	240
Institutions	2%	2%	3%	15%	23%	11%	595
State firms	1%	3%	5%	42%	48%	25%	1,192
Individual firms	1%	6%	2%	4%	2%	3%	245
Farmers	92%	85%	82%	28%	11%	44%	8,790
Other occupations	2%	3%	5%	5%	7%	8%	432
CURRENT JOB STATUS							
Agricultural work	71%	27%	65%	8%	1%	28%	7,027
Wage work	6%	29%	16%	35%	19%	30%	1,732
Retired and receive a public pension	5%	6%	4%	27%	50%	20%	1,242
Retired and receive no pension	12%	20%	6%	13%	15%	9%	1,449
Not working	7%	18%	8%	18%	16%	13%	1,209
Annualized expenditure on food	7.38	10.98	7.78	12.01	15.41	11.53	12,084
Annualized expenditure on other things	13.27	24.52	15.33	21.8	28.97	23.52	12,623
Household durables wealth	6.47	10.74	6.41	11.46	22.74	11.97	12,811
HOUSE OWNERSHIP							
None	8%	33%	9%	12%	17%	10%	1,202
Partially	5%	2%	7%	2%	7%	3%	584
Fully	87%	65%	85%	85%	77%	87%	10,837
Length of migration	0	22.84	6.31	0	31.65	8.02	12,729
SOCIAL ACTIVITY							
None	55%	57%	48%	43%	37%	39%	5,811
One type	35%	32%	33%	35%	36%	37%	3,925
Two types	10%	9%	18%	17%	18%	19%	1,365
Three types	0%	1%	1%	5%	9%	5%	190
HEALTH STATUS							
Excellent and very good	6%	12%	8%	9%	11%	9%	940
Good	15%	17%	15%	19%	20%	18%	2,030
Fair	44%	43%	47%	51%	53%	52%	5,861
Poor	31%	25%	28%	19%	15%	20%	3,567
Very poor	3%	2%	2%	2%	1%	2%	353
Sample sizes for migrant groups	8,220	349	1,234	2,052	285	685	12,825

TABLE 2 | Decision to smoke logistic regressions (rural base).

Model specifications	1 +Age	2 +Sex	3 +Early-life	4 +Socioeconomic	5 Full
Rural non-migrants					
Rural-to-urban migrants	0.796	1.048	1.052	1.181	0.869
	(0.412–1.538)	(0.456–2.410)	(0.477–2.320)	(0.620–2.250)	(0.361–2.091)
Rural return migrants	2.654***	1.207	1.220	1.246*	1.098
	(2.249–3.132)	(0.981–1.485)	(0.986–1.510)	(1.005–1.545)	(0.856–1.409)
N	6,935	6,935	6,935	6,935	6,935
Pseudo R-sq	0.0224	0.3938	0.3968	0.3999	0.4006

*Odds ratios in the table *p < 0.05, **p < 0.01, ***p < 0.001. Ninety-five percent confidence intervals in parentheses, calculated based on robust standard errors.*

urban non-migrants. The odds ratio for this group is 1.699 ($p < 0.01$) after adjusting for age and sex in model 2. Then it largely stays around this level in later models. This odds ratio is 1.7 ($p < 0.01$) after adjusting for early-life factors, is 1.714 ($p < 0.01$) after controlling for socioeconomic factors and is 1.79 ($p < 0.01$) after adjusting for factors related to migration in the final model. For urban-to-urban migrants, there is a statistically significant increased risk of ever smoking after adjusting for age and sex. Adjusting for early-life and socioeconomic factors attenuates this relationship slightly. But this difference is explained after adjusting for factors related to migration in the final model. For instance, the odds ratio for this group is 1.479 ($p > 0.05$) after adjusting for age. It becomes 1.875 ($p < 0.05$) after adjusting for differences in sex. It is 2.216 ($p < 0.05$) after adjusting for early-life factors in model 3 and is 1.927 ($p < 0.05$) after controlling for differences in socioeconomic factors. Finally, it is 2.366 ($p > 0.05$) after controlling for factors related to migration in the final model. In addition, from **Table S5**, the results show that urban non-migrants are less likely to start smoking compared with rural non-migrants. For instance, the odds ratio for urban non-migrants is 0.597 ($p < 0.001$) after controlling for age and sex. It becomes 0.701 ($p < 0.05$) after controlling for early-life and socioeconomic factors and is 0.697 ($p < 0.05$) in the full model.

Table 4 shows that rural-to-urban migrants are more likely to quit smoking compared with the rural non-migrants. The odds ratio for this group is 6.481 ($p < 0.001$) after controlling for age and sex in model two. Adjusting for early-life factors slightly attenuates this to 5.901 ($p < 0.001$). This odds ratio becomes 3.832 ($p < 0.01$) after controlling for current socioeconomic factors and it is 7.1 ($p < 0.001$) after additionally adjusting for factors related to migration and current health status. In terms of rural return migrants, the results show that there are no statistically significant differences between rural return migrants and rural non-migrants.

Table 5 shows the results for quitting smoking for urban areas. Compared with urban non-migrants, urban-to-urban migrants are less likely to stop smoking. The odds ratio for this group is 0.379 ($p < 0.05$) after adjust for age and sex in model two. It is 0.341 ($p < 0.05$) after additionally adjusting for early-life factors, is 0.361 ($p < 0.05$) after controlling for current socioeconomic factors, and is 0.314 ($p < 0.05$) in the final model after accounting for factors related to migration and current health status. Similar to the results of rural return migrants in **Table 4**, there are no statistically significant differences in decisions to quit smoking between urban return migrants and urban non-migrants. Additionally, from **Table S6**, the results show that urban non-migrants are more likely to stop smoking compared with rural non-migrants after adjusting for differences in age and sex. But this difference is explained by controlling for early-life factors, such as youth nutrition. For instance, the odds ratio for urban non-migrants is 1.452 ($p < 0.05$) after controlling for age and sex. It becomes 1.293 ($p > 0.05$) after controlling for early-life factors and is 1.101 ($p > 0.05$) in the full model.

For the control variables in tables of starting to smoke, social activities, a measure of levels of social integration, shows a statistically significant and positive relationship with the decision to start smoking in urban areas. But this does not hold in the rural sample. Forty-seven percent of smokers in the rural sample participated in at least one type of social activity, this compares to 62% of smokers in the urban sample. This may suggest that social activities in urban arears have a stronger association with smoking initiation (37). Compared with having no formal education, having a tertiary education shows statistically significant and negative relationship with the decision to start smoking, but having a primary or a secondary education shows no significant relationship. That rural-to-urban migrants are more likely to quit smoking may be related to financial considerations. Compared with rural non-migrants in **Table 1**, almost double the proportion of rural-to-urban migrants are retired and receive no pension and are in non-working groups. This may also be related to their agricultural hukou status, which limits their access to local welfare and resources. The results from **Table S3** shows smoking cessation is strongly associated with being in these two groups compared with doing agriculture work. For the control variables in tables of quitting smoking, length of migration shows a negative relationship with the decision to stop smoking in rural sample, with an odds ratio of 0.967 ($p < 0.05$). But this is not present in urban sample. Moreover, there is a statistically significant and negative relationship between the decision to stop smoking and current self-reported health status. This is true for both rural and urban samples. This may partly explain why urban-to-urban migrants are less likely to quit smoking as they have better self-reported health, for instance 15% of urban migrants reported poor health

TABLE 3 | Decision to smoke logistic regressions (urban base).

Model specifications	1 +Age	2 +Sex	3 +Early-life	4 +Socioeconomic	5 Full
Urban non-migrants					
Urban-to-urban migrants	1.479	1.875*	2.216*	1.927*	2.366
	(0.685–3.191)	(1.007–3.489)	(1.199–4.096)	(1.117–3.325)	(0.956–5.851)
Urban return migrants	3.401***	1.699**	1.700**	1.714**	1.790**
	(2.594–4.459)	(1.217–2.373)	(1.202–2.404)	(1.203–2.442)	(1.202–2.666)
N	1,713	1,713	1,713	1,713	1,713
pseudo R-sq	0.0555	0.3588	0.3728	0.3814	0.3958

*Odds ratios in the table *p < 0.05, **p < 0.01, ***p < 0.001. Ninety-five percent confidence intervals in parentheses, calculated based on robust standard errors.*

TABLE 4 | Decision to stop smoking logistic regressions (rural base).

Model specifications	1 +Age	2 +Sex	3 +Early life	4 +Socioeconomic	5 Full
Rural non-migrants					
Rural-to-urban migrants	6.486***	6.481***	5.901***	3.832**	7.100***
	(2.461–17.092)	(2.449–17.152)	(2.264–15.379)	(1.682–8.727)	(2.464–20.459)
Rural return migrants	0.962	0.963	0.979	1.007	1.257
	(0.744–1.243)	(0.744–1.247)	(0.753–1.272)	(0.772–1.314)	(0.932–1.696)
N	2,963	2,963	2,963	2,963	2,963
pseudo R-sq	0.037	0.037	0.0449	0.0609	0.0766

*Odds ratios in the table *p < 0.05, **p < 0.01, ***p < 0.001. Ninety-five percent confidence intervals in parentheses, calculated based on robust standard errors.*

compared to 19% of urban non-migrants. These results are shown in full in the **Supplementary Material**.

DISCUSSION

Previous studies on smoking behaviors and migration in China have largely looked at one type of migration, rural-to-urban migration; and the results are inconclusive. This may partly be due to heterogeneity among migrants (38). This paper investigates the relationship between smoking behaviors and a fuller range of types of migration in China, covering rural to urban migration, but also migration within rural and urban areas and including return migration. We have also examined both the decision to smoke and the decision to quit smoking. To do this, we use a nationally representative dataset, the CHARLS, and an empirical model informed by the literature. This paper also addresses the selective features of migration, by excluding early-life migrants and adding measures of early-life nutrition and socioeconomic position into the analyses.

Our results show that there is a strong association between smoking behaviors and migration status in later-life in China. Compared with non-migrants, migrants who have returned to their place of origin have the greatest proportion of people who have ever smoked and have the lowest proportion of ever smokers who have stopped smoking. Migrants who have not returned have the lowest proportion of people who have ever smoked and have the highest proportion of people who have stopped smoking, except for urban-to-urban migrants. We also find smoking is more prevalent in rural areas in China compared to urban areas. Urban non-migrants are less likely to start smoking compared to rural non-migrants, and they are more likely to stop smoking partly due to early-life factors. Different types of migration processes are associated with smoking behaviors differently. First, there are no statistically significant differences between rural-to-urban migrants and rural non-migrants to have ever smoked across all our models. However, rural-to-urban migrants are more likely to quit smoking compared with the rural non-migrants. Second, urban-to-urban migrants are more likely to smoke than urban non-migrants. But this difference is explained after adjusting for factors related to migration, particularly social activities, a measure reflecting levels of social integration. Moreover, urban-to-urban migrants are less likely to stop smoking compared with urban non-migrants. Third, rural return migrants seem to be more likely to start smoking compared with rural non-migrants. Although this difference is explained after adjusting for gender, it becomes statistically significant again after adjusting for differences in current socioeconomic factors. But this difference is explained in the final model after adjusting for factors related to migration. In urban areas, urban return migrants are more likely to start smoking compared with urban non-migrants. Furthermore, there are no statistically significant differences in terms of the decision to quit smoking between return migrants from both rural and urban locations and non-migrants in rural and urban areas, respectively. Note that these return migrants are people

TABLE 5 | Decision to stop smoking logistic regressions (urban base).

Model specifications	1 +Age	2 +Sex	3 +Early life	4 +Socioeconomic	5 Full
Urban non-migrants					
Urban-to-urban migrants	0.379*	0.379*	0.341*	0.361*	0.314*
	(0.161–0.893)	(0.161–0.891)	(0.139–0.837)	(0.150–0.868)	(0.103–0.957)
Urban return migrants	0.877	0.888	0.916	0.894	0.889
	(0.571–1.348)	(0.574–1.372)	(0.597–1.407)	(0.569–1.405)	(0.528–1.497)
N	676	676	676	676	676
pseudo R-sq	0.0421	0.0423	0.0671	0.0965	0.125

*Odds ratios in the table *p < 0.05, **p < 0.01, ***p < 0.001. Ninety-five percent confidence intervals in parentheses, calculated based on robust standard errors.*

who had a migration experience, thus this may suggest that return migration may have lasting effects on smoking behaviors after migration in adult life, as having experienced an episode of migration is negatively associated with smoking behaviors. The exact mechanism may be associated with reasons for returning, such as poor health (15). In addition, our results also find that poorer current health strongly predicts quitting smoking.

There are important limitations to this study. The data are collected cross-sectionally and causal inferences cannot be straightforwardly drawn from these results, although we have controlled for some self-selective features of migration. In addition, because of limitations in the coverage of the data, the timing of initial migration for returnees may contain some errors, thus we may have overestimated the length of migration for return migrants.

These findings contribute to the literature by examining the relationship between smoking behaviors and a fuller range of migration status in China. Rather than looking at migrants and non-migrants, we have separately examined migrants according to their place of origin, and have also identified those migrants who have returned to their places of origin. As return migrants seem to have worse smoking behaviors than non-migrants, neglecting this group of people may cause bias in attempts to explore the association between migration and smoking behaviors. A fruitful topic for future research is to look into the mechanisms through which return migration affects smoking behaviors. Also, our findings contribute to the literature by looking at the older population in China. Rapid demographic and epidemiological changes in China have taken place over the last several decades, the burden of diseases related to health behaviors is steadily increasing and smoking has become a major risk factor for ill-health and disability (39). The benefits of smoking cessation are significant and often underestimated, stopping smoking even at middle age can substantially reduce the risk of smoking-related death (40). Strengthening government policies for smoking prevention and cessation is required in China to decrease smoking-related morbidity and mortality. Given the size of internal migration and its projected future trend in China, national policies that target the returned migrant population may be particularly effective in terms of smoking prevention and cessation.

AUTHOR CONTRIBUTIONS

BH conducted the analyses and wrote the manuscript. JN, JB, and AM guided the data analysis procedures and reviewed the manuscript. All authors approved the final version of the manuscript.

ACKNOWLEDGMENTS

We thank colleagues at Social Statistics, the University of Manchester for useful comments. BH thanks the China Postdoctoral Exchange Fellowship Program for financial support.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2018.00346/full#supplementary-material

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Conflict of Interest Statement: 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.

Gildner TE, Ng N, Wu F, Guo Y, Snodgrass JJ and Kowal P (2018) Ideal Cardiovascular Health and Cognitive Test Performance: Testing a Modified Index of Life's Simple 7 Among Older Chinese Adults. Front. Public Health 6:352. doi: 10.3389/fpubh.2018.00352

Abstract

有证据表明，老年人的认知能力下降受心血管健康（CVH）的影响，其代谢和血管机制被认为是认知障碍病因的基础。高收入国家的研究表明，改善CVH与降低认知障碍风险有关，但尚不清楚这种模式在低收入国家是否明显。在中国收集的具有全国代表性的数据摘自世界卫生组织（World Health Organization）的关于全球老年与成人健康第一轮研究（2007–2010； n = 11,295）。七个CVH因素被归类为"理想"或"不理想"：吸烟和饮酒的频率，体重指数，身体活动运动水平，血压，饮食和自我报告的焦虑。此外，还使用了五项认知能力测验（即时和延迟的语言回忆，前向和后向数字跨度，语言流利度）的得分来创建复合的认知功能变量。线性回归分析测试了理想的CVH量度是否与较高的综合认知表现相关联，并控制了社会人口统计学因素。如假设的那样，理想的CVH通常与较高的认知能力有关。较低的焦虑水平和可靠地获得充足的食物（包括农产品）尤其与较高的认知功能有关。这些结果表明，尽早发现和控制可改变的CVH风险可以保护中国的老龄化人群免受认知能力下降的影响。

frontiers in Public Health

ORIGINAL RESEARCH
published: 28 November 2018
doi: 10.3389/fpubh.2018.00352

Ideal Cardiovascular Health and Cognitive Test Performance: Testing a Modified Index of Life's Simple 7 Among Older Chinese Adults

Theresa E. Gildner[1], *Nawi Ng*[2,3], *Fan Wu*[4], *Yanfei Guo*[4], *J. Josh Snodgrass*[1] *and Paul Kowal*[1,5,6,7*]

[1] Department of Anthropology, Dartmouth College, Hanover, NH, United States, [2] Unit of Epidemiology and Global Health, Department of Public Health and Clinical Medicine, Umeå University, Umeå, Sweden, [3] Centre for Demographic and Ageing Research, Faculty of Social Sciences, Umeå University, Umeå, Sweden, [4] Shanghai Municipal Center for Disease Control and Prevention, Shanghai, China, [5] World Health Organization SAGE, Geneva, Switzerland, [6] Priority Research Centre for Generational Health and Ageing, University of Newcastle, Newcastle, NSW, Australia, [7] Research Institute for Health Sciences, Chiang Mai University, Chiang Mai, Thailand

Evidence suggests that cognitive decline in older adults is influenced by cardiovascular health (CVH), with metabolic and vascular mechanisms hypothesized to underlie the etiology of cognitive impairment. Research in high-income nations suggests that improved CVH is linked with decreased cognitive impairment risk, but it is unclear if this pattern is evident in low-income countries. Nationally-representative data collected in China were drawn from the World Health Organization's Study on global AGing and adult health Wave 1 (2007–2010; $n = 11{,}295$). Seven CVH factors were classified as "ideal" or "not ideal": smoking and drinking frequency, body mass index, physical activity level, blood pressure, diet, and self-reported anxiety. Additionally, scores from five cognitive performance tests (immediate and delayed verbal recall, forward and backward digit span, verbal fluency) were used to create a composite cognitive function variable. Linear regression analyses tested whether ideal CVH measures were associated with higher composite cognitive performance, controlling for sociodemographic factors. As hypothesized, ideal CVH was generally associated with higher cognitive performance. Low anxiety levels and reliable access to sufficient food (including produce) were particularly associated with higher cognitive function. These results suggest early detection and controlling modifiable CVH risks may protect aging individuals in China from cognitive decline.

Keywords: cardiovascular disease risk factors, dementia prevention, global aging, lifestyle, heart disease

OPEN ACCESS

Edited by:
Colette Joy Browning, Australian National University, Australia

Reviewed by:
Pradeep Nair, Central University of Himachal Pradesh, India
Julie Byles, University of Newcastle, Australia

***Correspondence:**
Paul Kowal
paul.r.kowal@rihes.org

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

Received: *27 July 2018*
Accepted: *14 November 2018*
Published: *28 November 2018*

Citation:
Gildner TE, Ng N, Wu F, Guo Y, Snodgrass JJ and Kowal P (2018) Ideal Cardiovascular Health and Cognitive Test Performance: Testing a Modified Index of Life's Simple 7 Among Older Chinese Adults. Front. Public Health 6:352. doi: 10.3389/fpubh.2018.00352

INTRODUCTION

The global population is currently experiencing a rapid aging transition, largely due to increased life expectancies and decreased fertility in many countries; however, global aging and health patterns are not uniform. At the start of the Twenty-first century, the number of Chinese adults aged 60 years and older reached an estimated 130 million, roughly 10% of the total Chinese population and 21% of the world's older population (1, 2). This trend is expected to continue such that the population of older adults in China will nearly triple and comprise 25% of the national population by

2030 (2), presenting considerable opportunities and challenges for China in coming decades. To put this into context, China had more cases of Alzheimer's disease in 2010 than any other country in the world (3). Over the last three decades, the prevalence of both Alzheimer's disease and vascular dementia has significantly increased, and it appears previous work has underestimated the burden and growth of dementia in China (4).

This increased disease burden will challenge healthcare systems to reform as they seek to meet the demands of patients and their caregivers in the coming years. It is therefore critical to identify potential interventions to promote healthy aging and reduce both the economic and social costs of dementia. Evidence suggests that improving cardiovascular health (CVH) among older adults represents one such prevention strategy. Factors associated with poor vascular health (such as smoking, obesity, low physical activity levels) are associated with cognitive aging (5, 6). Specifically, vascular and metabolic mechanisms may underlie the etiology of cognitive impairment, and poor vascular and metabolic health likely contribute to cognitive deficit at older ages (7). Models linking poor vascular/metabolic health to cognitive performance indicate that potential pathways between poor CVH and cognitive deficit include metabolic imbalance, altered distribution of cerebral blood flow, nerve demyelination, and microinfarction (8). Several factors that impair vascular and metabolic health have also been linked with increased dementia risk in older adults: smokers experience a significantly more pronounced decline in cognitive function, flexibility, and speed (9); high alcohol consumption has been associated with poorer neurological function (10); and, overweight and obese adults display significantly lower cognitive function compared to healthy weight individuals (8, 11).

Conversely, physical activity level (PAL) appears to be related to improved neuronal plasticity and the release of hormones linked with neuronal creation and function; physical inactivity may therefore exacerbate cognitive decline (12). High blood pressure also appears to be associated with an increased risk of cognitive decline, including neural atrophy and lesions (13). Thus, hypertension may contribute to dementia risk (13). Further, poor diet (including low fruit and vegetable intake and the inability to acquire sufficient food) is linked with diminished cognitive function via impaired metabolic and vascular health, increasing subsequent risk of diabetes and coronary heart disease (14). Finally, chronic psychological stress is associated with poor cardiovascular health, potentially leading to cognitive decline (15).

Prior studies have combined several of these CVH risk factors into a panel that represents overall CVH: Life's Simple 7, a proxy measure used to test the cumulative influence of CVH on cognitive performance in older persons (6). Previous findings support the hypothesis that individuals with healthier CVH measures are more resistant to impaired cognitive processing speed, executive function, and episodic memory (6). However, this work has focused primarily on populations from high-income nations. It is unclear whether these patterns are also evident in lower income nations. This research is especially important given the substantial increases in older adults residing in LMICs, such as China, expected to occur in coming years (2). It is therefore necessary to determine whether interventions designed to improve cognitive performance during aging through targeting CVH factors can be expected to have the same effects in all populations.

The present study addresses this need by examining the links between CVH factors and cognitive performance in China using data from the World Health Organization Study on global AGing and adult health (SAGE) Wave 1 (16). This research clarifies how a modified panel of seven factors known to influence CVH (smoking, alcohol consumption, body mass index [BMI; calculated from individual height and weight values], PAL, blood pressure, diet, and self-reported anxiety) is linked with specific measures of cognitive performance among older Chinese individuals, while controlling for sex, age, wealth, and education level. These results will help determine whether CVH is linked with poor cognitive function in China. These findings also have potentially important clinical applications, including the identification of CVH factors most strongly linked with cognitive deficits in this population. This knowledge is required for the development of interventions designed to successfully improve CVH and subsequently reduce dementia risk. We hypothesize that the combined ideal measure score of the seven CVH factors will be positively associated with performance on a battery of cognitive function tests.

MATERIALS AND METHODS

Study Design and Participants

A nationally-representative sample of adults ≥50 years old ($n = 13{,}367$) were collected using a multistage stratified cluster sample design (16, 17). In-person interviews were used to collect household and individual level data between 2007 and 2010. Specifically, eight of China's 22 provinces were randomly selected. One county in the rural regions and one district/city in the urban regions was then selected at random from each province. Next, four townships in each selected county and four community blocks in each selected city were selected using probability proportional to size (PPS) sampling, for a total of 64 primary sampling units. Two villages/enumeration areas per township/community were then selected using PPS sampling, for a total of 128 secondary sampling units. Two residential blocks were then selected from each village/neighborhood community using random cluster sampling, for a total of 256 tertiary sampling units. Finally, 84 households were randomly selected (with a 95% response rate) from each sampled residential block using simple random sampling. Post-stratification corrections were applied to these weights to compensate for under-coverage. All analyses are carried out using these weights. At the time of data collection, China was classified as a lower middle-income nation (18).

Ethical Approval

SAGE China was approved by the Chinese Center for Disease Control and Prevention Ethical Review Committee,

and World Health Organization's Ethical Review Committee. Written informed consent was obtained from all study participants.

Measures of Cardiovascular Health

To test associations between CVH and cognitive function, seven measures associated with CVH were included in the analyses: smoking, alcohol consumption, BMI, PAL, blood pressure, diet, and self-reported anxiety. Each of these factors was classified as either "ideal" or "not ideal." This approach was largely based on criteria defined by the American Heart Association (6). First, ideal smoking was defined as never smoked (6). Second, ideal alcohol consumption was classified as do not drink daily (10). Third, ideal BMI was calculated from measured height and weight and was defined as 18.5–22.9 kg/m^2, based on the modified WHO definition of normal, healthy BMI in Asian populations (19).

Fourth, ideal PAL was defined as $\geq$ 150 min/week (6). Total PAL was calculated from interview data using questions from the Global Physical Activity Questionnaire (GPAQ) to determine self-report physical activity patterns (20). This questionnaire collects information about physical activity patterns across a range of daily activities. Participants reported the amount of time during a typical day spent in vigorous-intensity activities (those that caused large increases in breathing or heart rate) as part of their work, in moderate-intensity activities (those that caused small increases in breathing or heart rate) as part of their work, in vigorous-intensity activities during leisure time, and in moderate-intensity activities during leisure time. Self-reported time spent in vigorous or moderate exercise for both work and leisure were combined to create a composite PAL measure (min/week).

Fifth, ideal overall blood pressure was defined as exhibiting both ideal SBP ($<$ 120 mm Hg) and ideal DBP ($<$80 mm Hg) (6). Participant systolic (SBP) and diastolic blood pressure (DBP) were individually measured three times using a Boso Medistar Wrist Blood Pressure Monitor Model S. The three SBP values were averaged together to create a composite SBP measure; likewise, the three DBP values were combined to create an average DBP measure. Sixth, ideal diet was defined as typically consuming $\geq$ 5 servings of fruit or vegetables daily combined with reporting access to an adequate amount of food (6). Finally, given the negative effects of chronic anxiety on CVH (15), ideal anxiety levels were defined as reporting either no or mild anxiety, conversely not ideal anxiety was defined as reporting moderate, severe, or extreme levels of anxiety. Specifically, respondents were asked: "Overall in the last 30 days, how much of a problem did you have with worry or anxiety?" The number of ideal CVH factors was summed for each participant (range of 0–7 ideal characteristics) and this continuous variable was used as the primary predictor of interest during analysis.

Measures of Cognitive Function

Five cognitive function assessments were used to create a summary variable of cognitive performance for each individual, with higher values indicating better cognitive function. These tests included immediate and delayed verbal recall, forward and backward digit span, and verbal fluency. During the immediate verbal recall test, interviewers read a list of 10 words aloud and asked the participants to immediately recall as many words as they could in 1 min. Three trials of this assessment were performed and the average test score was calculated. The interviewer then administered other cognitive tests, after which delayed recall ability was determined by asking subjects to remember the list of words without the interviewer reading the list again. The digit span test required participants to repeat back progressively longer series of numbers; the total score was recorded as the longest digit span repeated without error. This process was then repeated, but with the respondent repeating new sets of increasingly longer digit spans in reverse. The verbal fluency test consisted of naming as many animals as possible in 1 min; the final verbal fluency score was correct responses minus errors.

Preliminary analysis indicated that these tests were moderately correlated (Pearson correlation scores ranging from 0.327 to 0.706). Thus, principal component analysis was used to develop a composite cognitive performance from the battery of tests. This analysis computed component scores and weighted the contribution of each individual test to overall cognitive performance. The composite factor score resulting from this analysis (for each participant) was used as a measure of overall cognitive function during hypothesis testing.

Participant Characteristics

Individual characteristics known to influence cognitive performance were controlled for in all analyses. Evidence suggests that sex and age influence the extent of cognitive decline in older adults (21). Socio-economic factors appear to affect cognition, such that individuals with lower education and household income levels experience an increased risk of cognitive decline during aging (21). In addition, individuals living in rural settings have been shown to exhibit a higher dementia prevalence compared to urban areas (22). Reported annual household income was combined with an index of durable goods ownership, dwelling characteristics, and access to services; this wealth variable was then classified into household income quintiles for the analyses. Reported highest attained education level was standardized using the International Standard Classification of Education (23). Individual education level was then categorized as: (1) no formal schooling; (2) less than a high school degree; or, (3) high school degree or beyond.

Statistical Analyses

All analyses were conducted using Stata version 14, results were regarded as significant at $p < 0.05$. Household and individual weights were post-stratified according to country-specific population data (17). Linear regressions were conducted to test the hypothesis and evaluate the relative contribution of the total CVH score to composite cognitive performance score, while controlling for sociodemographic factors. Additional linear regressions were run to determine the associations between individual CVH components (categorized as ideal vs. not

ideal) and composite cognitive performance. Individuals missing one or more variables were excluded from regression analysis ($n = 2{,}071$). Preliminary analysis indicated individuals missing data tended to be slightly older (mean of 62.1 years vs. 60.3 years), but otherwise there were no marked participant characteristic differences between individuals missing data and those included in the analysis. In addition, a single individual had zero CVH ideal traits, every other participant had at least one trait. This outlier disrupted the general linearity of the data and was there removed from analysis, resulting in a final sample of 11,295 participants.

RESULTS

Descriptive Statistics

Table 1 shows the characteristics of the study population (**Table 1**). The study population contained slightly more females (53.6%) than males (46.4%), but was roughly equally split between urban (50.6%) and rural (49.4%) households. Most participants had received some formal schooling, but had not earned a high school degree or the equivalent (59.0%). Over half the study participants reported ideal smoking (66.6%), drinking (92.6%), physical activity (60.5%), diet (87.1%), and anxiety levels (95.9%). Conversely, less than half of the subjects exhibited ideal BMI (38.9%) or BP (12.3%). Mean age was 63 years old and average number of combined ideal CVH measures was 4.5 ($SD = 1.0$). Cognitive test scores varied based on test type, from the wide range of scores evident on the verbal fluency test (mean of 12.74, range of 0–68) to the lower scores recorded on the backward digit span test (mean of 3.40, range of 0–8).

TABLE 1 | Description of the Chinese study population (unweighted data), SAGE Wave 1 (2007–2010), $n = 11{,}295$ individuals.[a,b].

Variables	*n* (%)
Male sex	5,242 (46.4)
Urban dwelling	5,711 (50.6)
Income quintile 1 (low)	2,196 (19.4)
Income quintile 2	2,254 (20.0)
Income quintile 3	2,283 (20.2)
Income quintile 4	2,365 (20.9)
Income quintile 5 (high)	2,197 (19.5)
No formal education	2,558 (23.6)
Less than high school	6,660 (59.0)
High school or beyond	1,967 (17.4)
Ideal smoking	7,519 (66.6)
Ideal drinking	10,457 (92.6)
Ideal BMI	4,397 (38.9)
Ideal PAL	6,828 (60.5)
Ideal BP	1,384 (12.3)
Ideal diet	9,835 (87.1)
Ideal stress	10,835 (95.9)
MEAN (RANGE)	
Age	62.9 (50 – 95)
Combined ideals score	4.5 (−3.62 – 3.56)
Immediate verbal recall	5.62 (0 – 10)
Delayed verbal recall	4.97 (0 – 10)
Forward digit span	7.03 (0 – 9)
Backward digit span	3.40 (0 – 8)
Verbal fluency	12.74 (0 – 68)

[a] *Body Mass Index (BMI), Blood Pressure (BP), Physical Activity Level (PAL)*
[b] *Ideal cardiovascular health measures:*
Ideal smoking = never smoked
Ideal drinking = do not drink daily
Ideal BMI = 18.5–22.9 kg/m^2
Ideal PAL ≥ 150 min/week
Ideal BP = ideal SBP (< 120 mm Hg) and ideal DBP (< 80 mm Hg)
Ideal diet = consuming ≥ 5 servings of fruit and/or vegetables daily combined with reporting access to an adequate amount of food
Ideal stress = reporting either no or mild anxiety.

Combined CVH Measures and Composite Cognitive Function Score

Total number of ideal CVH factors significantly contributed to variation in cognitive test results, although the association between total CVH traits and the composite cognitive score appears to be modest (**Table 2**). Still, a positive relationship was observed between number of CVH ideals and cognitive performance ($B = 0.03$, $P < 0.05$), indicating that a higher number of individual CVH traits corresponded to higher overall cognitive performance.

Individual CVH Measures and Composite Cognitive Function Score

Interestingly, regressions examining the individual contributions of ideal smoking, drinking, BMI, PAL, and BP to composite cognitive performance variation were not significantly related to the composite cognitive test scores (**Table 3**). Only ideal diet ($B = 0.180$, $P < 0.001$) and ideal anxiety ($B = 0.308$, $P < 0.001$) classifications were significantly associated with cognitive performance. As expected, ideal diet and ideal anxiety levels were related to higher overall cognitive performance.

DISCUSSION

The results of this study generally support the hypothesis that ideal measures of the seven CVH factors are positively associated with cognitive performance on a battery of tests. Furthermore, our findings are consistent with the positive linear associations documented between ideal CVH metrics and mortality (24) and other non-cardiovascular outcomes (25) in meta-analyses.

Overall CVH and Cognitive Performance

The total number of CVH ideal characteristics was positively related to composite cognitive performance score (**Table 2**). As expected, a higher number of ideal CVH traits corresponded with higher composite cognitive function scores, supporting previous findings in high-income nations (5, 6, 26), in addition to a meta-study of both US and non-US populations (27). Therefore, regardless of where implemented, a consistent pattern evident between a higher number of ideal CVH traits and lower prevalence of cognitive impairment—similar to what was found

in our study. There are several potential explanations for the observed relationship between CVH and composite cognitive performance.

TABLE 2 | Linear regression modeling the association between composite cognitive score and total number of CVH factors (ranging from 1 to 7 ideal traits) in the Chinese study population (weighted data), SAGE Wave 1 (2007–2010).

Variable	β (SE)
Sex	−0.106 (0.034)**
Age: 60–69 years old	−0.219 (0.026)***
70–79 years old	−0.498 (0.032)***
80+ years old	−0.931 (0.056)***
Income quintile: 1	−0.476 (0.066)***
2	−0.384 (0.060)***
3	−0.294 (0.062)***
4	−0.107 (0.050)*
Household setting	−0.215 (0.042)***
Education: < high school	0.484 (0.020)***
High school or beyond	0.872 (0.052)***
Total number of ideal CVH factors	0.031 (0.015)*

Parameter estimates (β) with standard error (SE).[a–c]
[a]*Cardiovascular Health (CVH)*
[b]*Comparisons are statistically significant at: *P <0.05, **P <0.01, ***P <0.001*
[c]*Reference groups used in the creation of pacifier codes for each categorical variable:*
Sex = 0 (male)
Age = 50-59 years old
Income quintile = 5 (high income)
Household setting = 0 (urban)
Education level = no formal schooling.

First, previous research indicates that improved cardiovascular health enhances vascular health and brain tissue perfusion, resulting in cognitive gains (28). High levels of general CVH therefore likely support learning and cognitive function later in life. Moreover, better vascular function also results from the avoidance of risky behaviors (like smoking and heavy drinking). These risky behaviors introduce toxins into the bloodstream, resulting in the development of atherosclerosis (a main contributor to cardiovascular disease) and causing systematic inflammation that impairs cognitive function (5). Thus, improved levels of cumulative CVH likely offer some protection from cognitive impairment during senescence.

Individual CVH Measures and Cognitive Performance

Unexpectedly, when the CVH measures were considered separately only ideal diet and anxiety were significantly associated with composite cognitive performance. These findings are likely due to the importance of proper nutrition to mental acuity and the detrimental effects of chronic anxiety. While fruit and vegetable intake is not a comprehensive measure of overall diet, it provides a macro-level indication of diet quality and key components of the diet in relation to disease burden. The association between produce consumption and cognitive function documented here is consistent with results from analyses of SAGE data conducted by other analysts. Specifically, previous work indicates that the consumption of both fruit and vegetables is related to higher cognitive health among SAGE participants (29). It should also be noted that a preliminary

TABLE 3 | Linear regressions modeling associations between composite cognitive score (the dependent variable) and each individual CVH factor (the final independent variable entered in each model) in the Chinese study population (weighted data), SAGE Wave 1 (2007–2010).

	Sex	Age	*Income quintile*: 1	*Income quintile*: 2	*Income quintile*: 3	*Income quintile*: 4	Household setting	*Education*: < high school	*Education*: high school or beyond	Ideal CVH trait
Ideal Smoking	−0.092 (0.034)**	−0.029 (0.002)***	−0.460 (0.068)***	−0.369 (0.061)***	−0.280 (0.063)***	−0.098 (0.049)	−0.225 (0.043)***	0.472 (0.021)***	0.848 (0.052)***	0.006 (0.331)
Ideal Drinking	−0.095 (0.030)**	−0.029 (0.002)***	−0.462 (0.068)***	−0.371 (0.062)***	−0.278 (0.063)***	−0.098 (0.049)	−0.222 (0.043)***	0.472 (0.021)***	0.848 (0.052)***	0.038 (0.038)
Ideal BMI	−0.090 (0.028)**	−0.029 (0.002)***	−0.458 (0.067)***	−0.368 (0.061)***	−0.279 (0.063)***	−0.098 (0.049)	−0.224 (0.042)***	0.471 (0.021)***	0.849 (0.052)***	−0.018 (0.019)
Ideal PAL	−0.089 (0.028)**	−0.029 (0.002)***	−0.462 (0.065)***	−0.371 (0.058)***	−0.281 (0.060)***	−0.099 (0.047)*	−0.227 (0.044)***	0.472 (0.021)***	0.850 (0.052)***	0.012 (0.046)
Ideal BP	−0.089 (0.028)**	−0.029 (0.002)***	−0.461 (0.068)***	−0.370 (0.062)***	−0.280 (0.063)***	−0.098 (0.049)	−0.224 (0.043)***	0.472 (0.021)***	0.849 (0.052)***	0.021 (0.025)
Ideal Diet	−0.090 (0.028)**	−0.028 (0.002)***	−0.451 (0.068)***	−0.366 (0.062)***	−0.279 (0.063)***	−0.100 (0.049)*	−0.225 (0.043)***	0.467 (0.021)***	0.841 (0.053)***	0.130 (0.049)*
Ideal Anxiety	−0.087 (0.029)**	−0.028 (0.002)***	−0.451 (0.067)***	−0.362 (0.061)***	−0.277 (0.063)***	−0.096 (0.049)	−0.226 (0.042)***	0.469 (0.020)***	0.846 (0.052)***	0.242 (0.077)**

Full models including all covariates are presented; parameter estimates (β) with standard error (SE).[a–c]
[a]*Body Mass Index (BMI), Blood Pressure (BP), Physical Activity Level (PAL)*
[b]*Comparisons are statistically significant at: *P < 0.05, **P < 0.01, ***P < 0.001*
[c]*Reference groups used in the creation of pacifier codes for each categorical variable:*
Sex = 0 (male)
Income quintile = 5 (high income)
Household setting = 0 (urban)
Education level = no formal schooling.

analysis testing for an interaction between BMI and diet in relation to cognitive function was not significant ($p = 0.711$), indicating that diet influences cognition independent of any relationship with BMI.

There are several possible mechanisms accounting for this association. For instance, it is possible that antioxidants in fruit and vegetables play an important role in preventing oxidative stress (e.g., caused by free radicals), thereby protecting neural cells from damage (30–32). Similarly, key nutrients found in produce (i.e., zinc) appear to directly protect neurological functions (33). Fruits and vegetables are also high in fiber, which may support a healthy gut microbiota linked with higher cognitive health (34). It should also be noted that a preliminary analysis testing for an interaction between BMI and diet in relation to cognitive function was not significant ($p = 0.711$), indicating that diet influences cognition independent of any relationship with BMI.

Likewise, the association between cognitive function and anxiety documented here may be explained by multiple factors. First, the energetic costs of chronic anxiety may contribute to this relationship. Chronic anxiety has long been known to affect the proper processing, storage, and mobilization of energetic reserves (i.e., glucose availability), which may have implications for energetically-expensive cognitive functions (35). Chronically elevated stress hormones have also been shown to alter brain cell structure and lead to a loss of neurons, impairing various aspects of cognition, such as memory (35). Moreover, personality traits (e.g., neuroticism) have been linked with self-reported anxiety and have also been connected to poor cognitive performance in older adults (36, 37). Aspects of participant personality may therefore also contribute to anxiety risk and subsequent cognitive decline.

The promotion of increased produce consumption and techniques to reduce anxiety levels may therefore represent promising strategies to support healthy cognitive function among older Chinese adults. This would also support findings in China which suggest that improvements in diet and physical activity are needed to improve CVH and prevent strokes (38). It is unknown why other CVH factors—identified in studies of other populations—did not significantly influence cognitive performance in this sample. We speculate that this may due to a combination of population characteristics and measurement techniques. For example, a relatively low percentage of participants in the study population were obese (14.3%); it is therefore possible that BMI does not have the same effect on cognitive performance as has been observed in wealthier nations with higher prevalence of obesity over the lifespan. Likewise, a large proportion of participants reported never having smoked (66.6%) or having consumed alcohol (69.1%) in their lifetimes. Again, this may decrease our ability to detect the influence of these behaviors on cognitive function.

The high rate of ideal CVH traits documented among the study population is consistent with recent work indicating that, compared to other populations outside of the United States, a larger proportion of Chinese adults exhibit 6–7 ideal CVH traits (15% of the study population; as defined using American Heart Association CVH measures) (27). Older Chinese adults may therefore generally exhibit higher levels of CVH, relative to older adults in other groups. Still, in concordance with the lack of significant associations between individual CVH traits and cognitive performance documented here, a review of how CVH interventions affect overall health in LMICs (including improvements in physical activity and body weight) found inconsistent patterns cross-culturally (39). This inconsistency suggests that the influence of individual CVH measures on health (including cognitive function) may vary across populations. Furthermore, the seven CVH factors used in the present study are interrelated; thus, a composite measure of overall CVH may function as a more reliable predictor for health outcomes.

Limitations and Strengths

The present study has several limitations. First, because the data are cross-sectional, it is not possible to determine causality between the variables assessed. It is therefore conceivable that cognitive impairment might cause poor CVH (due to changes in diet and activity patterns resulting from dementia). Second, while the battery of cognitive tests used to determine cognitive performance has been tested and used in numerous countries (6, 11, 14) and was tested during preliminary SAGE data collection, these cognitive measures were not developed in China. In the future, a more diverse range of cognitive tests may better capture different aspects of cognitive performance.

Furthermore, PALs were determined using self-report questionnaire-based data. Although this is a commonly used measure, self-report data often overestimates physical activity levels. Finally, this study was unable to use the exact 'Life's Simple 7' CVH panel developed by the American Heart Association (6). Two of the variables included in this original panel (total cholesterol and fasting plasma glucose levels) were not collected as part of the SAGE Wave 1 study protocol. Two other factors known to influence CVH (drinking frequency and self-reported anxiety) were included in their place, potentially altering the comparability of results to similar analyses in other countries.

Despite these limitations, this study provides a unique examination of the associations between CVH and cognitive performance in older Chinese adults. Prior research testing these relationships has typically been limited to high-income countries and reliant on data collected from small and non-representative population samples. Conversely, the SAGE sample is large and captures the range of living conditions across China (16). Further, the use of self-reported anxiety levels in this study reveals the influence of mental health and perceived well-being on health outcomes, indicating this inexpensive measure may be a useful tool in future population risk assessments.

CONCLUSION

These results support previous findings in high-income populations and suggest that general CVH is positively associated with cognitive test performance in older Chinese adults. Future research should therefore test whether increasing total number of patient CVH ideal traits is beneficial for cognitive function in an aging cohort. Decreasing the rate of neurological decline and promoting healthy cognitive aging will continue

to be of utmost importance in coming years as the population of China continues to age and dementia rates increase. An increased focus on these topics is required to determine how targeting chronic disease risk factors (including poor CVH) can decrease physical and mental health burdens on older adult populations, thus contributing to improved health during aging.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in WHO Multi-Country Studies Data Archive at http://apps.who.int/healthinfo/systems/surveydata/index.php/catalog/13

AUTHOR CONTRIBUTIONS

TG carried out background research, performed the statistical analysis, and drafted the manuscript. NN participated in designing the statistical methods used and helped to draft the manuscript. PK and FW conceived of the study and helped to draft the manuscript. YG and JS participated in the study design and helped draft the manuscript. All authors read and approved the final manuscript.

FUNDING

This work was funded by the Science and Technology Commission of Shanghai Municipality under Grant No. 10XD1403600; Shanghai Municipal Organization Department and the Shanghai Bureau of Human Resource and Social Security; the World Health Organization; and the US National Institute on Aging through Interagency Agreements (OGHA 04034785; YA1323-08-CN-0020; Y1-AG-1005-01) and through a research grant (R01-AG034479).

ACKNOWLEDGMENTS

We thank Nirmala Naidoo for help with data management, all the study respondents, and the study PIs and teams. WHO's Study on global AGEing and adult health is supported by the respective governments in collaborating countries and WHO.

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Conflict of Interest Statement: 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.

Heine C, Browning CJ and Gong CH (2019) Sensory Loss in China: Prevalence, Use of Aids, and Impacts on Social Participation. Front. Public Health 7:5. Doi: 10.3389/fpubh.2019.00005

Abstract

在世界范围内，包括老龄化进程迅速加快的中国，视力和/或听力障碍的老年人的数量正在增长。感官丧失会影响老年人参与其社区的能力及其生活质量。这项研究调查了中国老年人口中视力丧失，听力丧失和双重感觉丧失（合并视力和听力丧失）的患病率，并描述了这些感觉丧失与人口统计学因素，眼镜和助听器的使用，未满足的需求，对社会参与的影响之间的关系。《中国健康与养老追踪调查》是一项基于人群的纵向调查，始于2011年。本研究采用了2013年60岁及以上人群的数据。分析的项目包括人口统计数据（年龄，性别，教育程度，农村地区和SES），自我报告的视力等级（包括法定失明，长距离和短距离远视力以及戴眼镜的使用和频率），听力（听力差和使用助听器效果差），双重感官丧失（视力差/视力差和听力）以及社会参与。在样本中，有80.2％的人认为自己视力差，64.9％的人认为自己听力差，57.2％的人有视力/听力差。很少有受访者（10％）经常戴眼镜，而20.1％的人则偶尔戴眼镜。尽管有听力损失的比例很高（64.9％），但只有0.8％的受访者戴着助听器。眼镜和助听器未满足需求的比例分别为54.9％和63.9％。低的社会经济地位（SES），受教育程度低和农村地区与普遍存在的视力差和听力差，眼镜和助听器的使用以及眼镜/助听器的未满足需求密切相关。视力差和/或听力差，以及对眼镜/助听器的需求未得到满足，与社会参与度呈负相关。感官丧失对于中国老年人来说是一个重要的健康问题，会影响他们的社会参与。需要对初级保健专业人员进行鉴定和康复方法方面的培训，并需要增加在现场工作的视力和听力专家的数量。向老年人提供有关感官丧失和使用辅助工具的信息，也将有助于改善老年人的生活质量。

frontiers in Public Health

ORIGINAL RESEARCH
published: 24 January 2019
doi: 10.3389/fpubh.2019.00005

Sensory Loss in China: Prevalence, Use of Aids, and Impacts on Social Participation

Chyrisse Heine[1], Colette J. Browning[2,3] and Cathy Honge Gong[3,4]*

[1] Department of Community and Clinical Allied Health, La Trobe University, Bundoora, VIC, Australia, [2] International Institute for Primary Health Care Research, Shenzhen, China, [3] Centre for Research on Ageing, Health and Wellbeing, Research School of Population Health, College of Health and Medicine, The Australian National University, Canberra, ACT, Australia, [4] ARC Centre of Excellence in Population Ageing Research (CEPAR), Sydney, NSW, Australia

The number of older adults with vision and/or hearing loss is growing world-wide, including in China, whose population is aging rapidly. Sensory loss impacts on older people's ability to participate in their communities and their quality of life. This study investigates the prevalence of vision loss, hearing loss, and dual sensory loss (combined vision and hearing loss) in an older adult Chinese population and describes the relationships between these sensory losses and demographic factors, use of glasses and hearing aids, unmet needs, and impacts on social participation. The China Health and Retirement Longitudinal Study is a population-based longitudinal survey conducted since 2011. The 2013 dataset for people aged 60 and over was used in this study. Items analyzed included demographic data (age, gender, education, rurality, and SES), self-reported ratings of vision (including legally blind, excellent-poor long, and short distance vision and the use and frequency of wearing glasses), hearing (excellent-poor hearing and the use of hearing aids), dual sensory loss (both poor/fair vision and hearing), and social participation. Of the sample, 80.2% reported poor/fair vision, 64.9% reported poor/fair hearing, and 57.2% had poor/fair vision and hearing. Few respondents (10%) wore glasses regularly and 20.1% wore glasses from time to time. Only 0.8% of respondents wore hearing aids although the proportion with hearing loss was high (64.9%). The proportion of unmet needs for glasses and hearing aids was 54.9 and 63.9%, respectively. Low socio-economic status (SES), poor education, and rurality were significantly associated with the prevalence of poor/fair vision and hearing, the use of glasses and hearing aids and the unmet needs of glasses/hearing aids. Poor/fair vision and/or hearing, and the unmet needs for glasses/hearing aids were significantly and negatively associated with social participation. Sensory loss is a significant health issue for older Chinese people that impacts on their social participation. Training primary care health professionals in identification and rehabilitation approaches is needed as well as increasing the numbers of vision and hearing specialists working in the field. Providing information on sensory loss and the use of aids to older adults will also help improve older adult's quality of life.

Keywords: sensory loss, prevalence, unmet needs, social participation, China, The China Health and Retirement Longitudinal Study

OPEN ACCESS

Edited by:
William Edson Aaronson, Temple University, United States

Reviewed by:
Kim Matthew Kiely, University of New South Wales, Australia
Guang-Hui Dong, Sun Yat-sen University, China

****Correspondence:***
Chyrisse Heine
c.heine@latrobe.edu.au

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

Received: *20 August 2018*
Accepted: *04 January 2019*
Published: *24 January 2019*

Citation:
Heine C, Browning CJ and Gong CH (2019) Sensory Loss in China: Prevalence, Use of Aids, and Impacts on Social Participation. Front. Public Health 7:5. doi: 10.3389/fpubh.2019.00005

INTRODUCTION

As adults age, they experience a range of physical changes, including changes in vision and hearing acuity. According to the WHO (1), 253 million people worldwide have vision impairment with 36 million people classified as legally blind. China accounts for ∼18% of the world's blindness (2). Eighty one percent of the global population with vision impairment are aged 50 years and over with this percentage set to increase as the numbers of older people increases worldwide. The WHO (3) estimated that in 2012 there was a high proportion of people worldwide with disabling hearing loss (360 million people or 5.3% of the world's population), although disabling hearing loss in East Asia is estimated to be much higher at 22% (2). Of the proportion of people worldwide with hearing loss, approximately one-third are older adults aged 65 years and over. The burden of disabling hearing impairment is highest for older adults in Southern Asia and the Asia pacific region (4).

In China, few population–based studies have explored the prevalence and impact of the co-occurrence of vision and hearing loss, known as Dual Sensory Loss (DSL). Dual Sensory Loss (DSL) is defined as "the acquired loss, in various degrees of severity of both vision and hearing acuity, associated with aging and prevalent in older adults" (5) (p. 1). The focus of the current paper is to investigate the prevalence and impact of vision, hearing and dual sensory loss in a representative sample of older Chinese.

Population-based studies of vision loss in China have shown the extent of the problem especially in older age groups. Zhao et al. (6) analyzed the findings of the China Nine-Province Survey of 45,747 adults aged 50 years and over living in rural China and found that the prevalence of visual impairment ranged from 3.76 to 38.40% and blindness ranged from 0.50 to 14.80%. In the 60 year and older age group, the prevalence of visual impairment was 17.05 and 3.91% for blindness. In addition, the increased prevalence of visual impairment and blindness was associated with older age, female gender, lack of education, and geographical area (or province). Zhang et al. (7) surveyed 5,770 persons aged 40 years and older in both urban and rural communities in 2013 in Baotou, China. They defined low vision as visual acuity in the better eye as 20/400-20/60, and blindness as visual acuity in the better eye as <20/400. In this study overall bilateral prevalence rates of low vision and blindness amongst those aged 40 years and over were 3.66 and 0.99%, respectively, and the proportion of low vision increased rapidly from 2.61% for those aged 60–69 years to 28.57% for those aged 90 years and over. Wang et al. (8) evaluated survey data from the Global Burden of Diseases, Injuries, and Risk Factors study 2015 and concluded that the prevalence of eye diseases in China had increased both in prevalence and type from 1990 to 2015, and will continue to increase until 2020 due to population growth and population aging. The burden from vision loss due to eye disease was ranked 11th amongst the causes of health loss in China in 2015.

Hearing impairment is also a prevalent condition in China that increases with age. A 1998 study conducted in Shanghai, China found that out of 2,044 people aged 65–74 years, 486 people (23.8%) rated their hearing as poor, whilst out of 1,050 people aged 75 years and over, 415 people (39.5%) rated their hearing as poor (9). Similarly, in a study conducted in Sichuan, China, Liu et al. (10) used ear and hearing examinations and found that out of a sample of 11,421 people aged 60 years and over, there were 1,465 cases (35.18%) of people with a hearing loss. Of these older adults aged 60 years and over, the prevalence rate of hearing loss was 12.83%. In a more recent study, Gong et al. (11) investigated the prevalence of self-reported hearing loss in 6,984 older adults aged 60 years and older in China. Findings of this study suggested that the prevalence of hearing loss was 58.85% with age and gender highly correlated with hearing loss. In 65–69 year olds, the prevalence of hearing loss was 57.59% which increased to 81.36% in adults aged 80 years and over. Hearing loss was also more prevalent in males (60.87%) than females (56.99%) and there were significant variations in hearing loss by urban/rural residence, education, and annual HH income.

Prevalence estimates of DSL (5) vary greatly between studies due to for example, differences in sample size or sample characteristics (12). In a recent study by Swenor et al. (13) the prevalence of DSL (or Dual Sensory Impairment) in a US sample was estimated as 11.3% of all adults aged 80 years or over. This is in contrast to Caban et al. (14) who investigated 1,110 community residing people in the US and found the prevalence of DSL to be 7.3% in participants aged 69–79 years and 16.6% in participants aged 80 years and over.

Limited prevalence data is available on DSL in the Chinese population. In a study of 2,003 older residents (aged 60 years and over) in Hong Kong, Chou and Chi (15) found that 20.0% had poor vision, 17.5% had hearing impairment, and 6.5% had vision and hearing loss. The prevalence of dual sensory loss is expected to increase with the aging of the population (16) and particularly in China, with increases in the number of older people aged 80 years and over.

Sensory loss impacts on older peoples' abilities to communicate and participate in society and can contribute to decreased productivity and quality of life (17, 18).

Communication difficulty is significantly impacted by sensory loss and consequently often leads to decreased social interaction and participation. In particular, people with vision loss have difficulty perceiving visual cues such as visual detail, distance perception, illumination and facial acuity of the communication partner (19). People with severe visual loss (low vision or legal blindness) thus frequently experience difficulty seeing their communication partner's face and therefore have difficulty with lipreading or perceiving non-verbal cues such as gesture, facial expression, and body posture. This decreased visual perception interferes with effective verbal communication, particularly in social situations. People with severe vision loss usually rely on the auditory modality to compensate for their difficulties. However, when auditory acuity is also reduced and cannot compensate for diminished visual acuity (as occurs in DSL), effective communication is compromised (17).

Visual aids are not always helpful for people with severe vision loss and many older adults with hearing loss or DSL do not successfully use amplification or other assistive listening devices successfully to improve their hearing (20). In China, many adults with vision and hearing loss do not use aids

to assist with their sensory loss. Although self-reported vision problems are common in China, particularly rural China, there is comparatively limited use of glasses due to poverty, misinformation, and mistaken views (for example that wearing glasses leads to further loss of vision) (21, 22). Similarly, there is less uptake of hearing aid use than expected for the large number of people in China with hearing loss (23). Reasons posited by these authors for poor uptake of hearing aids include traditional attitudes toward hearing loss in older people ("it is a normal part of aging"), financial constraints, unfamiliarity with hearing aids, and difficulty manipulating hearing aids. Furthermore, these authors found that many older people find the enhanced signal too loud, feel that the signal has a muffled effect and believe that the hearing aid does not assist with speech recognition. These authors also concluded that hearing healthcare services for older people in China is still under-developed.

Sensory loss in older people in China is thus a major chronic health issue that has the potential to impact on the social participation and the quality of life of older Chinese. The availability and use of sensory aids are important components in assisting older people with sensory loss to function at their full potential.

There are few population-based studies that examine in detail vision, hearing and dual sensory loss in China. The China Health and Retirement Longitudinal Study (CHARLS) used in this study is a national representative population-based longitudinal survey of people aged 45 years and over, that includes a number of items on sensory loss and aid use as well as social participation.

The aims of this study are to:

1. estimate the prevalence of self-rated vision and hearing and DSL in the older adult cohort (60 years and over) of the CHARLS study;
2. evaluate the relationship between the prevalence and severity of self-reported sensory loss and age, gender, socioeconomic status, and rurality;
3. evaluate the relationship between the prevalence of self-reported sensory losses and the uptake of visual aids (glasses) and auditory aids (hearing aids) to assess unmet needs; and,
4. evaluate the relationship between self-reported sensory loss, visual aids (glasses) and auditory aids (hearing aids) use and social participation.

METHODS

Data Source

The CHARLS is the first nationally representative and longitudinal survey of people aged 45 years or above on aging and health in China. It was designed by following the protocols of the Health and Retirement Survey (HRS) in the US and conducted by the China Center for Economic Research at Peking University (24). Face-to-face interviews in respondents' homes collected detailed information on demographic characteristics, social and economic conditions, self-rated health, chronic diseases, activities of daily living (ADL) limitations, disabilities, and psychological well-being amongst other variables. In the first wave of CHARLS in 2011, participants were randomly sampled using a multi-stage probability-proportional-to-size technique, stratified by regions and then by urban districts or rural counties and per capita gross domestic product (GDP).

In the first wave of CHARLS in 2011, 17,596 respondents aged 45 years and over were surveyed. In the second wave in 2013, the sample size increased to a total of 18,246 respondents, in which 14,988 were from Wave 1.

For our investigation of hearing and vision loss, which are most prevalent in older people, we only included older adults (those aged 60 years and over) in the analyses (n = 8,268). There are some missing data or non-response for each of our study variables. For instance, 7,401 have reported information on vision capacity, 7,396 on vision capacity for long distance, 7,398 on near vision capacity, 8,193 on wearing glasses or not, 7,430 on using hearing aid or not, and 7,431 on social activities.

Missing data have not been imputed. We used observations with responses to related variables to conduct descriptive analyses of the prevalence rates of vision/hearing loss by age, gender, and SES. The correlational and regression analyses between social participation and vision/hearing loss, were restricted to the final 7,212 respondents with reported information on all the related variables of social participation, vision/hearing capacity, and the use of glasses/hearing aids used in the final regression models.

Methods

First the prevalence rates of self-reported vision and hearing loss and unmet needs for glasses or hearing aids by age, gender, urban/rural residence, education, socio-economic status (SES) (relative living standard and quintile of household expenditure) were calculated followed by Spearman correlations between the prevalence rates of vision and hearing status, unmet needs and social participation. Finally, a multivariate regression analysis was performed to examine the conditional associations of poor/fair vision/hearing, DSL and the unmet needs for glasses or hearing aids with social participation by controlling for age group and gender. The ordered logit model was run for the number of types of social activities, while the logit model was run for whether respondents participated in any, leisure, helping others or learning social activities. The multivariate regression models used in this study are simple without controlling for other important factors, such as disability, deafness, blindness, or psychological problems. However, the modeling approach serves the broad purpose of the paper to investigate the conditional associations between social participation, vision/hearing loss, and the use of sensory aids.

The statistical software we have used for the analysis is STATA/SE 15.1. Individual weights denoting the inverse of the probability that the observation are included because the sampling design with household and individual non-response adjustments, are used for our analysis.

Measures

In CHARLS 2013, there are three questions asking respondents about their vision: (1) Do you usually wear glasses or corrective lenses (1 = Yes, 2 = Legally blind, 3 = No, 4 = Sometimes)?

(2) How good is your vision for seeing things at a distance, like recognizing a friend from across the street (with glasses or corrective lenses if you wear them, 1 = excellent, 2 = very good, 3 = good, 4 = fair, or 5 = poor)? (3) How good is your near vision, like reading ordinary newspaper print (with glasses or corrective lenses if you wear them, 1 = excellent, 2 = very good, 3 = good, 4 = fair, or 5 = poor)? The two questions for hearing are, "Do you ever wear a hearing aid (1 = yes or 2 = no)?" "Is your hearing excellent, very good, good, fair, poor, or very poor (with a hearing aid if you normally use it and without if you normally don't)?"

In the current literature, vision/hearing loss has been defined either objectively passing certain thresholds in medical examination/testing, e.g., Kuang et al. (25) or subjectively self-reporting poor/fair vision/hearing capacities, e.g., Yu et al. (9) reflecting needs for sensory aids to help daily and social activities. In this study, for the analysis of the prevalence of DSL and its association with social participation, both vision and hearing, subjective ratings were categorized into two groups: good (including excellent/very good/good), and poor (including fair/poor).

Based on these responses, we created five different variables to measure vision or hearing loss: (1) having poor/fair vision (for either long distance or near vision); (2) having poor/fair vision for long distance; (3) having poor/fair near vision; (4) having poor/fair hearing; (5) dual sensory loss (having poor/fair vision and hearing). In addition, we included self-reported blindness.

Since wearing glasses or using hearing aids could be influenced by both affordability and services needs, a variable was derived to measure the unmet needs for glasses and for hearing aid/s use as follows: (1) Unmet needs for glasses = a vision loss was reported but glasses were not used; (2) unmet needs for hearing aid/s = if a hearing loss was reported but hearing aid/s were not used. The counterpart of unmet needs includes those without vision/hearing loss who do not need sensory aids, and those with vision/hearing loss who use glasses/hearing aid/s regularly or from time to time.

Socioeconomic status (SES) is an economic and sociological combined total measure of a person's work experience and of an individual's or family's economic and social position in relation to others, based on their income, education, and occupation (26). There are a number of measures of socio-economic status (SES) in CHARLS which might be related to DSL and the use of sensory aids, including: (1) household income; (2) household expenditure, (3) self-reported relative living standards, and (4) individual educational attainment. Estimating income for old people in China is complicated and fluctuates. Older people have multiple income sources from their wages, age pension, savings, investments, rent, intergenerational transfer and children's support amongst others In order to characterize the impact of the large variations across regions in both income and living costs, the relative living standard and quintiles of household annual expenditure were used together to measure SES (26). Household expenditure includes household spending on food and non-food (including eating out, alcohol, cigarettes, cigars, and tobacco) as well as the market value of food and other products that members of the household consumed and that they grew or produced by themselves. The weekly value of spending from the survey is timed by 52 weeks in order to obtain the yearly value. The quintile of household expenditure is calculated based on the whole household expenditure at a national level among all respondents aged 45 and over in CHARLS 2013. The relative living standard is self-reported by respondents by answering the question: "Compared to the average living standard of people in your city or county, how would you rate your standard of living relative to those in your city/county: much better, a little better, about the same, a little worse, much worse?" Answers were grouped into three categories: "better;" "worse;" and "about the same," since using five groups did not enhance the interpretation beyond using the three categories used in the model.

Educational attainment was categorized into three groups: (1) primary or under schooling; (2) secondary schooling; (3) college or above degrees. The urban and rural areas were defined according to the most recently published statistical standard by the National Bureau of Statistics of China (NBS) (27), where urban areas include both communities and villages located within access to the city or town facilities, while rural areas include only villages out of the city or town facilities.

To measure social participation in the CHARLS 2013 dataset, respondents were asked "Have you done any of these activities in the last month (multiple options)? (1) Interacted with friends, (2) Played Ma-jong, played chess, played cards, or went to community club, (3) Provided help to family, friends, or neighbors who do not live with you, and who did not pay you for the help, (4) Went to a sport, social, or other kind of club, (5) Took part in a community-related organization, (6) Done voluntary or charity work, (7) Cared for a sick or disabled adult who does not live with you and who did not pay you for the help, (8) Attended an educational or training course, (9) Stock investment, (10) Used the Internet, (11) Other (12) None of these. Options 1, 2, 4, and 5 are defined as leisure activities, options 3, 6, and 7 as social activities helping others out and options 8, 9, 10, and 11 as learning activities for new knowledge.

Five variables were generated to define social activities based on the respondents' responses to this question and are as follows: (1) the number of types of social activities as described above; (2) any of these social activities; (3) any of the leisure activities; (4) any of the activities helping others out; and (5) any learning activities for new knowledge.

RESULTS

Table 1 reports the sample size, weighted, and unweighted proportions by individual characteristics of the respondents from both the full and restricted CHARLS samples. The full sample (8,268 respondents) was used for descriptive analysis (**Tables 1–3**), although in some of the analyses, the number of respondents is <8,268 due to missing data for some variables as noted above. The restricted sample (7,212) was used to check unconditional and conditional associations between hearing/vision loss and social activities (**Tables 4–6**). There were no large differences between weighted and unweighted

TABLE 1 | Sample size, unweighted, weighted proportions by individual characteristics for full and restricted samples.

	Full sample			Restricted sample		
	Sample size (*n*)	**Unweighted (%)**	**Weighted (%)**	**Sample size (*n*)**	**Unweighted (%)**	**Weighted (%)**
All respondents aged 60+	8,268	100	100	7,212	100	100
(1) Male	4,093	49.5	49.1	3,587	49.7	49.6
(2) Female	4,173	50.5	50.9	3,625	50.3	50.4
(1) Aged 60–64	2,677	32.4	30.4	2,418	33.5	33.5
(2) Aged 65–69	2,197	26.6	25.3	2,020	28.0	28.0
(3) Aged 70–74	1,539	18.6	18.3	1,360	18.9	18.9
(4) Aged 75+	1,855	22.4	26.0	1,414	19.6	19.6
(1) Rural	4,957	60.0	59.9	4,395	60.9	60.6
(2) Urban	3,311	40.0	40.1	2,817	39.1	39.4
(1) Primary or under	4,768	57.7	58.5	4,093	56.8	57.2
(2) Second schooling	3,343	40.4	39.9	2,991	41.5	41.2
(3) College and above	155	1.9	1.6	128	1.8	1.6
(1) Better living standard	256	3.1	2.8	242	3.4	3.2
(2) Average living standard	1,674	20.3	19.6	1,621	22.5	22.3
(3) Worse living standard	4,151	50.2	49.5	4,030	55.9	56.1
(4) Living standard not reported	2,187	26.5	28.1	1,319	18.3	18.5
(1) Household expenditure quintile 1	2,095	26.1	27.3	1,627	22.7	22.4
(2) Household expenditure quintile 2	1,926	24.0	23.2	1,828	25.5	25.1
(3) Household expenditure quintile 3	1,558	19.4	19.0	1,466	20.4	20.4
(4) Household expenditure quintile 4	1,283	16.0	15.7	1,197	16.7	16.7
(5) Household expenditure quintile 5	1,150	14.4	14.8	1,064	14.8	15.4
(1) Good vision	1,404	19.0	19.8	1,372	19.0	19.8
(2) Poor/fair vision	5,997	81.0	80.2	5,840	81.0	80.2
(1) Good hearing	2,555	34.4	35.1	2,496	34.6	35.1
(2) Poor/fair hearing	4,875	65.6	64.9	4,716	65.4	64.9
(1) Without DSL	3,079	41.7	42.8	3,030	42.0	42.8
(2) With DSL	4,298	58.3	57.2	4,182	58.0	57.2
(1) Met needs for glasses	1,940	26.2	25.4	1,894	26.3	25.4
(2) Unmet needs for glasses	4,056	54.8	54.9	3,945	54.7	54.8
(3) Good vision no need for glasses	1,403	19.0	19.8	1,371	19.0	19.8
(1) Met needs for hearing aid	41	0.6	0.5	38	0.5	0.5
(2) Unmet needs for hearing aid	4,798	65.0	64.3	4,643	64.8	64.8
(3) Good hearing no need for aid	2,547	34.5	35.2	2,488	34.7	34.7
Social activities: reported	7,431			7,212		
(1) Social activities: any (yes)	4,040	54.4	54.7	3,928	54.5	54.9
(2) Social activities: any(no)	3,391	45.6	45.3	3,284	45.5	45.1
(1) Social activities: leisure (yes)	3,731	50.2	50.3	3,627	50.3	50.6
(2) Social activities: leisure (no)	3,700	49.7	49.6	3,585	49.7	49.4
(1) Social activities: helping others (yes)	800	10.8	10.4	772	10.7	10.5
(2) Social activities: helping others (no)	6,631	89.2	89.5	6,440	89.3	89.5
(1) Social activities: learning (yes)	276	3.3	3.7	269	3.73	3.82
(2) Social activities: learning (no)	7,155	96.64	96.22	6,943	96.27	96.18

Data source: CHARLS 2013. http://charls.pku.edu.cn/en.

(1) Among all the 8,268 respondents in the full sample, all of them have reported information on age and urban/rural residence, 8,266 on gender and education, 6,081 on relative living standard, 8,012 on household expenditure, 7,401 on either long or near vision capacity, 7,396 on long vision capacity, 7,398 on near vision capacity, 7,430 on hearing capacity, 7,377 on dual sensory loss, 7,399 on unmet needs for glasses, 7,386 on unmet needs for hearing aids, and 7,431 on social activities. (2) Full sample (8,268 respondents) is used for descriptive analysis, while restricted sample (7,212) is used to check associations between hearing/vision loss and social activities. (3) Weighted and unweighted proportions (%) are calculated based on respondents in full or restricted samples with reported information on each of the variables. For instance, in the full sample, 8,266 have reported gender information, and the proportion of males and females are calculated based on 8,266 instead of 8,268 respondents.

proportions for the full and restricted samples hence no systematic bias was expected by using the full or restricted sample.

In the 2013 CHARLS sample, there were 8,268 respondents aged 60 years and over, of which, 49.5% were men whilst 50.5% were women. More specifically, there were 32.4% of respondents aged 60–64 years, 26.6% of respondents aged 64–69 years, 18.6% of respondents aged 70–74 years, and 22.4% of respondents aged 75 years and over. Sixty percent of respondents were from rural areas whilst 40.0% were from urban areas.

The educational attainment was very low in this sample. Of all the respondents aged 60 years and over, only 1.9% had a college or above degree, 40.4% had secondary schooling, and 57.7% had primary or under primary schooling. About 3.1% of all respondents reported having a better living standard than the average in their cities or counties, 20.3% reported about the same and 50.2% reported a worse living standard than the average in their cities or counties. About 26.1% of respondents were located in the lowest quintile of household expenditure, while 14.4% were in the highest quintile of household expenditure (based on all respondents aged 45 and over in CHARLS 2013).

Amongst all respondents aged 60 years and over, the following information was evident: (1) 81.0% reported poor or fair vision capacity for either long or near distance, <1% of respondents across the age groups reported blindness, 65.6% reported poor or fair hearing capacity, and 58.3% reported Dual Sensory Loss (DSL); (2) 19.0% of respondents reported good vision with no need for glasses, 26.2% wore glasses and 54.82% reported having no glasses even though they reported poor or fair vision; (3) 34.5% of respondents reported good hearing without the need for hearing aids, very few respondents (0.6%) used hearing aids and 65.0% of respondents reported having a hearing loss, yet did not use hearing aids.

Of the 7,431 respondents (89.9% of the full sample) who reported information about their social activities, 54.4% of respondents reported having any social activities in last month, 50.2% reported participating in leisure activities, 10.8% reported helping others and 3.3% participated in learning activities.

Prevalence of Sensory Loss and Aid Use: Age and Gender Effects

The prevalence rates of self-reported vision loss, hearing loss and DSL, the use of aids (glasses and hearing aid/s), and social participation were obtained and analyzed by age, gender, education, urban/rural residence, and SES (relative living standard, quintile of household expenditure).

Table 2 presents the prevalence rates of sensory loss and aid use by age and gender based on the full sample. Across the whole sample the prevalence of self-reported poor/fair vision for near or long distance was 80.2%. Only 10% of the sample wore glasses regularly. The prevalence of poor/fair self-rated vision for either long or near distance and long distance only was highest for the 70–74 year age group. The prevalence of DSL across the whole sample was 57.2%, increasing by age and was the highest for the 70–74 year age group (60.0%). This age group also had the highest prevalence for wearing glasses regularly. Across the whole sample the prevalence of self-rated poor/fair hearing was 64.9% on average, and was the highest in the 75 years and over age group as was this age groups' wearing of hearing aids. However, hearing aid use was extremely low across the whole sample (0.5–1.4%).

Men in the 70–74 year age range consistently had the highest prevalence of self-rated poor/fair short or long vision, poor/fair hearing and DSL although the respondents 75 years and over were the highest group to regularly use glasses or wear hearing aids. The pattern for women is different. Women in the 60–64 age group reported the highest prevalence of short or long poor/fair vision while women in the 70–74 age group reported the highest prevalence of wearing glasses regularly. For women, the 75 years and over age group reported the highest prevalence of poor/fair hearing and DSL. The youngest age group (those 60–64 years) had the highest prevalence for wearing hearing aids.

In summary the prevalence rates for short or long poor/fair vision, poor/fair hearing, and DSL are high in this older sample. However, it should be noted that the prevalence range across the age groups is small. Overall, in comparison to the prevalence of poor/fair vision, poor/fair hearing and DSL, only a small proportion used glasses (10.0% regularly and 20.1% from time to time) or wore hearing aid/s (0.8%). Glasses and hearing aid use were much lower than the proportion of respondent's reporting poor/fair vision (80.2%) or poor/fair hearing (64.9%) demonstrating an unmet need.

Prevalence of Poor/fair Vision/hearing and Unmet Needs by Education, Rurality, and SES

Table 3 provides the sensory loss and unmet needs for sensory aids by SES. As is apparent from **Table 3**, there are significant differences by education and SES in terms of the prevalence of sensory loss, the use of sensory aids and unmet needs. **Table 3** indicates that: (1) Respondents with primary or under schooling had the highest proportion of vision loss, hearing loss, and dual sensory loss as well as the highest proportion of unmet needs for glasses and hearing aid/s; respondents with college or above degrees had the highest proportion of wearing a hearing aid, wearing glasses regularly, and those with secondary schooling had the highest proportion of wearing glasses from time to time. (2) Respondents in rural areas had a higher proportion of vision loss, hearing loss, DSL and unmet needs for glasses and hearing aids, whilst respondents in the urban areas had a higher proportion of wearing glasses (either regularly or from time to time), and wearing a hearing aid; (3) Respondents with a worse living standard than the average had the highest proportion of vision loss, hearing loss, DSL and unmet needs for glasses and hearing aids whilst respondents with a better living standard had the highest proportion of wearing glasses regularly and wearing hearing aids, and those with an average living standard had the highest proportion of wearing glasses from time to time; (4) Respondents in the lowest two expenditure quintiles had the

TABLE 2 | Poor/fair vision and/or hearing by age groups and gender among older Chinese aged 60+, 2013.

Weighted proportion (%)	Sample size CHARLS 2013	Poor/fair vision for long distance/near vision	Poor/fair vision for long distance	Poor/fair near vision	Wearing glasses regularly	Wearing glasses from time to time	No glasses	Poor/fair hearing	Wearing hearing aid/s	Dual poor/fair vision & hearing	Unmet needs for glasses	Unmet needs for hearing aid
Persons	*n*	%	%	%	%	%	%	%	%	%	%	%
Aged 60–64	2,677	80.6	64.6	68.3	9.8	22.9	67.2	61.4	0.6	55.2	53.6	60.8
Aged 65–69	2,197	80.2	70.2	67.3	9.8	23.7	66.0	64.4	0.5	56.6	53.2	63.3
Aged 70–74	1,539	81.5	72.2	66.8	11.8	19.7	67.4	67.0	0.7	60.0	54.3	66.0
Aged 75+	1,855	78.7	70.7	62.8	9.0	13.5	76.5	68.9	1.4	58.5	59.3	67.2
Total aged 60+	8,268	80.2	68.9	66.6	10.0	20.1	69.4	64.9	0.8	57.2	54.9	63.9
Men	*n*	%	%	%	%	%	%	%	%	%	%	%
Aged 60–64	1,278	77.4	59.2	64.7	12.2	23.8	63.8	61.1	0.4	53.8	49.1	60.5
Aged 65–69	1,125	77.9	66.8	66.4	10.8	25.4	63.2	64.9	0.6	55.2	49.9	63.7
Aged 70–74	787	80.7	68.8	67.3	12.7	23.4	63.6	70.3	1.0	62.5	49.8	68.9
Aged 75+	903	76.0	67.7	60.5	13.1	16.4	70.3	69.1	2.4	57.5	54.4	67.1
Total aged 60+	4,093	77.9	65.0	64.7	12.2	22.3	65.2	65.7	1.1	56.7	50.6	64.5
Women	*n*	%	%	%	%	%	%	%	%	%	%	%
Aged 60–64	1,398	83.4	69.5	71.6	7.6	22.0	70.2	61.6	0.7	56.5	57.6	61.1
Aged 65–69	1,071	82.7	73.9	68.3	8.8	21.8	68.9	63.8	0.4	58.1	56.7	62.8
Aged 70–74	752	82.3	75.7	66.3	10.9	16.0	71.9	63.7	0.4	57.4	59.0	63.1
Aged 75+	952	81.3	73.6	65.1	5.4	11.0	82.1	68.7	0.5	59.6	64.0	67.4
Total aged 60+	4,173	82.5	72.7	68.3	7.9	17.9	73.4	64.2	0.5	57.8	59.0	63.3

Data source: CHARLS 2013. http://charls.pku.edu.cn/en.

(1) The proportions (%) here are weighted proportions based on observations with reported information on each of the variables. (4) The proportions of unmet needs for glasses/hearing aid are based on the proportions of respondents with vision/hearing loss but without glasses/hearing aid among all respondents who have reported vision/hearing capacities. As shown in ***Table 1****, its counterpart includes both respondents who do not have vision/hearing loss, and those with vision/hearing loss but with glasses/hearing aid.*

TABLE 3 | Poor/fair vision and/or hearing by SES among older Chinese aged 60+, 2013.

Weighted proportion (%)	Sample size CHARLS 2013	Poor/fair vision for long distance/near vision	Poor/fair near vision	Poor/fair near vision	Wearing glasses regularly	Wearing glasses from time to time	No glasses	Poor/fair hearing	Wearing hearing aid	Dual poor/fair vision & hearing	Unmet needs for glasses	Unmet needs for hearing aid
By education	*n*	%	%	%	%	%	%	%	%	%	%	%
Primary or under	4,768	82.21	71.7	67.8	6.0	15.0	78.4	66.5	0.7	59.1	63.0	65.8
Second schooling	3,343	77.9	65.4	65.3	15.0	27.4	57.2	63.2	0.9	55.2	44.5	62.0
College and above	155	69.28	59.1	55.1	30.8	23.7	45.5	49.2	1.6	42.6	30.0	41.9
Total aged 60+ with educational information	8,266	80.2	68.9	66.6	10.0	20.1	69.4	64.9	0.8	57.0	54.9	63.9
By residence	*n*	%	%	%	%	%	%	%	%	%	%	%
Rural	4,957	82.2	72.0	68.0	7.3	18.0	74.2	68.1	0.6	61.0	60.0	67.4
Urban	3,311	77.21	64.0	64.0	14.1	23.0	62.2	60.0	1.1	52.1	47.5	58.4
Total aged 60+	8,268	80.2	68.9	67.0	10.0	20.1	69.4	64.9	0.8	57.2	54.9	63.9
By living standard	*n*	%	%	%	%	%	%	%	%	%	%	%
Better living standard	256	73.45	57.1	60.6	15.7	19.1	64.4	57.4	1.9	47.2	46.2	55.0
Average living standard	1,674	77.67	65.1	64.1	10.5	22.0	67.4	62.3	1.0	53.2	52.5	60.7
Worse living standard	4,151	82.21	71.4	68.5	9.3	20.3	69.9	67.1	0.5	59.8	57.7	66.2
Living standard not reported	2,187	78.5		64.6	10.2	18.3	70.3	1.2	62.9	1.2	50.7	62.1
Total aged 60+	8,268	80.2	69.2	66.6	10.0	20.1	69.4	0.6	64.9	0.8	54.87	63.88
By expenditure	*n*	%	%	%	%	%	%	%	%	%	%	%
HH expenditure quintile 1	2,095	80.68	71.5	65.2	8.6	15.6	74.6	66.0	1.1	58.9	58.1	65.0
HH expenditure quintile 2	1,926	82.33	70.8	70.1	9.9	20.0	69.9	68.0	0.8	60.3	57.8	67.1
HH expenditure quintile 3	1,558	81.79	70.1	68.7	8.0	22.1	69.4	63.2	0.6	56.2	57.1	62.1
HH expenditure quintile 4	1,283	78.39	65.3	64.1	12.7	22.2	64.9	63.6	0.5	55.2	50.0	62.9
HH expenditure quintile 5	1,150	76.17	64.7	62.7	12.0	23.6	63.8	62.3	0.7	53.5	47.7	60.6
Total aged 60+ with information on HH expenditure	8,012	80.3	69.0	66.6	10.0	20.1	69.4	64.9	0.8	57.3	54.9	63.9

Data source: CHARLS 2013. http://charls.pku.edu.cn/en.

(1) The proportions (%) here are weighted proportions based on observations with reported information for each of the variables. (4) The proportions of unmet needs for glasses/hearing aid are based on the proportions of those respondents with vision/hearing loss but without glasses/hearing aid among all respondents who have reported vision/hearing capacities. As shown in ***Table 1****, its counterpart includes those who do not have vision/hearing loss, and those with vision/hearing loss but with glasses/hearing aid.*

highest proportions of vision loss, hearing loss and DSL, and unmet needs for glasses and hearing aids whereas respondents in the highest two expenditure quintiles had the highest proportion of wearing glasses either regularly or from time to time.

Relationships Between Vision Loss, Hearing Loss, DSL, Unmet Need, and Social Participation

Distribution (**Table 4**) and Spearman correlations (**Table 5**) were calculated between DSL, unmet needs and social activities, and a simple multivariate model (**Table 6**) controlling for age and gender was used to investigate the associations between self-rated poor/fair vision and hearing, unmet needs for sensory aids, and social participation. From **Table 4** it was evident that older people with poor/fair vision and/or hearing, or unmet needs for glasses or hearing aids had significantly lower participation in all of the social activities, compared to those with excellent, very good or good vision or hearing.

The Spearman correlations shown in **Table 5** further confirm that poor/fair vision and/or hearing, and the unmet needs for glasses or hearing aids are negatively associated with participation in all types of social activities.

Since vision and hearing capacities were strongly correlated with age, multivariate binominal logit or ordered logit models were conducted to examine the conditional associations between DSL and social activities by controlling for age group, gender, poor/fair vision/hearing, DSL, and the unmet needs for glasses or hearing aids into the regression models. The regression results are presented in **Table 6**.

From **Table 6**, it is evident that once other variables were controlled for, participation in social activity (the number of social activity types and activities of helping others) decreases significantly with age. This was however not the case for the social activities for leisure and learning. Furthermore, whilst the unmet needs for glasses was significantly related with all activity types, poor/fair vision or hearing and the unmet needs for hearing aids did not have significant influences on any of the social activities.

It must be noted however that the sample size of people wearing hearing aids was very small in this survey hence its related results need to be treated cautiously. In general, a Pseudo *R*-square value within 0.2 to 0.4 represents excellent fit. The Pseudo *R*-square in our final model is 0.01–0.04, less than the level of excellent fit, but we argue that it serves our purpose to investigate the conditional associations between social participation, vision/hearing loss, and the use of sensory aids. The low level of model fit could due to other factors, which are not included in this study, but have influence on later life social participation, such as severe disabilities and health conditions (mobility difficulty, blindness, deaf, psychological problems etc.), which were beyond the scope of this study.

DISCUSSION

Results of the current study are that self-assessed sensory loss [vision loss (defined as self-rated poor/fair vision), hearing loss

TABLE 4 | Participation in social activities (%) by self-rated vision and hearing, and unmet needs.

Participation (%) of social activity	All restricted sample	By vision capacity		By hearing capacity		By DSL		By needs for glasses		By needs for hearing aids	
By social activity type	**Average**	**Good vision**	**Poor/fair vision**	**Good hearing**	**Poor/fair hearing**	**Without DSL**	**DSL**	**Good vision or with glasses**	**Unmet needs for glasses**	**Good hearing or with health aids**	**Unmet needs for hearing aid**
Social activity: any (yes)	54.9	58.5	54.1*	58.9	52.8*	58.1	52.5*	60.3	50.5*	58.7	52.8*
Social activity: leisure(yes)	50.6	54.0	49.8*	53.6	48.9*	53.3	48.6*	55.0	47.0*	53.5	48.9*
Social activity: helping (yes)	10.5	11.9	10.2	11.8	9.8*	11.4	9.9*	12.6	8.8*	11.8	9.8*
Social activity: learning(yes)	3.8	5.4	3.4*	5.5	2.9*	5.2	2.8*	5.6	2.3*	5.5	2.9*

*The numbers reported here are the weighted proportions (%) of respondents who have reported participation in any social activities. These numbers are calculated based on the restricted sample (7,212 respondents) used in the final regression models. The differences in this table are all statistically significant at a significant level 5% (as indicated by *), except for the insignificant correlation between poor/fair vision and social activity of helping others. The reference groups for the comparisons of differences in proportions are: good vision, good hearing, without DSL, good vision or with glasses, good hearing or with health aids. Data source: CHARLS 2013. http://charls.pku.edu.cn/en.*

TABLE 5 | Spearman correlation between social activity participation and poor/fair vision and/or hearing, and unmet needs.

Spearman correlations	Social activities: number of types	Social activities: any (yes/no)	Social activities: leisure (yes/no)	Social activities: helping others (yes/no)	Social activities: learning (yes/no)
Poor/fair vision	−0.044*	−0.028*	−0.028*	−0.018	−0.046*
Poor/fair hearing	−0.054*	−0.042*	−0.035*	−0.036*	−0.046*
DSL	−0.062*	−0.047*	−0.046*	−0.025*	−0.049*
Unmet needs for glasses	−0.125*	−0.101*	−0.088*	−0.068*	−0.080*
Unmet needs for hearing aid	−0.053*	−0.040*	−0.034*	−0.034*	−0.049*

*(1) The spearman correlations are based on the restricted sample (7,212 respondents) used for the final regression models; (2)*indicates statistically significant at a significant level of 5%. Only the correlation between social activities of helping others and poor/fair vision is insignificant. Data source: CHARLS 2013. http://charls.pku.edu.cn/en.*

(defined as self-rated poor/fair hearing), and DSL (defined as self-rated poor/fair vision and hearing)] are highly prevalent conditions experienced by older adults in China. Vision loss was more prevalent (80.2%) than hearing loss (64.9%) and DSL was experienced by over half of the cohort (57.2%).

The prevalence rates of sensory loss in the present study are higher in comparison to the prevalence of vision and hearing loss in older people in Western countries. For example, in Australia, the prevalence of vision loss in Australia ranges from 4.37 to 46.15% (28) for indigenous and non-indigenous people aged 60 years and over. The prevalence of hearing loss in Western countries ranges from 45.5 to 100% with large variations by age (29). The prevalence of DSL in the current study is also higher than in Western countries. In an Australian study (30), based on vision and audiometric assessments, the prevalence of DSL for those aged 60 years and over, was 6.93%. In comparison to the present study, a lower prevalence rate of DSL has also been reported by researchers in other countries such as the US [Brennan et al. (31) estimated the rate of DSL as 22.5%] and Japan [Harada et al. (32) estimated the prevalence range of DSL as 3% in cohorts aged 60–69 years to 21.9% in those aged 80 years and older].

Other population-based studies of vision and hearing loss in China found similar results to the present study. Based on 4 datasets collected in 2012 (National Rural Vision Care Survey, Private Optometrist Survey, County Hospital Eye Care, Rural School Vision Care Survey Survey), Bai et al. (22) found a similar prevalence rate (61%) of self-reported vision loss for people aged 50 and plus.

According to a survey of 6,984 older adults, Gong et al. (11) found the prevalence of hearing loss to be 58.9% for those aged 65 years and above. Based on the 2005–2006 cycle of the China National Health and Nutritional Examination Survey, Lin et al. (33) found the prevalence of hearing loss to be 63.1% for Chinese aged 70 years and over. These three rates are very close to the findings of the present study (80.2% for vision loss and 64.9% for hearing loss).

This differences in the prevalence of vision loss, hearing, and DSL between the current study to those conducted in Western countries is not surprising since there are country disparities in the general health status of populations, exposures to environmental and occupational hazards, identification of sensory loss (measures of visual acuity and audiometric data have often been used, whereas in the current study, self assessed sensory loss was used), access to healthcare and service delivery design for those with sensory losses. The Global Aging Watch Index (34) indicated that the health status of older people aged 60 years and older in China in 2014 was ranked 58th in the world, which is much lower than the health status of older people in developed countries (Australia, Japan and New Zealand were ranked within the top 10, and the US and UK were ranked within the top 30).

Comparison between the Household, Income, and Labor Dynamics in Australia (HILDA) Survey (35) and CHARLS 2013 data also show differences in self-rated health, chronic conditions and ADL limitations amongst older men aged 60–64 years. In the Australian dataset (HILDA), 25.5% of respondents reported poor/fair general health, 42.0% reported having any chronic diseases/conditions and 14.7% of respondents reported any ADL limitations. For the same age group in China (CHARLS data), the rates were 76.5, 73.1, and 11.3%, respectively. In comparison to Australians, Chinese older people are much more likely to report poor/fair general health and have chronic diseases, although they are slightly less limited in ADL limitations. Country differences in sensory loss prevalence as measured by self-report may also be influenced by cultural understandings of terms such as "fair" and "poor." These linguistic nuances need to be further investigated.

Gender differences for the prevalence of poor/fair vision and hearing impairment in this study were evident but not large. Whilst there were slightly more women reporting vision loss than men, the opposite occurred for hearing loss. This is consistent with previous research that supports these gender differences. According to Courtright and Lewallen (36), more women than men are affected by visual impairment and blindness possibly due to risk factors (social and cultural differences), access to services (for example, reduced services for women) and life expectancy (in most cultures, women have a longer life expectancy than men). A gender disparity is also evident in relation to hearing loss confirming previous studies (37), particularly since significantly more men than women are exposed to hazardous occupational noise (38). However, in terms of aid use women appear to be more disadvantaged than men although sensory aid use overall was very low across the whole sample. More men used glasses regularly and hearing aids than women. Little literature is available regarding gender disparities in hearing aid use, although

TABLE 6 | Estimated results from multivariate regression models on sensory loss and social activities.

All persons aged 60+	Social activities: number of types			Social activities: any (yes/no)			Social activities: leisure (yes/no)			Social activities: helping others (yes/no)			Social activities: learning (yes/no)		
	Coefficient	**Std. err.**	***P*-value**	**Coefficient**	**Std. err.**	***P*-value**	**Coefficient**	**Std. err.**	***P*-value**	**Coefficient**	**Std. err.**	***P*-value**	**Coefficient**	**Std. err.**	***P*-value**
60–64 (REFERENCE)															
65–69	−0.022	0.071	0.760	0.059	0.072	0.411	0.000	0.076	0.998	−0.109	0.100	0.276	0.195	0.252	0.439
70–74	−0.142*	0.070	0.042	0.001	0.078	0.994	−0.002	0.078	0.978	−0.328*	0.125	0.009	−0.120	0.197	0.544
75+	−0.304*	0.079	<0.001	−0.159	0.083	0.054	−0.092	0.082	0.262	−1.164*	0.156	<0.001	−0.305	0.214	0.155
MALE (REFERENCE)															
Female	−0.115*	0.055	0.035	−0.051	0.058	0.375	0.001	0.059	0.992	−0.098	0.086	0.258	−0.265	0.176	0.133
Poor/fair vision	0.148	0.112	0.186	0.190	0.119	0.111	0.135	0.126	0.284	0.002	0.155	0.990	0.330	0.371	0.373
Poor/fair hearing	−0.247	0.297	0.407	−0.314	0.302	0.300	−0.159	0.301	0.597	−0.310	0.506	0.541	0.281	0.528	0.595
DSL	−0.005	0.160	0.977	0.016	0.166	0.923	−0.027	0.167	0.871	0.249	0.232	0.284	−0.110	0.388	0.778
Unmet needs for glasses	−0.454*	0.061	<0.001	−0.444	0.068	<0.001	−0.351	0.071	<0.001	−0.384*	0.098	<0.001	−0.925*	0.231	<0.001
Unmet needs for hearing aid	−0.003	0.270	0.992	0.076	0.272	0.781	0.016	0.270	0.952	−0.032	0.489	0.948	−0.830	0.509	0.103
Intercept				0.482	0.098	<0.001	0.236	0.099	0.016	−1.551	0.126	<0.001	−2.567	0.206	<0.001
Sample size	7,212			7,212			7,212			7,212			7,212		
R2	0.010			0.0105			0.006			0.027			0.039		

**indicates statistically significant at a significant level 5%.*

Data source: CHARLS 2013. http://charls.pku.edu.cn/en.

outcomes of a cross-sectional survey based on 4,979 adult males and 3,410 females in Switzerland suggested that women reported a higher prevalence of daily and regular hearing aid use than men (39). In comparison, no gender differences were found in older adults' hearing aid usage based on data from the National Health and Nutrition Examination Survey 2005–2006 and 2009–2010 (40).

Education, financial security and rurality impacted negatively on self-reported vision and hearing. Those people with less education or who lived rurally or had a poorer living standard or earned less, had a higher prevalence of self-reported poor/fair vision or hearing. This is not surprising since it is common for people who have financial constraints or live rurally to have less access to healthcare (especially specific services as supplied by allied health professionals such as Optometrists and Audiologists) as well as experience poorer health outcomes compared to their metropolitan counterparts (41). There is also a disparity between low and high-income countries accessing services such as visual examinations (42). In an analysis of a worldwide population-based dataset, Vela et al. (42) found that the number of people accessing visual examinations was 10% in low income countries and 37% in high income countries. Some of the factors associated with visual examinations included older age, female gender, more education, and urban residence.

There was a low uptake of glasses and hearing aids in this study although self-reported poor/fair vision were in comparison, large. This is not surprising and has been confirmed in previous research. According to Kuang et al. (25), in China, the awareness of eye care and vision improvement through the uptake of glasses or surgery (for example cataract surgery) is lower than expected. Barriers to widespread use of devices mentioned by these authors included the cost of spectacle frames and lenses, a decreased need due to older people not engaging in distance vision activities and the idea that vision loss is part of the natural aging process. Cataract surgery is also still low in China. In a retrospective cross-sectional study conducted in Shanghai, Zhu et al. (43) reported that although the cataract surgery rate increased from 2006 to 2009 by 26.94%, it is still low and less than the target suggested by the WHO. Yet, in a recent study of 87 Chinese older patients with low vision or blindness Ma, Zhang and Xu (44) suggested that reading glasses and visual aids were effective and an economical means of improving far and near visual acuity.

In the current study, although the prevalence of hearing loss was large, the use of hearing aids was small, leading to a high rate of unmet needs. This was especially so for those with low education, poorer SES and in those who lived rurally. Again, this is not surprising since in China, there is overall a smaller than expected uptake of hearing aids or assistive devices. In a review of the literature, Ji et al. (23) reported that although digital hearing aids are available in China, the number of people using hearing aids is small compared with the proportion of older people with hearing loss. Factors suggested as barriers include: a traditional attitudes toward hearing loss in older people; financial reasons; worries about unfamiliarity of hearing aids; and inability to manipulate hearing aids. Although bone anchored hearing aids, middle ear implants, and cochlear implants are also available in China, there is little data regarding their uptake by the older adult population.

Social participation is particularly important for general health and well-being and older people are encouraged to participate in social activities even if they have health difficulties (45). Social participation is impacted by sensory loss and associated communication difficulties (17). The results of this study suggest that people with poor/fair vision, poor/fair hearing or DSL, and high unmet needs for glasses or hearing aids, had significantly lower participation in social activities, compared to those with good, very good or excellent vision or hearing. This finding is especially important as there have been calls worldwide by peak bodies, consumer groups and governments to increase the participation of older people in civic life (46). Social participation is a key platform for active and healthy aging concepts. The reason for this policy approach has often been economic, we need more older people to be economically productive, however civic participation is a basic human right for all ages (47). Disabilities associated with vision and hearing loss in older people are often considered a "normal" part of aging by both older people themselves and health professionals. However, there is strong evidence that appropriate sensory screening and rehabilitation programs can greatly improve the quality of life for older people. Sensory loss in older people is often undetected and underestimated. Hearing loss in older adults for example is a leading cause of adult hearing handicap in the US and is originally slow to develop however, if left untreated impacts significantly on the person and significant others (48). Awareness of sensory loss, improved education and screening leads to early identification, and management such as fitting of aids and communication training, leading to improved well-being and quality of life.

CONCLUSIONS

In this paper we have provided strong evidence that the prevalence of sensory loss is a significant health issue for older Chinese that impacts on their ability to engage in social and work activities. However, unmet needs for sensory aids are high in China.

Regular vision and hearing screening for older Chinese is recommended and increasing the uptake of sensory aids is an important goal to reduce disability in those with sensory loss. The health system in China predominantly relies on doctors and nurses to deliver health care, mainly in tertiary hospital settings (49). The (2017–2025) Chinese State Council plan for the prevention and treatment of chronic diseases emphasizes better co-ordination of prevention and treatment and improved primary health care services (50). While the primary health care reforms seek to increase the numbers of doctors and nurses working in primary care settings, training in sensory loss screening, and rehabilitation and communication approaches is limited. The primary health care setting provides an important opportunity to meet the needs of older people with sensory loss through screening and encouragement in the use of aids.

The availability of audiologists or doctors and nurses with audiology training is low in China and thus identification of hearing loss and access to audiological services is uncommon especially for older people with low financial resources. To increase the use of sensory aids in older people with sensory loss, reduced financial barriers to both screening and the cost of aids is needed.

We recommend that further training in sensory loss and rehabilitation be made available to primary care health professionals, particularly those who have high older patient caseloads. There is also a need for the training of hearing specialists in hearing care. Some multinational private hearing care companies are now setting up hearing training centers in China but public facilities are limited (51). Finally, we recommend that consideration be given to the inclusion of greater screening and sensory aid reimbursements in medical insurance schemes in China.

STUDY LIMITATIONS

CHARLS is an excellent longitudinal survey on China's health but our findings should be interpreted with some caution as there are limitations which should be noted. Firstly, we have only examined the cross-sectional associations between sensory loss and social participation without aiming to understand the underlying causality. Secondly, CHARLS is a representative community sample in urban and rural areas but it does not cover the ∼1% older people living in an institution. Thirdly, CHARLS uses self-reported measures of sensory loss which has great ecological validity and reflective of sensory disability, yet might be subject to reporting bias and prone to cultural difference in conceptualisations of sensory loss, thus potentially limiting comparisons of our findings with similar studies in western developed countries. Future research could further explore the casual relationships between DSL and social participation and well-being using longitudinal data when more waves of CHARLS survey data become available.

ETHICS STATEMENT

The original CHARLS survey data was approved by the Ethical Review Committee of Peking University, and all participants signed informed consent at the time of participation. There is no need for ethics approval for second hand data users.

AUTHOR CONTRIBUTIONS

CH and CB conceptualized the paper. CG conducted all the statistical analyses. CH drafted the paper and CG and CB revised the paper. All authors have final approval of the published article and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

FUNDING

This study has been funded by an Australian Research Council (ARC) Discovery Project (Number: DP160103023).

ACKNOWLEDGMENTS

We would like to acknowledge the China Health and Retirement Longitudinal Study (CHARLS) team for providing the data and acknowledge financial support from both the Australian Research Council (ARC) Discovery Project (DP160103023), as well as the Centre for Research on Ageing Health and Wellbeing (CRAHW) at the Australian National University. The contents of this publication are solely the responsibility of the authors.

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Conflict of Interest Statement: 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.

Browning CJ, Qiu Z, Yang H, Zhang T and Thomas SA (2019) Food, Eating, and Happy Aging: The Perceptions of Older Chinese People. Front. Public Health 7:73. Doi: 10.3389/fpubh.2019.00073

Abstract

长期以来，中国政府及其人民一直在关注其人口的粮食安全，这是经济和社会发展中最重要的问题之一。中国许多老年人生活在粮食安全不稳定的时代。因此，尽管食物在所有中国人的中国文化中都处于中心地位，但它与老年人特别相关。在本文中，我们探讨了食物和饮食在中国老年人的生活中的意义，以及食物和饮食如何促进健康，从而快乐的变老。在这项研究中使用了焦点小组和定性访谈。参与者来自中国西南的永福县农村地区以及北京的方庄和海丹区。招募了42名年龄在62-83岁之间的参与者。所有焦点小组和访谈均以普通话进行，并在参与者允许的情况下进行录音。录音带由一名华语研究员录制，然后翻译成英语。对数据进行连续和比较的分析，对成绩单进行编码，并确定主题和子主题。然后在与所有作者的研讨会上介绍和讨论了最初的分析和解释。出现了两个主要主题-幸福的老年所需的食物数量和食物质量。参加者讨论了由于他们在童年时期经历饥荒的经历而渴望吃饱的愿望。但是，他们也认为，老年人应该为了健康少吃，特别是少吃高脂肪食物。还讨论了食品质量和负担能力的重要性。谷物和肉类被誉为"好"食物，并且在其饮食中对于幸福的老年很重要。参加调查的人员，特别是城市地区的人员，对食品安全性表示关注。这项研究证实了食品对中国老年人的高度文化重要性。社会和经济寿命的经历继续影响老年人的饮食习惯。在中国，老年人与食物相关的生活经历与年轻人有很大的不同，健康促进信息需要通过这些独特的视角来传达，以最大化其有效性。

frontiers in Public Health

ORIGINAL RESEARCH
published: 05 April 2019
doi: 10.3389/fpubh.2019.00073

Food, Eating, and Happy Aging: The Perceptions of Older Chinese People

Colette J. Browning[1,2]*, *Zeqi Qiu*[3], *Hui Yang*[2,4], *Touhong Zhang*[5] and *Shane A. Thomas*[1,2]

[1] Research School of Population Health, The Australian National University, Canberra, ACT, Australia, [2] International Primary Health Care Research Institute, Shenzhen, China, [3] Department of Sociology, Peking University, Beijing, China, [4] School of Primary Health Care, Monash University, Clayton, VIC, Australia, [5] WHO, Beijing Office, Beijing, China

China's government and its people have for a long time focused on food security for its population as one of the most important issues in economic and social development. Many older people in China have lived in times when food security was not stable. Thus, while food has a central position in Chinese culture for all Chinese people, it is of particular pertinence to older people. In this paper we explore the meaning of food and eating in the lives of older Chinese people in China and how it contributes to healthy, thus happy aging. Focus groups and qualitative interviews were used in this study. Participants were recruited from the rural Yongfu Province of Southwest China, and the urban Fangzhuang and Haidan districts in Beijing. Forty-two participants were recruited aged 62–83 years of age. All focus groups and interviews were conducted in Mandarin and audiotaped with the participants' permission. Audio-tapes were transcribed by a Chinese speaking researcher and then were translated into English. Data were analyzed continuously and comparatively, transcripts were coded, and themes and sub-themes were identified. The initial analysis and interpretation were then presented and discussed at a workshop with all the authors. Two major themes emerged—the quantity of food and the quality of food required to have a happy old age. Participants discussed the desire to eat "until you are full" because of their experiences of famine during childhood. However, they also believed that as an older person they should eat less for their health, particularly less high fat foods. The importance of the food quality and food affordability was also discussed. Grain and meat were characterized as "good" foods and important in their diets for a happy old age. The participants, especially those from urban areas, were concerned with food safety. The high cultural importance of food for older Chinese in China was confirmed in this study. Social and economic lifespan experiences continue to impact on the food and eating attitudes and practices of older Chinese. The food related life experiences of older Chinese in China are quite different from younger Chinese and health promotion messaging needs to be informed by these unique perspectives in order to maximize its effectiveness.

Keywords: food, eating, happy aging, China, older people

OPEN ACCESS

Edited by:
Sunjoo Kang,
Yonsei University, South Korea

Reviewed by:
Mary Odum,
Texas State University, United States
Fung Kuen Koo,
University of Sydney, Australia

***Correspondence:**
Colette J. Browning
colette.browning@anu.edu.au

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

Received: *22 November 2018*
Accepted: *14 March 2019*
Published: *05 April 2019*

Citation:
Browning CJ, Qiu Z, Yang H, Zhang T and Thomas SA (2019) Food, Eating, and Happy Aging: The Perceptions of Older Chinese People. Front. Public Health 7:73. doi: 10.3389/fpubh.2019.00073

INTRODUCTION

China's government and its people have for a long time focused on food security for its population as one of the most important issues in economic and social development. Many older people in China have lived in times when food security was not stable. Thus, while food has a central position in Chinese culture for all Chinese people, it is of particular pertinence to older people (1, 2). In this paper we explore the meaning of food and eating in the lives of older Chinese people and how it contributes to healthy, thus happy aging.

Like many countries China has an aging population. In 2017, 16.0% of the people living in China were aged 60 years and over (3). By 2050 29.9% and 6.8% of the population will be aged 65 years and over and 80 years and over, respectively (4). By 2060 the number of older people in China will peak. Life Expectancy in China in 1950–1955 was 40.8 years, and by 2025–2030 it is expected to reach 78.1 years. Population aging is occurring at a much more rapid rate in China than in many other countries. For example, it took only 30 years for the proportion of the Chinese population aged 60 and over to increase from 7 to 14%, while in the U.S and France, this rate of increase took 70 and 130 years, respectively (5). Most of this rapid change in China has occurred in the history of a low GDP per capita of $US1,000, although of course China's per capita GDP has grown strongly in the last decade. The Chinese social security and health systems have many challenges in responding to this demographic change.

Countries such as Australia and the UK have responded to population aging by developing specific aged and community care services and a strong primary health care system. In addition, the call for healthy and active aging policies are championed as a way of reducing the "burden" of aging populations, and also recognize the potential of older people to age well with support, challenging aging stereotypes (6, 7). In China, such approaches have great potential as active engagement in the family and community are strong values for older people. The Chinese Government has implemented in law an official agenda for aging programs:

> *All elderly people are to be provided for and enjoy proper medical care; all of them are to be given opportunities to pass on their experiences as well as to learn new things; all of them should be given the opportunity to do what they can for the society; all of them should enjoy their later years (8).*

In order to promote healthy/active aging it is important to understand older people's perceptions of aging and their aspirations for their lives as they age (9, 10). The study reported in this paper is part of a program of research that examined older people's conceptualizations of healthy aging across a number of countries including Australia, Malaysia and China (11–13). The program asked older people to reflect on what healthy aging meant to them and to consider factors that contributed to their quality of life as they aged. In Australia healthy aging was associated with emotional bonds, physical health and well-being, maintaining independence and social interaction. The focus for older Malays was financial independence, physical health and functioning, safe living environments, spirituality and peace of mind. The broad aim of the program was to investigate: how older people understand aging and healthy aging; older people's expectations of a healthy old age; and older peoples' experiences of aging and the factors that influence healthy aging.

This current paper focuses on the role of food security in the lives of older people living in China and how this basic need contributes to their conceptualizations and experience of "happy" aging. Based on advice from our Chinese colleagues the Chinese term for happy aging was preferred to healthy aging and is used throughout rest of this paper.

The vast majority of older people living in China today have lived through a number of key events in Chinese contemporary history. These included the second Sino-Japanese War (1937–1945); the Chinese Civil War (1946–50) and the Cultural Revolution (1966–1976). Many had also lived throughout significant natural disaster events, such as the Great Chinese Famine (1956–1961). Estimates of the number of people killed by the Great Chinese Famine are in the order of 30 million (14). Poverty and food security provide the historical and social backdrop for this study.

The importance of food security as a basic physiological need was highlighted by Maslow (15):

> *Anyone who attempts to make an emergency picture into a typical one and who will measure all of man's goals and desires by his[her] behavior during extreme physiological deprivation, is certainly blind to many things. It is quite true that man [people] live(s) by bread alone — when there is no bread* (1943, p.375).

According to Maslow's hierarchy of needs, until basic physiological needs are satisfied other motivating factors such as social and psychological needs cannot be addressed. Similarly, food, as a main parameter of life, was identified by the Chinese philosopher Sima Qian two thousand years ago. Based on his perspective, food is the most important need of ordinary people.

> *To the ruler people are all-important; while to the people foodstuff is all-important Sima Qian, the Records of Historian, Chinese historian in Han Dynasty, 145-87 BC (16).*

In oriental philosophy, food and eating do not merely satisfy a physiological need. Food is a vehicle for family relationships, emotional well-being, and social harmony.

A number of research questions were addressed in this study:

1. How do older Chinese people in China conceptualize food and eating in their health and well-being in old age?
2. What is the importance of food and eating in the aspirations for a happy old age of older Chinese people in China?
3. What influence do early life experiences have on the role of food in happy aging for older Chinese people in China?

METHODS

Ethics approval for this study was obtained from Monash University Human Research Ethics Committee, approval number 2007000453.

Qualitative interviews and focus groups were used in this study. An inductive analysis method was used to extract themes and interpret the words of the participants in the context of the historical and political changes that have occurred in China during the participants' lives. As researchers working in the fields of aging, psychology and sociology our assumptions were that older people are willing and able to reflect on their life experiences and that their attitudes to food and eating would be impacted on their experiences across the lifespan, particularly their experiences during significant historical events such as the Great Famine. In terms of methodological approaches, our opinion is that the study research questions are most suited to qualitative inquiry. Focus group methodology allows interaction between the participants and can facilitate insights by the participants about their experiences. However, the researcher needs to ensure that each participant has opportunity to express their opinions. Where some participants preferred individual or couple interviews this was accommodated and provided triangulation of methods.

Participants were recruited for the study through local Chinese neighborhood committees and community health services personnel. These local contacts liaised with potential participants and organized a location and time for a researcher to meet with and explain the study to the participants. The participants were recruited from the rural Guilin in the Yongfu Province of Southwest China, and the Fangzhuang and Haidan districts in Beijing. Yongfu (population 268,000) is located in the northern part of Guanxi Province in the south of China. Fangzhuang is a large urban community (population 1.57 million) in the southeast of Beijing and Haidan (population 2.1 million) is located in the north west of Beijing and houses a number of universities and technology industries. These areas were selected as they provided a range of individuals from different SES backgrounds. Purposive sampling was used. Participants were women and men aged 60 years and over, from varied occupations and living circumstances (living alone, living with spouse and living with family).

A total of five focus groups were conducted. Two were conducted in Yongfu and three in Beijing. Focus groups were conducted in Mandarin by team members from PKU and Monash University. In addition to the focus groups, some face to face interviews were also conducted by the PKU research team with individuals or married couples who preferred that method of interview. Basic sociodemographic information including age, gender and occupation was collected for each participant.

The interview protocol was developed based (1) a review of the healthy/successful aging literature and (2) research team meetings with older Chinese to test the validity of the questions and feasibility of the project methodology. Questions for both the focus groups and interviews included: What words do you use to describe aging? What are the most important things to have when someone reaches old age? What does happy old age look like? How can we achieve a happy old age?

Interviews and focus groups lasted ∼60 min and were audiotaped with participant permission. Audio-tapes were transcribed by a research assistant at PKU and YH translated the transcripts into English so that the English-speaking members of the team (CB and ST) could contribute to the analysis. YH used notes to explain some of the responses from participants, such as historical references or the meaning of Chinese proverbs. Backtranslation was used in a sample of the translated interviews, to ensure rigor and reliability.

Data were analyzed continuously and comparatively. The transcripts were read and re-read, phrases were coded, and themes and sub-themes were identified. Similarities and differences in the responses of the participants were identified. A workshop method was used involving all authors to present and discuss the findings and add further interpretation of the findings based on historical events that may have impacted on the participants attitudes to food and eating. The workshop allowed the identification of any differences in the interpretation of the transcripts and to revisit any key thematic areas and clarify meaning. At the conclusion of the last focus group the team concluded that data saturation was reached as no new themes were emerging.

Trustworthiness of the study was addressed using the following approaches. *Credibility* was established through the use of appropriate qualitative methods relevant to the research questions, our familiarity with the culture under investigation and our access to historical documents to interpret the impact of participants' experiences at particular times in history. Credibility was also established through the use of thick description. *Confirmability* was demonstrated by the documentation of our assumptions detailed above related to our disciplinary backgrounds and previous work with older people and our use of triangulation. In most qualitative studies, findings are relevant to specific population groups or situations so demonstrating *transferability* to other population groups or situations is not feasible. In the current study the participant's background, gender, age, occupation and living circumstances are provided and based on this information it is highly likely that the findings are transferable to others with similar characteristics.

The research findings are illustrated below using quotes from the participants.

Table 1 provides information about the age, gender, occupation and place of residence of the participants. The participants in this study came from a range of socioeconomic backgrounds and living circumstances. The participants included people living with their spouses, people living alone and people living with their children. Some had responsibility for the care of their parents, spouse or their grandchildren and others did not have any children. Formal schooling varied from as little as 3 years to university level education.

Forty-eight individuals participated in either an interview or a focus group. Six women in one focus group had to be

TABLE 1 | Participant Characteristics.

Participant	Age	Gender	Geographic location	Occupation
1	60–64	M	Beijing	Retired Farm worker
2	80–84	M	Beijing	Retired Factory Worker
3	70–74	M	Beijing	Unknown
4	60–64	M	Beijing	Family massage since retirement
5	60–64	M	Beijing	Retired general manager of a large store
6	70–74	M	Beijing	Retired accountant
7	60–64	M	Beijing	Retired French interpreter
8	85–89	M	Beijing	Unknown
9	70–74	M	Beijing	Unknown
10	65–69	M	Beijing	Retired hotel worker
11	75–79	F	Beijing	Retired Kindergarten Manager
12	70–74	F	Beijing	Retired School Teacher
13	70–74	F	Beijing	Retired teacher
14	65–69	F	Beijing	Retired salesperson
15	70–74	F	Beijing	Retired bus ticket salesperson
16	65–69	F	Beijing	Retired worker
17	65–69	M	Beijing	Retired Communist Party Secretary
18	Unknown	F	Beijing	Unknown
19	65–69	F	Beijing	Retired vegetable farmer (worked in a greenhouse)
20	65–69	F	Beijing	Retired high school teacher
21	70–74	M	Beijing	Retired engineer
22	80–84	F	Beijing	Retired factory worker
23	70–74	F	Beijing	Unemployed
24	Unknown	M	Beijing	Worker
25	65–69	F	Beijing	Farmer
26	75–79	M	Beijing	Retired technician from Peking University
27	75–79	F	Beijing	Unknown
28	80–84	F	Beijing	Retired researcher and old revolutionary
29	65–69	F	Beijing	Retired farmer.
30	70–74	F	Yongfu	Farmer, still working
31	70–74	F	Yongfu	Farmer
32	70–74	F	Yongfu	Unemployed, makes her own living
33	60–64	F	Yongfu	Worked for the local government.
34	65–69	F	Yongfu	Retired financial worker
35	65–69	F	Yongfu	Retired nurse
36	70–74	F	Beijing	Has never worked outside of the home
37	60–64	M	Yongfu	Retired teacher
38	75–79	M	Yongfu	Retired veteran cadre
39	75–79	M	Yongfu	Retired teacher
40	65–69	M	Yongfu	Farmer
41	65–69	M	Yongfu	Unemployed
42	70–74	M	Yongfu	Retired worker

excluded from the analysis because of the poor quality of one of the recorded interviews. This left a total of 42 participants, aged between 62 and 83 years old. Twenty women and 22 men participated in the interviews. Most of these ($n = 30$) lived in Beijing, with 12 from the rural Yongfu district.

RESULTS AND DISCUSSION

A number of themes and sub-themes concerning food, eating and a happy life in old age were extracted from the transcripts. This paper focuses on two major themes, the (1) *quantity of food* required to have a happy old age and the (2) *quality of the food* to have a happy old age. Other themes will be the subject of another paper. The themes and subthemes are summarized in **Table 2**. Before discussing these themes in detail, we provide a discussion of early life experiences of the participants whose attitudes to food and eating have been shaped by the historical periods they have lived through. Their descriptions of their experiences as children and younger adults, have shaped their cultural and societal values and their views of how food and eating impact on their lives in old age. The participants came from both rural and urban environments which also impacted on the way they understand the role of food in their lives.

Early Life Experiences: I Was Tired and Hungry All the Time

Many experienced extreme hardships as children:

> *I worked in a factory since the age of 10. At that time, I was a child laborer. There was not enough food in my family. I went to school from the age of 6 to 9. I used to walk to the factory at night on foot. I worked 12 hours each night. An 8-hour day? No way! I only had one*

TABLE 2 | Themes and subthemes.

Theme	Subtheme
Quantity of food	Eat until you are full
	Eat less
	Eat what you want to eat
Quality of food	Eat good food
	Meat is a good food
	Food affordability
	Dietary supplements/health products
	Food safety

day of rest in a week (Participant 2, 80–84-year-old Male, retired factory worker).

Others discussed their experiences with poverty, and the impact that this had on their lives and how these life experiences were important in shaping their current views about life and values in old age. Most notably, participants discussed how in the presence of poverty, family solidarity and harmony became a driving force in their lives:

We lived a particularly difficult life. We were extremely poor. My parents had seven daughters and they raised us through hardships and tribulations. There were times when we were dying of hunger and we had to go and collect wild vegetables in the field. We worked so hard, but never had enough to satisfy our hunger (Participant 16, 65–69-year-old Female, retired worker).

My experience is based on my past-present comparison. I have experienced the Old Society and the New Society. I have experienced many dynasties. I have formed my conclusions based on experience. Seniors like me have a lot of life experience, and we should learn from seniors and listen to them very carefully (Participant 2, 80–84-year-old Male, retired factory worker).

For all of the participants their early life experiences had profound impacts on their experience of old age and their views of a happy life as they age. The most salient and unforgettable past experiences of Chinese old people are hunger and poverty. Most of them lived very stressful lives when they were young. They worked hard for survival. Their limited earnings were spent on food, and this was often not enough. They are witnesses to the *Old Society* (before 1950s), in which older people had a miserable life, and some of them resorted to begging. They also witnessed the *Great Famine* (end of 1950s), where millions of people died from hunger. The experience taught them that they needed to satisfy their most basic need: obtaining food.

As well as early life experiences, life experiences across the entire lifespan, including SES experiences, also influenced the participants conception of eating and the role of food in their lives. In the last 25 years, in particular, the life of Chinese people has improved dramatically in terms of economic prosperity and the availability of goods and services. As survivors of the *Old Society* and the *Great Famine*, older people are now more satisfied with their current lives. When they compare their early lives with their lives today, the availability of adequate food and clothing contributes greatly to a happy life. The participants see this transition from famine to adequate food not only in terms of satisfying a physiological need but also in terms of social development for the whole society.

My partner is an old worker from the Qinghe woollen cloth factory. At the time of the Japanese [invading China], [he was] just [a child] wearing buns screen [the clothes only for child, which cover the private parts of the body]. [He] Just worked here. Worked as child laborer following the Japanese invasion. After liberation, he cared if food [was]available. He is not easy (Participant 25, 65–69-year-old, Female, farmer).

I just think, the elders in old society [meaning: before the 1950s] had to beg for food. And think again, there was no fire to heat [the food]. If collecting some firewood, [they] needed to make fire to heat. The elders…I saw elders were suffering in my childhood. Look, I am more than 70 now and have a happy life…I saw many elders in old society…their life…misery (Participant 11, 75–79-year-old, Female, retired kindergarten teacher).

At that time [early 1960s] there was a grain coupon. How much grain you could buy was determined by how many grain coupons you had. It was too hard at that time. Now I don't eat much. But at that time, it was too hard (Participant 28, 80–84-year-old Female, retired researcher).

My partner [he died] was… a worker. I moved in with his family after marriage. Later I was tortured by his family, which hurt me a lot. I tell you, I suffered greatly. In the old society, I went to work ... I did not have the right to speak. No right at all. I did not have a child after the liberation. I only had one thought in mind, I would say, just work hard, study hard, then the Communist Party will give you a bowl of food. I just started to work with this in mind (Participant 11, 75–79-year-old, Female, retired kindergarten teacher).

Rural vs. Urban Life

China has a traditional urban-rural dual social structure. Farmers, in ancient China experienced a much better life than urban residents. However, Chinese rural inhabitants, about 80% of the national population, were vulnerable victims of natural disasters and most current Chinese rural aged people experienced an era of famine. Unlike urban Chinese, farmers were rarely subsidized by the government. During the first three decades (1950–1970s) of the *New China*, urban workers were identified as the "leading class" and proletariat; while rural peasants were treated as a "coalition partner" of the revolution. The gap between urban and rural life was significant. Farmers engaged in heavy work, were poor and hungry. In the Communes of the 1960–70s, the collectivization further deprived farmers of their land and produce. In rural China, poverty contributed to poor food security and poor health (17).

At the end of 1980s, China's economic reform was launched in rural areas. Farmers enjoyed the "Household contract responsibility system" in which they would be able to increase their income through working on the leased land. Rural reform in China created a large increase in productivity, transitioning the farmer's experience from hunger to the availability of adequate

food. Farmers were contented, mainly because the food problem was solved. The national social and economic development agenda of the Twenty-first century aims to transition China from "adequate food and clothing" to "a well-off life." In other words, quality of life is the focus, rather than sufficient food and clothing (18).

> *Our past experience? We were too tired from working in the agriculture commune. We were in the agriculture commune during our early years. Work was too tiring. [We] could not even manage to consider our children's eating and drinking. [We] could not even take care of our children. Anyway, they [children] could eat until they were full* (Participant 19, 65–69-year-old Female, farmer).

> *When we were sent to the countryside [during the Culture Revolution], the salary was measured by work points. I worked hard and got more work points than other people. As there were many children in my family, they always lacked food. My family lived a comparatively hard life during those days* (Participant 31, 70–74-year-old Female, farmer).

> *I feel my life is a happy life now. No worries about eating, no worries about drinking. You see… there are no worries about money now… If you want to eat beef, go buy it; if you want to eat fish, go buy it; you buy what you want to drink. Previously? If you wanted to eat something? Nothing. We were peasants. In previous years, pickled vegetable could be eaten for a full meal. In one year, or at least for half a year, we needed to eat chaff and swallow [pickled] vegetable. [Now] we don't worry about this* (Participant 19, 65–69-year-old Female, farmer).

> *I just came for my husband. He had a heart attack [myocardial infarction]. I think it was caused by tiredness. Too tired. You see, on normal days there was no regulation [regular eating times]. He would not eat when it was the time for eating; not sleep when he should be sleeping; not drink when he should be drinking. You see, he was off duty at 12 o'clock or 1 o'clock, he had no time to prepare lunch. He also had a meeting, had something to say. He did not have time to eat* (Participant 23, 70–74-year-old Female, housewife).

Quantity of Food

We now turn to a discussion of the two main themes *Quantity of Food* and *Quality of Food*.

This theme included two main sub-themes that appear contradictory 'eating until you are full' and 'eating less.' While many participants recommended eating until you are full (in part a reaction to deprivation in their early lives), they recognized that they needed to eat less 'unhealthy' foods such as fried foods and eat more healthy foods such as vegetables.

"Eat Until You Are Full"—I Have Had Enough to Eat

President Deng Xiaoping's policy in the 1980s was to solve the problem of adequate food and clothing and the Chinese government declared that the target had been reached by the end of Twentieth-Century (19). The participants expressed their happiness that they now had enough food to eat. Most Chinese, especially older Chinese who experienced hardship before their retirement, believe that "eating until you are full" means that you have a good life. Their current life is much better than their earlier lives when they had little to eat. Participants from developed areas (such as urban Beijing) to developing areas (such as the rural villages of Guilin in Yongfu county), from north China to south China, commonly agreed that there had been improvement in food security. The provision of adequate food satisfies one of Maslow's physiological needs within the hierarchy of needs pyramid. Adequate food is necessary before other needs higher up the pyramid (safety, belonging, esteem, self-actualization) can be satisfied. Equating a good life with "eating to you are full" recognizes the importance of this basic physiological need to our participants, especially given their experiences of famine in their early lives.

"Eating until you are full" does not necessarily provide good nutrition but most of the participants, especially those from rural China, believed "eating until you are full" is "good enough"; there is no need to worry about food quality.

> *Yes, [I am] very happy. No worries about eating, no worries about clothes* (Participant 27, 75–79-year-old Female, retired worker).

> *Enough to eat. Life is OK. Not thinking of the issue of what to eat, to buy chicken, or, to buy chicken essence* (Participant 22, 80–84-year-old Female, retired librarian).

Not all Chinese old people are beneficiaries of the national economic prosperity. Some of them still cannot afford to "eat until you are full." Most Chinese farmers, for instance, are not eligible for retirement or to receive a pension (20). Where there are less government subsidies and the collapse of village collective funds, aged farmers have to seek basic support (including food) from traditional family-based caring and support. Therefore, "eat until you are full" is still a fundamental desire for older farmers. Rural women, who usually depend on their partners and/or children for financial support, are at greater risk of food insecurity.

There is significant variation in socioeconomic development between geographic regions in China. Rapid urbanization created bigger cities which quickly stretched into suburbs encroaching on the countryside. Between the 1950s and 2007 the number of cities in China increased from 69 to 670. Among the urban cities, 89 had a population of more than 1 million. Today more than half of the Chinese population live in cities while in the 1980s this figure was 20% (21). Many older people and their families lived in the transition areas (the urban-rural integration area) and lost the opportunity to work on farms. Their children had to find work in the cities and the tradition of family caring is facing a significant challenge due to the internal migration of younger workers. Pensions for older rural Chinese (or compensation for losing farm work opportunities) is lower (358 RMB per month) than for their urban counterparts (541 RMB per month) (22). Urbanization has brought new difficulties to older farmers who escaped from famine but now face the prospect of low income and less support from their families.

However, poverty is also an issue in the urban areas of China, particularly for older people or for families caring for older people. While many urban older people have a retirement

pension, price increases for food and other consumables have put a strain on their budgets.

> *… The two of us [husband and wife] are fed by one person's salary. Is it enough? Hey, that depends on the situation. How can I compare our life with others? Having a full meal [eat full] is all right. [If] no full meal? That is just the way it is. I have no way to change the situation. Situations cannot be compared; our life may be different than others* (Participant 23, 70–74-year-old Female, housewife).

> *Now this [my] life could be called a happy kind of life. I do not have retirement payment; I am not eligible for a retirement pension … The monthly income is different [from person to person]. Some people get several thousand [a month]; while others get several hundred [a month]. I am not on a pension. Anyway, it is ok to have meals. For the elders in the past, there was no retirement and they had no money at all* (Participant 28, 80–84-year-old Female, retired researcher).

In addition, if their children have lost jobs as a consequence of the reform of state-owned enterprises, they may seek help from their older parents. These unemployed young people are called *ken lao zi*, a generation who depend on their parents.

> *This group of young people do not have a stable job. They have no ability to solve their own financial problems. They have to rely on their parents and they create a significant burden for older people* (Participant 25, 66–69-year-old Female, farmer).

This quote reflects the tension in role of mutual/filial obligation within Chinese families. The expectation is that parents will support their children when young who in return will assist their parents as they age (23). Economic circumstances can shift the flow of support at a time when older people may be vulnerable and needing economic support from their children. While in general our participants felt that their socioeconomic circumstances and access to food had improved in their later years, those on low incomes or those who were supporting their children were concerned about food insecurity.

"Eat Less"—Us Older People Should Eat Less

The participants mentioned "eat less" frequently as one of their core beliefs. They agreed that they should: "Eat until we know when to stop." Eating less (particularly fewer fatty foods) was seen as a good way of reducing the burden on the digestive system and to feel comfortable after a meal. In addition, they suggested having several small meals each day, rather than a few large ones.

> *…Eating, [we] just do not eat [too] much… Eat what you want to eat today. Buy some, not much, enough is ok. Is that right?* (Participant 21, 70–74-year-old Male, retired engineer).

> *[for aged people], according to my theory, we should eat… eat less… you may have an additional small meal …but you are not comfortable if you eat too much at one time when you are old* (Participant 23, 70–74-year-old Female, housewife).

> *Old women, they are easy to feed … being old, we can't eat much* (Participant 16, 65–69-year-old Female, retired worker).

Some old people explained in more detail the meaning of "less." For instance, eating less for health reasons such as less intake of oil, less intake of food containing cholesterol, or eating less meat. Some others mentioned "eating until you are half full."

One retired worker in Beijing (participant 5, 60–64-year-old Male, retired manager of a large store), however, did not fully agree with "eat less." He maintained that eating less and eating more are both a hazard to your health. He emphasized a "balanced diet." He stated that: "many of us like to eat meat; we would like to have meat in every meal." He concluded "we cannot accept meat free meal; while we also cannot endure greasy food."

While talking about "eat less," participants also suggested eating more of some foods. Vegetables and fruits were the most common foods they believed should be eaten more often. Participants also specifically promoted eating more "coarse foods," such as corn.

> *Which things are most important [for happy ageing]? Just playing well and eating well are the most important. First you pay more attention to eating and drinking for your diet. Eat less, but more often, but not more than six meals [per day]. Is that right? Eat more vegetables, eat more coarse cereals. Eat less oil. Those foods with a lot of oil should be eaten less* (Participant 17, 65–69-year-old Male, retired village carder).

> *I like to eat meat. Meat should be in each meal. Otherwise your health will be poor. [Some diseases are] caused by eating [too much or too little meat]… In my fried beans [dish], I just need a meat taste, a small amount of meat. [I] have hypertension, also my age is high [nian ji da le, means become much older], I should eat less meat. Look, I listen to TV and the elders say, elders should try to eat less meat* (Participant 36, 70–74-year-old, Female, retired worker).

Eat What You Want to Eat

Our participants believed that eating what you want ensures a happy and satisfying old age. This belief is related to their ability to independently choose what they want to eat.

> *To take care of ourselves, that is enough. Stay happy and glad for the whole day. Eat what you want to eat. That is enough… I have good health through physical exercise. Another thing is to be happy. To play what I can play, to eat what I can eat. It is simply that* (Participant 21, 70–74-year-old Male, retired engineer).

> *My favorite meal is just steamed buns and rice, and some stir fried dishes. Then… it does not matter what else* (Participant 21, 70–74-year-old Male, retired engineer).

> *I know a cancer [patient]… He is back at home and eats what he wants to eat, then exercises the Happy Kungfu … He is nearly recovered… Now his health is good* (Participant 21, 70–74-yearold Male, retired engineer).

> *Eat what you want to eat... it is important for your condition* (Participant 17, 65–69-year-old Male, retired architect).

In summary, our participants agreed that today, because food is more readily available than when they were young, they are able to "eat until they are full." However, they believe that as an

older person they need to have smaller meals and avoid foods that are "unhealthy" such as fried foods and eat more "healthy" foods such as vegetables.

Our findings are consistent with similar studies of habits and beliefs of older Chinese. In a qualitative study of Chinese-American older women, participants noted the importance of a balanced diet for health, eating regular simple meals, and maintaining a stable weight. The consensus from the participants was that a healthy diet should include vegetables and fruit, "eating less meat," not eating too little or too much, and avoiding high fat foods (24). A study in rural China highlighted grandparent's concerns about not having enough food for their grandchildren and the avoidance of hunger based on their experiences in the Great famine (25). A Hong Kong study highlighted that older people were concerned about overeating fatty or fired foods and understood the role of healthy eating, including eating fruit and vegetables, in maintaining good health (26).

Our findings are also consistent with Western studies of older people and their eating beliefs and habits. For example, in an Australian study, older adults valued eating well for health and acknowledged the influence of childhood patterns of eating on current patterns (27).

Our participants also discussed food quality.

Quality of Food

Eat Well, Eat Good Food, Eat Simple Food

Participants often maintained that they should "eat well," "eat better," or "eat good food." This is in part an indication of their desire to eat good quality food and food that is good for their health.

> *We are now retired and stay at home. We have a willingness for a relaxed life, a little bit of relaxation, not too busy like in the past. We would like to slow down the rhythm of life a little bit, slow down a little... In financial terms, we also want to be a little bit richer. Except for subsidizing, the children and the grandson, we also would like to eat better, and dress better* (Participant 12, 70–74-year-old Female, retired high school teacher).

However, there is variation in what is meant by "good food" in Chinese culture and these different meanings are described below (28).

Expensive food may be judged as good food. For instance, before the 1980s, the price of corn was much lower than that of wheat, and wheat was less available than corn. Therefore, wheat was recognized as a "good food." In recent years, the price of corn has increased and exceeded the price of wheat. *High fiber foods* derived from wheat and corn are considered "good foods." *Scarce foods* are also considered good foods. During the Great famine meat was virtually unavailable to most of the population. Therefore, meat is seen as a "good food." *Restaurant food* is considered good due to the skill of the chef, the physical environment and the community atmosphere. *Enjoyable or satisfying food*, or *food that is easy to digest* is considered good food. *Homemade food* enables the person to satisfy their personal preferences and often is eaten in a family environment and is therefore considered good food. Food that is consistent with what was eaten when they were younger is considered good food and is often related to local legends such as "birds are more tasty than beasts," or with eating *simple food* associated with their childhood.

Among these descriptions about what is "good food," the most popular one for the participants in this study is *cu cha dan fan*, literally translated as "ordinary tea and a simple meal," or in Western terms, "a simple diet." Their judgement on good food quality is closely related with their previous life experiences. They are easily satisfied because the food quality was so poor in their childhood. Simple food is good because it evokes memories of their childhood, their struggle, and joys and sorrows of their life.

> *I also pay attention to my diet, because like us, we all had a hard life previously, especially those who went through the hard times [meaning the years of severe natural disasters in the 1960's]. Many people died from starvation; grain was very tight. There were many siblings in my family, and life was also difficult. Therefore, we usually had a simple diet, the most normal diet. If you really let us eat chicken, duck, meat, fish, I feel, we will be tired of this after several meals, and will not be used to it. I just like to eat the green vegetables from our home town… that is a simple meal* (Participant 20, 66–69-year-old Male, retired high school teacher).

> *When our prime minister visited four seniors in Shanghai, each of them told him the secret to longevity. One of them said 'green tea and simple food', which symbolizes a simple life. Simple as his life is, he was never haunted by hunger. He kept a balanced diet, ate very simple food, but more vegetables. So that explains it. And we do not seem to have much to care about, do we?* (Participant 37, 60–64-year-old Male, retired teacher).

Meat as Good Food

In China, vegetarians are minorities and most of those refuse to eat meat for religious reasons. The *Nirvana Sutra* of Buddhism suggests "to eat meat will break off root of mercy." However, it seems not all believers of Buddhism do not eat meat. In the three main streams of Buddhism, the monks of Chinese Buddhism claim to be meat free; while Theravada and Tibetan Buddhists can eat "clean meat." The traditional Chinese religion, Taoism, also recommends a no meat diet, however, only Taoists of Quanzhen Taoism refuse to eat any meat (29).

In contemporary mainland China, the majority of people claim no religious affiliation. Among the Chinese general population, foods containing meat and/or oil have been traditionally described as "good food." Children and teenagers are encouraged to eat more meat in order to promote physical development.

There are many Chinese idioms and legends about meat. For instance, *jiu rou peng you* (good friends are those who can share meat and wine), *rou shi zhe bi* (people who eat meat are shallow, where the people are from the elite). "Plenty of fish and of plenty meat" (*da yu da rou*) is a metaphor for being rich and attaining high social status; while "behind the vermilion gates meat and wine go to waste while out on the road lie the bones of those frozen to death" (*zhu men jiu rou chou lu you dong si gu*) is a ballad from Old China, a snapshot of the difference in food security between rich and poor (30).

As discussed previously, most of our participants experienced the Great Famine at the end of 1950s. At that time, the participants were teenagers or young adults. They lived in either urban or rural areas and survived extreme poverty. Eating meat was an extreme or unusual event. In addition, most families used animal oil/fat for cooking because vegetable cooking oil was unavailable at that time. In rural China, there was virtually no meat consumed. Most people had food with meat or fried food only at their family reunion dinner, the supper celebrated on Chinese New Year's Eve.

Those traditions and experiences significantly impact on the belief that "meat is good food" in Chinese culture and as such meets a physiological need.

> *I was in the countryside for decades and married a teacher at that time… lived in the countryside when I was nineteen years old. … At that time, meat was bought with meat vouchers. [In the early years of liberation, many daily necessities such as rice, eggs, meat, clothes were purchased with vouchers]. In that period, a family had many children and only a limited number of vouchers. So, they dissolved fat meat into liquid lard and used it for cooking. As soon as the children came back, they wanted to eat the meat from which fat had been extracted. But it was not enough for them. I think those were tough days and I shed tears many times* (Participant 31, 70–74-year-old, Female, farmer).

However, the participants suggested that eating this "good food" should be moderated: "Meat is delicious but should be eaten less." They believe that to eat too much meat will be bad for their health. Other studies of dietary practices of Chinese older adults have noted the competing values concerning the consumption of meat: there is a preference to eat meat but participants understand that too much meat, particularly fatty meats can cause health problems (24, 25).

> *In the past, we wanted to eat meat but there was no meat to eat. Now we can eat meat at any time, but we should not eat too much* (Participant 32, 70–74-year-old Female, unemployed).

> *I do not like eating chicken, duck and fish, and I would not like to eat those things. Considering the fact that only my wife and I live at home and our children do not live with us, we only need to prepare meals for ourselves, two aged persons. That is enough for us. We do not eat meat every day. Now things are different than in 1956, a hard year, when there was no meat or fish to eat. Currently, if you want to eat meat, there is enough meat on the market. However, some people do not like or do not want to eat meat* (Participant 34, 65–69-year-old Male, retired financial worker).

> *Too much fat and meat in the diet will affect health, but it is ok to have some comparatively good food. This is what I really think of… diet. A light diet without much meat and… fish is good for your health* (Participant 33, 60–64-year-old Female, local government worker).

> *I have a part time job, looking after children, cooking meals … 'What do you like to eat?' my children always say to me, 'You do not have regular meals'… look, sometimes I eat less, sometimes I eat more… I normally have rice… Only during the winter do I like to eat Chinese cabbage. I like to eat fried capsicum. I like to eat garlic bolt. My teeth are not good, I cannot chew. I do not like eggplant… I do not eat meat on hot days, I just eat less meat… Young people cannot be without meat to eat. If you [young people] do not eat meat, you cannot keep up. If you do not eat meat when young, your strength cannot keep up. But you cannot just eat meat* (Participant 14, 65–69 Female, retired salesperson).

Food Affordability

Before the 1980s in China, food availability impacted on what older people could eat. Since the 1980s the Chinese food market has developed in terms of quantity and quality with accompanying increases in the price of food. Affordability of food is a key determinant of older people's diet. Food price increases are the main contributor to CPI increases in China According to the Chinese National Health Service Survey (2003), food expenditure comprised 44.4% of total family expenditure in urban families, while the proportion was 37.0% in rural families. Based on the survey, family expenditure on food as a proportion of total family expenditure decreased by 10% between 1998 and 2003 (31). Family expenditure on education and medical care increased dramatically over that period. More recently, the proportion of household expenditure on food has further decreased to 36.2 percent (32).

The Chinese government is acutely aware of the impact of price rises on people's lives, especially those who are retired and on low incomes. The retirement pension and low-income allowances are adjusted frequently, to support a good quality life for retired people but the participants were very concerned about food price rises (22).

In this study, participants often commented that their pension or allowance was just for food or was used as insurance for unexpected events. Significant uncertainty or unexpected expenses in the future (for example medical care) drove older people to save money from their pension or allowance. If the price of food increased the participants would spend less on food. Participants expressed their worries concerning increasing food prices. The following participants reflect on price rises in the past and present.

> *Yes, I know everything. I can tell you some past stories. Three dynasties… Japanese is a dynasty, Kuomintang is a dynasty, the Communist Party is a dynasty. Let us talk about Japan. I have full experience in the Japanese dynasty. I had dealings with the Japanese, worked for the Japanese, and was bullied by the Japanese. Let us talk about Kuomintang… the most unforgettable was that we ate 'mixed flour'. In the Kuomintang period, rising prices happened so fast! Skyrocketing! The Kuomintang did something… gave you more salary… adjusted the salary many times a month. You can buy a bag of rice today; however, you might buy a half bag of rice tomorrow. The price increase was too fast. So, up to now, I am scared when prices rise. Although our country is stable now, prices of food and oil are increasing, seriously. Am I right? Of course, the current price increase is not as serious as that of the Kuomintang. But that is reality… that is reality. Do you agree with me? In the Kuomintang, the government printed big bills… a bill of a million dollars, a bill of 10 million dollars… The price rise was almost the same in the early years of the New China. The Communist government launched many programs to provide adequate clothing*

and food to people. But, saying it politely, the problem was not solved. In 1960 (the Great Leap Forward) bad climate conditions caused the Great Famine, it was the most difficult time for us. We had to find waste vegetables to eat. We had to eat steamed corn bread] every day. That was the most difficult time. I have experienced that. Those past dynasties, I remember all the details… about the ordinary situation, the community in general. I am afraid the situation will happen again (Participant 2, 80–84-year-old Male, retired factory worker).

We just think we have not got what we particularly want. Now the vegetables and the fruits are all too expensive (Participant 12, 70–74- year-old Female, retired high school teacher).

Dietary Supplement Products

During the last two decades, the dietary supplement market (vitamins, herbs, protein supplements) in China has grown rapidly (33) and further growth is expected. The China Healthcare Association Health Food Market Working Committee recently valued the health food market in China at US$30 billion. It forecasted that the market will grow 10 per cent year-on-year between 2015 and 2025 (34).

Many of these so-called health products focus on the aging population. Marketing of these products is directed to "buying health" but the market is poorly regulated. In the mid 1990s the dietary supplement market was buoyant in China but by the end of the decade questions concerning the quality of the products, and exaggerated and false claims regarding their efficacy, impacted the market. The arrival of "trusted" Western brands has seen an increase in the market (34, 35).

Participants from Beijing expressed their distrust of those health products. The believed that the products provided nothing to improve their health. More than half of the participants who used health products did so because others sent the products to them as gifts. Around only one third of those using health products brought the products themselves.

Chinese aged people do need accurate and relevant information about food and food supplements for maintaining and promoting their health. However, many of our participants distrust the claims of those marketing dietary supplements.

Of course, health is the most important, definitely! Old people have to protect their health. It is meaningless to show how much money you have. If you are in bad health, all of the money is useless. There is a lot nonsense on the media [rubbish or gibberish messages]. There are many "health care products" on the market. Can we maintain our health through eating those "health care products"? I think that is nonsense. I think everyone knows his [or her] way of maintaining their health. They know how to protect their health (Participant 2, 80–84-year-old, Male, retired factory worker).

Ok, let me say… for instance, in life (note: life style), I think 'Cha Bu Duo' [literally, no significant difference, no more than enough, better but not the best] is appropriate. Over nutrition has no benefit. Am I right? I think Cu Cha Dan Fan (literally, cheaper tea and simpler food, plain food) is always good. If needed, you can add some meat or milk (to your meal). I do not trust the 'health care products'. All the products are useless (Participant 2, 80–84-year-old Male, retired factory worker).

Food Safety

Food supply has been dramatically improved since the 1990s in China. Chinese people can buy any food and vegetables across the year. Before the 1990s, both rural and urban families stored and ate Chinese cabbages only during the 3 months of winter.

Food safety was considered a concern by the participants, particularly those from Beijing, rather than food availability. Many participants worried about the safety of food and stated that the safety issue could be a barrier to accessing essential foods for their health. They worried about foods containing high levels of fertilizers and pesticides, although they were aware that the government had stated that those hazards were lower than the required minimum standards (36).

In the recent decades, many contaminated foods were reported in China's media. Food producers and suppliers added illegal chemicals for improving or maintaining food appearance and taste. The contaminated foods usually had better presentation and a higher price. Consumers, especially older people, have insufficient information about food safety The participants wanted the government to strengthen food inspection and surveillance. With their increased worries about food safety, the participants tried to seek out safe food or avoided food reported in the media as contaminated (37).

How to say, the Nation [government] says it checks [food quality] everyday, it doesn't work. My son bought a basket of apples. After they were opened, [the apples were] red outside, all are sticky… At the end when he was not in front of me, I secretly threw them into the rubbish. I was afraid that when he was back [he would] scold me, say that I am wasteful. Indeed, the apples can't be eaten at all (Participant 12, 70–74-year-old Female, retired high school teacher).

Vegetables and fruits can give us diarrhea after eating (Participant 12, 70–74-year-old Female, retired high school teacher).

The food… currently… I mean… none of the food is assured and safe. We have to select simple… the simplest food. Cu Cha Dan Fan [literally, raw tea and pure rice. It is similar to the concept of 'bread and water'] is enough for us, and we feel it is safer. Do you know the 'Hainan Banana Event'? That banana [shipped from Hainan Province of China]! Can you eat that banana? The banana was soaked in some poisonous chemical liquid...to maintain freshness! What a taste… a puckering taste! I know officials can obtain safe foods, because they have special suppliers. Chemical fertilizers, pesticides, genetically modified… do you think these foods are good enough? At least, I think the foods are unsafe (Participant 1, 60–64-year-old Male, retired university worker).

I do exercise every day. In the morning, I pick or plant some vegetables of my own. It is safe to eat my own vegetables, which contain no residuals of pesticides. In the evening, I dance or walk in the square after supper (Participant 35, 65–69-year-old, Female, retired nurse).

STUDY STRENGTHS AND LIMITATIONS

This study uses qualitative methodology and as such cannot provide information about the frequency of the views expressed by the participants nor how frequent these views would be in similar populations. However, the study sample is large and includes a range of participants from different SES backgrounds. We sampled from rural and urban areas but due to the geographical diversity of China we may have missed groups living in more remote areas and this potentially impacts on the transferability of our findings. In addition, we did not sample from minority ethnic groups in China so our findings may not be relevant to these groups. The views of the participants are rich in detail and we were able to extract in-depth information about their food habits, beliefs and preferences and link these to their early life experiences and current circumstances. Translation of transcripts into English for English readership can be problematic as meaning can be lost. Three of our team members are native Chinese speakers and through back-translation and our analysis workshops we were able to use their skills in interpreting the meaning of the transcript text.

CONCLUSION

In this study we explored the meaning of food and eating in achieving happy aging for older Chinese people. This qualitative research project involving older Chinese people discussing the issues they identified in their own terms. The results clearly demonstrate that food and eating rituals are perceived as very important components of the enjoyment of a happy old age. The study fits within the tradition of using qualitative methods to interpret healthy eating. As noted by Bisogni et al. (38) p. 282:

> *'The rich descriptions and concepts generated by qualitative research can help practitioners and researchers think beyond their own experiences and be open to audience members' perspectives as they seek to promote healthy ways of eating.'*

The collective and personal histories of older people in China described by the participants show they have experienced significant changes across their lifespans in the quantity and quality of food. These changes have been closely linked to their well-being and economic prosperity. In 1960 life expectancy at birth in China was 43.7 years and in 2018 it is 76.4 years. Some of the participants had experienced extreme hunger in their early lives but now were able to eat "until they were full."

However, the participants also recognized that overeating and inappropriate unhealthy eating could be a problem for their health. The quality of food was important to them and many discussed the merits of eating simply and the role of "good" foods such grains and previously scarce foods such as meat. Despite the increased general availability of food, affordability was a key issue for many of the participants, as was food safety. In this article the different meanings of "good food" are compared and discussed. These provide important insights into the varying conceptualizations of food.

The study has demonstrated that social and economic lifespan experiences continue to impact on the food and eating attitudes and practices of older Chinese. It is important for health professionals working with older Chinese to understand these impacts and provide health education and promotion approaches to maximize healthy food choices that align with the aspirations of older people to achieve happy aging. The food related life experiences of older Chinese are quite different from younger Chinese and health promotion messaging needs to be informed by these unique perspectives in order to maximize its effectiveness.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of Monash University Human Research Ethics Committee with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Monash University Human Research Ethics Committee.

AUTHOR CONTRIBUTIONS

CB, ST, ZQ, HY, and TZ led the conception of the study. All the authors obtained research and operational funding. CB and HY drafted the paper and all authors contributed to critical revision. HY led the data analysis and all authors contributed to the interpretation of the data. All the authors had full access to the study data and take responsibility for the integrity of the data and the accuracy of the data analysis. All the authors have approved the final version of the manuscript.

FUNDING

The study was funded by Monash University, Australia and in-kind support was provided by Monash University, Australia and Peking University, China. The funders of the study had no role in study design, data collection, data analysis, data interpretation, writing of the report, or decision to submit for publication. Australian Research Council Discovery Grant—Aging in China and Australia: Promoting health, productivity and well-being DP160103023 funded the publication of this paper.

ACKNOWLEDGMENTS

The Sanming Project of Medicine in Shenzhen, Sanming Project team code: SZSM201511046 (Thomas team) provided support for this project. We thank Professor Farzad Sharifian, Monash University for his work on Cultural Linguistics which was an inspiration for this study.

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Conflict of Interest Statement: CB, ST, ZQ, and HY are Editors of the research topic: Chronic Illness and Aging in China; they had no involvement in the review of this manuscript.

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

Heine C, Gong CH and Browning CJ (2019) Dual Sensory Loss, Mental Health, and Wellbeing of Older Adults Living in China. Front. Public Health 7:92. Doi: 10.3389/fpubh.2019.00092

Abstract

简介：视力和听力下降通常随着年龄的增长而发生。现有文献表明，双感觉丧失(DSL)是老年人中普遍存在的一种情况。在中国，估计有57.2％的人口经历DSL。根据少量研究论文，可以确定DSL影响心理健康和幸福。这项研究的目的是探索居住在中国的老年人样本中DSL与心理健康和幸福之间的关系；并研究功能性依赖(日常生活活动(ADL)和工具性生活活动(IADL))与慢性疾病的共病关系是否影响DSL对心理健康和幸福感的影响。

方法：本研究使用2013年中国健康与养老追踪调查第2轮，收集了60岁及以上人群（n = 8268）的数据。选择进行分析的感觉损失变量包括自我报告的视力和听力损失（DSL）的组合变量。心理健康通过抑郁来衡量，总体幸福感通过生活满意度来衡量。此外，慢性疾病以及IADL和ADL的局限性被用于测试其与DSL的合并症如何影响心理健康和幸福感。使用描述性分析以及回归分析和其他技术对结果进行分析。

结果与讨论：DSL与高龄且呈正相关，在任何ADL或IADL中均存在困难，并且患有抑郁症且生活满意度较低。观察到的DSL与心理健康或幸福之间的负面联系是间接的，可以部分解释为DSL与慢性疾病的合并症以及与功能限制的关系。建议中国的健康服务部门对老年人的DSL进行筛查，并开发综合服务，以针对有DSL的老年人功能和精神健康问题进行适当管理和康复。

frontiers in Public Health

ORIGINAL RESEARCH
published: 24 April 2019
doi: 10.3389/fpubh.2019.00092

Dual Sensory Loss, Mental Health, and Wellbeing of Older Adults Living in China

Chyrisse Heine[1], *Cathy Honge Gong*[2*] *and Colette Browning*[2,3]

[1] Department of Community and Clinical Allied Health, La Trobe University, Bundoora, VIC, Australia, [2] Centre for Research on Ageing, Health and Wellbeing, Research School of Population Health, College of Health and Medicine, The Australian National University, Canberra, ACT, Australia, [3] International Institute for Primary Health Care Research, Shenzhen, China

Introduction: Deterioration in vision and hearing commonly occurs as adults age. Existing literature shows that Dual Sensory Loss (DSL) is a prevalent condition amongst older adults. In China, it has been estimated that 57.2% of the population experience DSL. Based on a small number of research papers, it has been identified that DSL influences mental health and wellbeing. The aims of this study were to explore the relationship between DSL and mental health and wellbeing in a sample of older adults residing in China; and investigate whether the comorbidities of functional dependency [Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL)] and chronic diseases influence the impacts of DSL on mental health and wellbeing.

Method: The China Health and Retirement Longitudinal Study Wave 2, 2013 data collection of a sample of people aged 60 years and over (n = 8,268) was used in this study. The sensory loss variables selected for analysis included a combined variable of self-reported vision and hearing loss (DSL). Mental health was measured by depression, and general wellbeing was measured by life satisfaction. In addition, chronic diseases, and limitations in IADL and ADL were used to test how their comorbidities with DSL influence mental health and wellbeing. Results were analyzed descriptively and using regression and modeling techniques.

Results and Discussion: DSL was significantly and positively associated with advanced age, having difficulty in any ADL or IADL and experiencing depression and less life satisfaction. The observed negative associations between DSL and mental health or wellbeing, are indirect and could be partially explained by its comorbidity with chronic diseases and relationship to functional limitations. It is recommended that health services in China screen for DSL in older people and develop integrated services to assist with appropriate management and rehabilitation of older people with DSL focusing on both functional and mental health issues.

Keywords: sensory loss, mental health, depression, wellbeing, life satisfaction, dual sensory loss, China

OPEN ACCESS

Edited by:
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Reviewed by:
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***Correspondence:**
Cathy Honge Gong
cathy.gong@anu.edu.au

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

Received: *24 August 2018*
Accepted: *03 April 2019*
Published: *24 April 2019*

Citation:
Heine C, Gong CH and Browning C (2019) Dual Sensory Loss, Mental Health, and Wellbeing of Older Adults Living in China. Front. Public Health 7:92. doi: 10.3389/fpubh.2019.00092

INTRODUCTION

Many adults experience sensory losses as they get older (1, 2). Dual Sensory Loss (DSL) is defined as "the acquired loss, in various degrees of severity of both vision and hearing acuity, associated with aging and prevalent in older adults" (3) (p. 1). The prevalence of vision loss and hearing loss in older adults is high. In a population study of adults aged

75 years and over (n = 14,600), 12.4% were visually impaired, 10.3% had low vision and 2.1% were blind (4). Likewise, in the Beaver Dam, Wisconsin study (5), the prevalence of hearing loss in older adults (average age of 65.8 years) was high (45.9%). The prevalence of DSL reported in the literature ranges from 5.9% in adults aged over 50 years (6) to as much as 25% in adults aged over 80 years (7). The prevalence of vision and/or hearing loss in older adults is also high in China. In a recent publication on this topic, Heine et al. (8) concluded that vision loss was present in 80.2% of the sample, 64.9% of the sample reported hearing loss and 57.2% experienced DSL. In comparison to the high prevalence rate of these sensory losses, there was low usage of aids (10% of respondents wore glasses regularly and only 0.8% used hearing aids) resulting in a high level of unmet needs for glasses (54.9%) and hearing aids (63.9%).

The causes of acquired vision and/or hearing loss in older adults are varied. Common causes of vision loss in older adults include age-related macular degeneration, glaucoma, ocular complications of diabetes mellitus and age-related cataracts (1, 9, 10). Common causes of hearing loss in older adults include presbycusis, noise-induced hearing loss, cerumen occlusion, middle ear ossification, viruses, bacteria, heart condition, stroke, brain injury, tumor, or ototoxic medication (11, 12).

The sensory losses resulting from vision and hearing acuity changes are numerous. People with vision loss experience vision ranging from moderate visual impairment to severe visual impairment to blindness (13). People with vision loss often have difficulty seeing fine detail, visualizing distant objects, discriminating detail, and reading print. In addition, they may have poor contrast sensitivity, intolerance for glare and restricted mobility. In China, poor vision for long distance is found to be one of the major reasons for vision impairment or blindness in later life (10). Similarly, hearing loss ranges from mild to profound loss with consequent impairment typically including varying degrees of difficulty with: hearing sounds, speech discrimination, and perception in quiet and noisy environments, or environments that are echoic and difficulty processing information (14). DSL thus results in a combination of these sensory difficulties. Brabyn et al. (15) suggested that the combined effect of vision and hearing loss could cause complex interactions with task performance because of the dimensions of both types of deficits.

DSL is also associated with poorer health, decreased wellbeing and quality of life. In a systematic review of the literature, Heine and Browning (16) reviewed 42 studies investigating DSL and its comorbidities. Results of this review found that the most common association examined in the literature was between DSL and functional difficulties [such as difficulty completing Activities of Daily Living (ADLs) and/or Instrumental Activities of Daily Living (IADLs)]. For example, based on the Longitudinal Study on Aging, Brennan et al. (17) explored the functional abilities of 5,151 adults aged 70 and older and found that one fifth of older adults with DSL had associated difficulty with ADLs and IADLs as compared to those with a single sensory loss. Outcomes of this study and a further study in China (10) suggested that effective vision and hearing rehabilitation (including sensory resources or aids) are essential for those with DSL to maintain their functional independence and quality of life. In a study of 393 members of the Hong Kong Chinese community aged 60 years and older, Chou (18) concluded that everyday competence was significantly and negatively associated with depressive symptoms in people with low functional capacities.

Within the DSL literature, studies investigating the association between DSL and mental health are rare. Based on the outcomes of a systematic review conducted by Heine and Browning (19), only a few studies have investigated the relationship between DSL and depression, whilst even fewer have investigated the association between DSL and quality of life. There were no studies in this systematic review that investigated the association between DSL and anxiety. According to Chou and Chi (20), in a sample of 2,003 community dwelling Chinese residents residing in Hong Kong, 6.5% displayed depression, with vision impairment significantly related to depression whilst hearing impairment had no significant association with depression. Similarly, based on a large population study (n = 2,689), McDonnall (21) found a significant relationship between DSL and depression, particularly at the onset of DSL. Poor Quality of Life has also been significantly associated with DSL (22), although the evidence base is small.

Since the review on DSL and mental health was published by Heine and Browning (19), some new studies have appeared. For example, based on cross-sectional data of 8,500 adults aged 50 years and older from Wave 1 of the Irish Longitudinal Study on Aging (TILDA), collected between 2009 and 2011, Lehane et al. (23) found that the loss of one's own or one's spouse's hearing and/or vision is a stressful experience. Furthermore, individuals with DSL reported greater levels of both anxiety and depression, whilst their spouses reported greater levels of depression only when compared to couples without sensory loss. Recent studies of Asian populations have shown similar impacts of sensory loss on mental health. Based on the data of 5,832 individuals from the 2006 to 2014 Korean Longitudinal Study of Aging (KLSoA), Han et al. (24) found that hearing, vision and dual sensory impairment are significantly associated with depressive symptoms. These authors suggested that treatment or rehabilitation of either hearing or vision impairment would assist in the prevention of depression.

Heine and Browning (16) conducted a systematic review of DSL and other comorbidities such as life satisfaction, chronic illnesses, and dementia. Again, there were few studies investigating these relationships. For example, Bazargan et al. (25) explored the psychological wellbeing of 988 older African American people and found that those with DSL experienced multiple comorbidities such as poorer health and disparities in their health and social roles as compared to people with no DSL. In a study based on the China Health and Retirement Longitudinal Study (CHARLS) data of 8,268 older adults aged 60 years and over residing in China (published in this Special Topic), Heine et al. (8) found that over two-thirds of respondents reported vision loss (80.2%) and hearing loss (64.9%) whilst over a half of respondents (57.2%) reported DSL. Furthermore, vision and hearing loss together with the unmet needs for glasses and hearing aids were negatively associated with participation in social activities.

There is thus limited information about DSL and its association with mental health and wellbeing and even less information about these associations in the Chinese older population[1]. The prevalence of DSL will increase as China's population ages. It is important to understand how DSL impacts on mental health and wellbeing and how other age-related conditions may impact on that relationship. This information can help inform the design of health services and rehabilitation programs to improve the quality of life of older Chinese with DSL by adding valuable life to years (26).

The aims of this study are to:

1. Explore the relationship between DSL and mental health and wellbeing (as measured by depressive symptoms and life satisfaction).
2. Investigate whether the comorbidities of functional dependency (ADL and IADL) and chronic diseases influence the impacts of DSL on mental health and wellbeing.

METHODS

Data Source

In the current study, the China Health and Retirement Longitudinal Study (CHARLS) dataset was used. The CHARLS is a national, longitudinal survey of people aged 45 years and over that explores aging and health in China (27). Detailed information on demographic characteristics, social and economic conditions, functional impairments, chronic diseases, activities of daily living (ADL) limitations, disabilities, and psychological wellbeing were collected via face-to-face interviews in respondents' homes. In the first wave of CHARLS (in 2011), random selection of participants took place using a multi-stage probability-proportional-to-size technique, stratified by regions and then by urban districts or rural counties and per capita gross domestic product (GDP). In the second wave of data collection (in 2013), respondents aged 45 and over were surveyed (n = 18,246), in which 14,988 were from Wave 1. Missing values had not been imputed in the survey data before its availability to the public. Individual weights denoting the inverse of the probability that the observation are included because the sampling design with household and individual non-response adjustments, are used for analysis. In the current study, only older adults (those aged 60 years and over) were included for analysis (n = 8,268). CHARLS was approved and is overseen by the Biomedical Ethics Review Committee of Peking University. There is no need to have a further ethics approval for the secondary data analysis. The software used for the data analysis in this study is STATA 15.1.

Measures

In the CHARLS dataset, there are multiple questions asking respondents about their vision and hearing. To form the construct of DSL, two questions relating to vision were included: (1) How good is your vision for seeing things at a distance, like recognizing a friend from across the street (with glasses or corrective lenses if you wear them, 1 = excellent, 2 = very good, 3 = good, 4 = fair, or 5 = poor)? (2) How good is your vision for seeing things up close, like reading ordinary newspaper print (with glasses or corrective lenses if you wear them, 1 = excellent, 2 = very good, 3 = good, 4 = fair, or 5 = poor)? A fair/ poor answer to either or both of these questions was classified as vision loss. One question relating to hearing was used for measuring hearing status: "Is your hearing excellent, very good, good, fair, poor, (with a hearing aid if you normally use it and without if you normally don't)?" A fair/poor answer to this question was classified as hearing loss. The variable of DSL was defined as having both fair/poor vision and fair/poor hearing.

Demographic variables included age, gender, marital status, and ethnicity (whether the minority or majority). Educational attainment, relative living standard, and residence (urban or rural) were used to measure Socio-Economic Status (SES), which have impacts on the access to health services use and other social and economic resources (28–30), hence may change the impacts of DSL on depression and wellbeing. Urban and rural areas are defined according to the most recently published statistical standard by the National Bureau of Statistics (NBS) (31), where urban areas include both communities and villages located within access to the city or town facilities, while rural areas include only villages out of the city or town facilities (32). Educational attainment was categorized in three groups: (1) Primary schooling or under (illiterate or some primary schooling); (2) Second schooling (completed primary or secondary school); (3) college or above degrees.

In order to address the impact of the large variations across regions in both income and living costs, the relative living standard (instead of absolute income or expenditure) was used in this study to measure SES (32). The relative living standard is self-reported by respondents by answering the question: "Compared to the average living standard of people in your city or county, how would you rate your standard of living relative to those in your city/county: much better, a little better, about the same, a little worse, much worse?" Answers were grouped into three categories: "better"; "worse" and "about the same," since using five groups did not enhance the interpretation beyond using the three categories used in the model.

The comorbidities of DSL included chronic diseases, ADL and Instrumental Activities of Daily Living (IADL). Chronic diseases were measured by whether the participant had any diagnosed conditions (hypertension, an unusual (high or low) lipoprotein level, diabetes, cancer, chronic lung diseases, liver or gallbladder disease, heart disease, stroke, kidney disease, stomach, or other digestive disease, emotional, nervous, or psychiatric problems, memory-related disease, rheumatism/arthritis or asthma). ADL limitations were measured by any self-reported difficulty in any of the following activities of daily living domains: bathing /showering, eating, dressing, getting into or out of bed, using the toilet, or controlling urination and defecation. IADL limitations were measured by any self-reported difficulty in any of the household activities: such as doing household chores, preparing hot meals, shopping for groceries, managing your money and taking medications.

[1] As this paper focuses on DSL among older people, we did not review any literature about DSL and depression in younger people. DSL in young people is often diagnosed in early life and has a separate literature. The psychological response to deaf-blindness in early life is likely to be different to DSL acquired in later life as an age-related condition.

The mental health and general wellbeing outcomes were measured by two variables: (1) depressed or not and; (2) life satisfaction. Depression in this study was measured by a group of ten questions in CHARLS selected from the Center for Epidemiologic Studies Depression Scale (CES-D) such as: being bothered by things, having trouble concentrating on things, feeling depressed, feeling everything was an effort, not feeling hopeful about the future, feeling fearful, having restless sleep, not being happy, feeling lonely or could not get going. A score of zero to three was assigned to each answer and then summed and divided into two groups according to the distribution of scores: no depression (score of 0–15), mild/ moderate/ major depression (score of 15–30). Life satisfaction was measured according to the respondent's response to the question "Please think about your life-as-a-whole. How satisfied are you with it? Are you completely satisfied (=5), very satisfied (=4), somewhat satisfied (=3), not very satisfied (=2), or not at all satisfied (=1)?" Satisfaction is defined as satisfied (=5), very satisfied (=4), somewhat satisfied (=3), while dissatisfaction is defined as not very satisfied (=2), or not at all satisfied (=1).

Methods

Descriptive analyses of DSL prevalence rate by age, gender, education and relatively living standard are first reported. These data were followed by Spearman correlations between the prevalence of DSL and the physical and mental health measures as well as the general wellbeing measure. Finally, multivariate logistic regression was used to investigate the associations between DSL and mental health or wellbeing by controlling for all the predisposing factors (age, gender, urban/rural residence, marital status, ethnic group), SES (education and relative living standard), functional dependency and chronic diseases.

As a $P < 0.05$ has been widely used for significance tests in health literature, we keep both the actual p-values (in the last table of multivariate regression results) and the indication of significance level ($^{***}P < 0.01$, and $^{**}P < 0.05$ in all tables).

RESULTS

The prevalence rate of DSL was obtained and analyzed by age and gender (see **Table 1**) and education, urban/rural residence and SES (relative living standard) (see **Table 2**).

As can be seen from **Table 1**, just over half of all participants reported DSL (57.2%). The prevalence increased across the age groups until 74 years with a slight decrease in prevalence in those aged 75 years and over. The pattern was somewhat different between men and women: for men, those aged 70–74 years had the significant and highest prevalence of DSL (62.5%), while for women, those aged 75 years and over had the highest prevalence of DSL (59.6%) but it is statistically insignificant.

Table 2 shows that those with a lower attainment in education (with primary school or under, or second schooling) reported a significantly higher prevalence rate of DSL (59.1 and 55.2% respectively), whilst those with the highest level of education (college and above) reported the lowest prevalence of DSL (42.6%). Those respondents living rurally reported a significantly higher prevalence of DSL (61.0%) compared to respondents living in an urban environment (52.1%). The prevalence of DSL was 47.2% for older people with a relatively better living standard, and increased to a significantly higher rate (59.8%) for those with relatively worse living standard.

Table 3 shows the relationship between DSL and depression, life dissatisfaction, any ADL or IADL limitation, and any chronic disease. Respondents with DSL had a higher proportion of reporting depression (18.1%), life dissatisfaction (14.58%), any chronic disease (76.72%) and difficulty in completing ADLs (11.21%) and IADLs (23.28%), compared to the group with no DSL. In addition, there are significant comorbidities between DSL and chronic diseases, ADLs or IADLs. About 44.95, 6.77, and 13.03% had DSL together with any chronic disease, ADL or IADL, respectively.

Spearman correlations were also calculated for the relationship between DSL and depression, life dissatisfaction, any ADL limitation, any IADL limitation and any chronic diseases (see **Table 4**). The Spearman correlations in **Table 4** indicate that depression, life dissatisfaction, ADL limitation, IADL limitation, or having any chronic disease are all significantly and positively correlated with DSL.

Table 5 presents results from the multivariate logistic regression models to investigate the associations between DSL and mental health or wellbeing. In the regression models, DSL, major predisposing factors (age, gender, ethnic group, marital status) and SES (urban/rural residence, educational attainment, and relatively living standard) are controlled for in all the four models. Having any chronic diseases, ADL or IADL are only controlled for in Model 2 and Model 4 so that it is possible to

TABLE 1 | Prevalence of DSL by age and gender among older Chinese, 2013.

Age group	Total sample size CHARLS 2013	Persons with DSL	Men with DSL	Women with DSL
60–64	2,677	55.2	53.8	56.5
65–69	2,197	56.6	55.2	58.1
70–74	1,539	60.0	62.5	57.4
75+	1,855	58.5	57.5	59.6
Total 60+	8,268	57.2	56.7	57.8

Sample size and weighted proportions from CHARLS 2013. http://charls.pku.edu.cn/en.

TABLE 2 | Prevalence of DSL by education, rurality, and SES among older Chinese, 2013.

Persons	Sample size CHARLS 2013	Dual poor/fair vision & hearing
Total 60+	8,268	57.2
Primary schooling or under	4,768	59.1
Second schooling	3,343	55.2
College and above	155	42.6
Rural residence	4,957	61.0
Urban residence	3,311	52.1
Better living standard	256	47.2
Average living standard	1,674	53.2
Worse living standard	4,151	59.8

Sample size and weighted proportions from CHARLS 2013. http://charls.pku.edu.cn/en.

TABLE 3 | The relationship between of DSL and mental health, wellbeing, functional limitations, and chronic disease.

Proportions (%) among those aged 60+	Depression	Life dissatisfaction	Any ADL limitation	Any IADL limitation	Any chronic disease
ALL	14.06	11.95	13.72	23.06	73.34
DSL_No	8.88	8.45	8.41	14	68.55
DSL_Yes	18.1*	14.58*	11.21*	23.28*	76.72*

**Indicates significant differences between DSL and non-DSL group at a significance level of 5%.*
CHARLS 2013. http://charls.pku.edu.cn/en.

TABLE 4 | Spearman correlations between key variables.

Spearman correlations	DSL
Depression	0.112*
Satisfaction	−0.077*
Any ADL limitation	0.042*
Any IADL limitation	0.098*
Any chronic disease	0.091*

**Indicates significant correlation with DSL at a significance level of 5%.*
CHARLS 2013. http://charls.pku.edu.cn/en.

examine how the associations between DSL and depression or life satisfaction will change.

After controlling for major predisposing factors and SES, the following results were evident: (1) DSL had significant influences on both mental health and wellbeing, however, the absolute value of association between DSL and depression (0.785) in Model 1 is higher than that of the association between DSL and life satisfaction (−0.593) in Model 3. (2) Older people who have any chronic diseases are more likely to report depression but there is no significant difference in their reporting of life satisfaction when compared to those without any chronic diseases. (3) Having any ADL or IADL limitation is significantly associated with both depression and less life satisfaction. (4) After controlling for having any ADL limitation, IADL limitation or any chronic diseases in Model 2 and Model 4, the estimated coefficients of DSL decreased significantly from 0.785 in Model 1 to 0.610 in Model 2 and from −0.593 in Model 3 to −0.491 in Model 4 respectively. This means that the observed associations between DSL and depression can be partially explained by having any chronic diseases, ADL limitation or IADL limitation, while the observed associations between DSL and life satisfaction can be partially explained by having any ADL limitation or IADL limitation, but not by having any chronic diseases.

DISCUSSION

DSL is prevalent in the older adult Chinese population with more than half (57.2%) of the CHARLS 2013 respondents reporting DSL. The prevalence rates of sensory loss in the current study are higher than Western population-based studies of vision and hearing loss, while are similar to other population-based studies of vision and hearing loss in China. For example, Swenor et al. (33) is a US study that reported the prevalence of DSL as 13.8%

TABLE 5 | Impacts of DSL on mental health and wellbeing.

All persons aged 60+	Depression		Life satisfaction	
	Model 1	Model 2	Model 3	Model 4
DSL	0.785*	0.610*	−0.593*	−0.491*
Any chronic diseases		0.457*		−0.157
Any ADL limitation		0.776*		−0.667*
Any IADL limitation		0.777*		−0.253*
60–64 (Omitted)				
65–69	−0.021	−0.128	0.154	0.198
70–74	−0.057	−0.288*	0.262*	0.361*
75+	−0.483*	−0.868*	0.404*	0.619*
Male (omitted)				
Female	0.491*	0.349*	−0.246*	−0.131
Minority	0.106	−0.044	−0.097	0.009
Urban	−0.514*	−0.554*	0.047	0.103
Primary schooling				
Second schooling	−0.445*	−0.303*	0.411*	0.370*
College and above	−0.401	−0.331	0.637	0.376
Better				
Average	0.201	0.281	−0.345	−0.515
Worse	0.702*	0.659*	−1.430*	−1.528*
Married with spouse present				
Married with spouse away	−0.296	−0.299	−0.425	−0.518
Separated/Divorced/Widowed	0.371*	0.335*	−0.403*	−0.380*
Single	−0.098	−0.278	−0.701*	−0.204
Cons	−2.779	−2.441	3.479	3.414
R-square	0.069	0.099	−0.056	−0.060

**Indicates significant at a significance level of 5%.*
CHARLS 2013. http://charls.pku.edu.cn/en.

for adults aged 60 years and over. This prevalence difference may be attributed to the use of different methodologies; for example, self -report was used in the CHARLS data, whereas Swenor et al. (33) evaluated DSL on the basis of postautorefraction visual acuity and pure-tone audiometric measurements.

A further finding of this study [as also reported by Heine et al. (8)] was that the prevalence of DSL increased from 55.2% in 60–64 year olds to 58.5% in adults aged 75 years and over and that DSL is more prevalent in those living in rural areas, those with worse than the average living standard, or those without textural education. Detailed comparison of DSL prevalence in Chinese population studies can be found in Heine et al. (8).

Results of the current study also suggest that DSL impacted on depressive symptoms and life satisfaction. Correlation and regression analysis found that in comparison to people with no DSL, people with DSL reported difficulties completing ADLs and IADLs, more depressive symptoms and less life satisfaction. Correlations were all significant. Furthermore, results of regression analyses revealed that DSL has a higher impact on depression than on life satisfaction. However, these relationships are in part impacted by other variables. The impact of DSL on depression is influenced by the presence of any chronic illness and any ADL or IADL limitation. The impact of DSL on life satisfaction is influenced by the presence of any ADL or IADL limitation. Harada et al. (34) examined the vision and hearing acuity of 843 people aged 65 years and over living in a rural Japanese town and found similar findings. Based on a questionnaire about sensory acuity, depression, subjective poor health, and functional activity, Harada and colleagues found that

sensory loss (or impairment) was significantly associated with negative wellbeing in older adults.

The estimated coefficients for other variables are all consistent with expectations. It was found that: (1) advanced age is significantly associated with less depression, as well as more life satisfaction, probably because the older cohort has more positive life attitudes; (2) females are more likely to report depression and less life satisfaction; (3) there is no significant difference in depression and life satisfaction between ethnic groups; (4) urban older people are less likely to report depression and there is no significant difference in life satisfaction between urban and rural older people; (5) older people with secondary schooling are less likely to report depression but more likely to report life satisfaction probably due to their relative low expectation when compared those with high education; (6) worse living standard is significantly associated with depression and less life satisfaction; (7) separated/ divorced/ widowed older people are more likely to report depression and less life satisfaction and; (8) single older people are more likely to report less life satisfaction, but not significant difference in reporting depression.

LIMITATIONS

This study is an empirical study based on the most recently available survey data on health and retirement in China. Though the innovation of the design and findings of this study is limited, it is novel and valuable to investigate the impact of DSL on the quality of life in a rapidly aging society such as China. Our findings are timely due to the paucity of empirical papers on DSL in China.

Another limitation of the study is not exploring whether correctly-adjusted assistive devices (hearing aids, glasses) can significantly improve life satisfaction and mental health. Future research can investigate the difference between respondents who had the appropriate use of aids and the correctly adjusted/adapted aids to help with vision and hearing loss, vs. those who did not.

CONCLUSIONS

DSL is thus a significant factor affecting the mental health and wellbeing of older adults in China through its relationships with IADL and ADL limitations and comorbidity with chronic illnesses. Many of the impacts of DSL including its impact on mental health and wellbeing may be ameliorated by appropriate rehabilitation and the use of aids (10). Since older adults with DSL frequently experience communication difficulty leading to poor psychosocial functioning and social isolation, rehabilitation options should include communication training for older people with DSL and their careers. Identifying and managing the personal, situational, and environmental factors that contribute to communication breakdown (14) are key to effective communication training programs. Furthermore, adequate use of visual and hearing aids may be of benefit. Useful visual aids include assistive technologies that can be adjusted for volume for people who have an additional hearing loss (such as a talking GPS system) or a hearing aid that adds volume. Assistive listening devices such as Remote Microphone technology (which overcomes the signal to noise ratio of a noisy environment) may be of particular benefit for those people with DSL. For people with DSL, overcoming communication difficulties positively impacts on socialization and health often leading to improved quality of life and wellbeing (14).

Health professionals, however, need to understand that older people with DSL may also have other chronic conditions that need to be addressed as part of a comprehensive treatment and rehabilitation program. Interventions need to address the functional aspects of DSL as well as the possible mental health impacts. This requires a cross-disciplinary collaboration across vision, hearing, mental health and chronic illness services in referral, assessment and rehabilitation (15). This is a common issue worldwide where many health systems fail to provide good integration of services across professions especially for older people with complex needs.

As discussed by Heine et al. (8) the availability and accessibility in China of specialty hearing and vision services for older people, particularly those with poor financial resources, is low. Whilst the Chinese primary health care reforms aim to deliver better care across the whole population there are gaps in the ability of the system to address the complex needs of older people with sensory losses, particularly those who have associated mental health conditions.

ETHICS STATEMENT

The original CHARLS survey data was approved by the Ethical Review Committee of Peking University, and all participants signed informed consent at the time of participation. There is no need for ethics approval for second hand data users.

AUTHOR CONTRIBUTIONS

CH and CB conceptualized the paper. CG conducted all the statistical analyses. CH drafted the paper and CG and CB revised the paper. All authors have final approval of the published article and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

FUNDING

This study has been funded by an Australian Research Council (ARC) Discovery Project (Number: DP160103023).

ACKNOWLEDGMENTS

We would like to acknowledge the China Health and Retirement Longitudinal Study (CHARLS) team for providing the data and acknowledge financial support from both the Australian Research Council (ARC) Discovery Project (DP160103023), as well as the Centre for Research on Ageing Health and Wellbeing (CRAHW) at the Australian National University. The contents of this publication are solely the responsibility of the authors.

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Conflict of Interest Statement: 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.

Sun W, Li Y, Hu Y, Rao X, Xu X, Browning CJ and Thomas SA (2019) Perspectives on the Training of Chinese Primary Health Care Physicians to Reduce Chronic Illnesses and Their Burden. Front. Public Health 7:168. doi: 10.3389/fpubh.2019.00168

Abstract

本文是关于培训中国的全科医生以减少慢性病及其负担的评论。首先，我们将考虑中国政府的政策立场，即为实施拟议中的初级卫生保健制度改革，发展一支合格和扩大的全科医师队伍。然后，我们回顾一下慢性病高负担的影响因素，尤其是在中国的老年人中。我们认为，全科医生的培训课程应与显示的高患病率慢性病及其危险因素相匹配，并应具备预防和减轻疾病及其危险因素的能力。

frontiers in Public Health

PERSPECTIVE
published: 02 July 2019
doi: 10.3389/fpubh.2019.00168

Perspectives on the Training of Chinese Primary Health Care Physicians to Reduce Chronic Illnesses and Their Burden

Wenmin Sun[1], *Yang Li*[1], *Yiting Hu*[1,2], *Xin Rao*[1,2], *Xingzhi Xu*[1,2*], *Colette Joy Browning*[2,3,4] *and Shane Andrew Thomas*[2,4]

[1] *Health and Family Planning Capacity Building and Continuing Education Center of Shenzhen Municipality, Shenzhen, China,* [2] *Shenzhen International Primary Health Care Research Institute, Shenzhen, China,* [3] *School of Nursing and Healthcare Professions, Federation University, Ballarat, VIC, Australia,* [4] *Research School in Population Health, Australian National University, Canberra, ACT, Australia*

OPEN ACCESS

Edited by:
Marcia G. Ory,
Texas A&M University, United States

Reviewed by:
Pradeep Nair,
Central University of Himachal Pradesh, India
Leon Piterman,
Monash University, Australia

***Correspondence:**
Xingzhi Xu
xu_xingzhi1992@hotmail.com

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

Received: *14 March 2019*
Accepted: *06 June 2019*
Published: *02 July 2019*

Citation:
Sun W, Li Y, Hu Y, Rao X, Xu X, Browning CJ and Thomas SA (2019) Perspectives on the Training of Chinese Primary Health Care Physicians to Reduce Chronic Illnesses and Their Burden. Front. Public Health 7:168. doi: 10.3389/fpubh.2019.00168

This paper is a commentary on the training of Chinese Primary Health Care Doctors to reduce chronic illness and its burden. First, we will consider the policy position of the Chinese government concerning the development of a competent and enlarged primary physician workforce to deliver the proposed primary health care system reforms. We then turn to a review of the drivers of the high burden of chronic illnesses especially in older people in China. We argue that the curriculum for the training of primary health care medical practitioners should match the demonstrated high prevalence chronic illnesses and their risk factors and that there needs to specific competencies in prevention and mitigation of the diseases and their risk factors.

Keywords: Chinese primary health care physicians, training, chronic illness, China, burden of disease

POLICY CONTEXT OF CHINA'S PRIMARY HEALTH CARE REFORMS

The various policy statements from the Chinese State Council (1) and the responsible ministries (2) regarding the physician workforce in China are clear and consistent. China needs more qualified doctors, especially general practitioners who have the skills required to meet the needs of the people and their population health needs. World Bank Indicators data (3) show that while China has experienced rapid growth in the size of its physician workforce, the OECD economies currently have approximately 150 to 200 per cent of the per capita (per 1,000 population) physician workforce compared to China and many OECD countries also consider themselves to be in a position of doctor shortage. The following figure shows the historical trends of physician ratios per 1,000 people from 1960 to 2018 for China and other key countries involved in primary health care reform (**Figure 1**).

China has also recognized the need for expansion of its primary care physician workforce and has set ambitious targets for the growth in this workforce (4). Its physician workforce is currently predominantly composed of specialists and there is a desire to modify this situation to increase the primary care physician workforce proportion.

THE HEALTH NEEDS AND BURDEN OF DISEASE WITHIN THE CHINESE POPULATION

In designing training systems for the Chinese primary care physician workforce it is necessary to understand the health needs of the people that the workforce is intended to service (5). The population health needs of the Chinese people are very well-documented in a many academic and government reports. Chronic illness in China is a major burden as it is in most countries globally. Sufficient numbers of well-trained doctors are needed to deal with what the World Health Organization (6) has labeled a "tsunami" of chronic illnesses currently being experienced in China and globally (7, 8). It is widely agreed that the Chinese health system needs to be able to prevent and reduce the rates and numbers of new cases of chronic illness and Non-Communicable Diseases and to mitigate the severity of existing cases of chronic and Non-Communicable Diseases.

The United Nation's Sustainable Development Goals for 2030 (9) include reducing premature mortality from non-communicable diseases (NCDs) by one third for all countries including China. This is an ambitious target. Li et al. (10) study specifically considers the feasibility of achievement of the United Nations Sustainable Development 30 percent reduction goal for China. The researchers used the 2013 Global Burden of Disease Study data from China to model projected premature mortality in 2030 of NCDs using different risk factor reduction scenarios. The risk factors used were high systolic blood pressure, smoking, high body mass index (BMI), high total cholesterol, physical inactivity, and high fasting glucose. The researchers found that if the current trends for each of these risk factors in China continued to 2030, then total premature deaths from NCDs would increase from 3.11 million to 3.52 million people. However, if the risk reduction targets were reached then one million deaths among persons 30 to 70 years old in China due to NCDs would be avoided. The authors argue that more strenuous efforts are required to achieve risk factor reduction. This is a widely shared view.

THE DEEPENING REFORM STUDY AND ITS IMPLICATIONS

The China Joint Study Partnership comprising the World Bank Group, the World Health Organization, the China Ministry of Finance, the National Health and Family Planning Commission, the Ministry of Human Resources and Social Security (2) recently released a comprehensive analysis of Chinese Health Service Reform in its Deepening Reform study program. The Deepening Reform analysis confirms the same issues raised in State Council policy directives and the large body of academic research that has focused on the health of the Chinese population. The report notes the important impact of the rapidly aging profile of China upon burden of disease in China and that China will soon overtake many OECD countries in its population proportion of older people. The report notes the rapid growth in the impact of NCDs and chronic illness upon the health of the Chinese population. It is noted that NCDs are responsible for 77 percent of the loss in healthy life and 85 percent of all deaths and that this trend is increasing. The report also comprehensively analyses the impact of risk factors upon the growth in chronic disease burden. It notes that, while population aging is important that, across the whole Chinese population, key high-risk behaviors including smoking, poor nutrition, low physical activity, hazardous alcohol consumption, and environmental factors are the key drivers of increasing disease burden for the whole population. The analyses identify the same issues in many of the other analyses of the epidemiology of the Chinese population.

However, the Deepening Reform report (2) differs from many others in that it also includes a deep analysis of potential policy measures and actions that may be taken to improve China's situation. The report identifies a set of influential "levers" for reform. These are:

1. Shaping a tiered health care delivery system in accordance with People-Centered Integrated Care models
2. Improving quality of care in support to People-Centered Integrated Care
3. Engaging citizens in support of People-Centered Integrated Care
4. Reforming public hospitals and improving their performance
5. Realigning incentives in purchasing and provider payment
6. Strengthening health work force for People-Centered Integrated Care
7. Strengthening private sector engagement in production and delivery of health services
8. Modernizing health service planning to guide investment.

The central inclusion of the concept of People-Centered Integrated Care reflects best global health care practice (11). This is the way that many health systems have gone, by placing the patient at the center of the health service efforts and design. This approach has delivered substantial benefits in program effectiveness and efficiency (see, for example, the Cochrane Collaboration Systematic review database https://www.cochranelibrary.com/ which at the time of writing had 162 systematic reviews of patient centered care with almost universally successful results). A further key feature of the Deepening Reform report is its evidence-based philosophy. The report focusses on what can be done to improve the efforts in the delivery of services that address the demonstrated health needs of the Chinese people.

TRAINING CONSIDERATIONS FOR CHINA'S PRIMARY HEALTH CARE MEDICAL WORKFORCE

While all the identified "levers" are certainly worthy of attention, our focus as educators of primary health care physicians in this commentary is on delivering the required numbers of appropriately trained doctors to participate in the new reformed Chinese system. This raises the question of what should be included in an appropriate Chinese primary care physician curriculum?

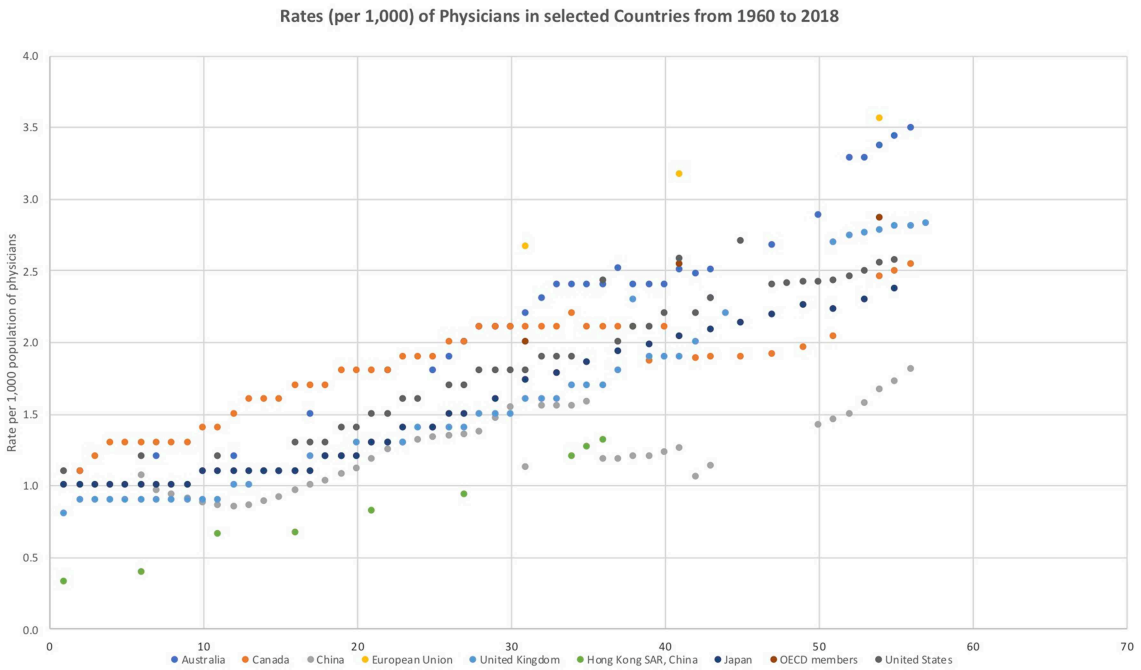

FIGURE 1 | Rates (per 1,000) of Physicians in selected Countries from 1960 to 2018.

We have made substantial progress in the development of the Shenzhen standards for primary care physicians. We have critically analyzed the major Western General Practice clinical standards. The new Shenzhen standard was developed using rigorous modified Delphi procedures with a large expert panel building on a detailed analysis of relevant international standards. Embedded in the standards are assumptions about what doctors will and should do in their everyday practice. We have separately reported the Shenzhen standards development in another publication[1] but a key feature of our strategy has been matching the standards content to meet the health needs of the Chinese population as well as matching or exceeding contemporary international standards. It is obvious that the prevention and management of chronic illness and non-communicable diseases must be a key focus in a primary care physician's training curriculum. There are two aspects to this focus. The first aspect is content knowledge about the most prevalent and burdensome conditions that afflict the community. The content needs to be evidence-based using the best epidemiological data concerning disease burden and also it needs to be evidence based in terms of the selection of effective treatments to treat these diseases.

The major illnesses associated with China's disease burden have been studied in detail by many government bodies and academic researchers. The same lists emerge from these analyses. The Deepening Reform Study (2) and the World Health Organization (12) China country assessment report on aging and health have considerable commonality as they draw from the same authoritative data sets. The analyses presented in the WHO country assessment (12) estimate that the following conditions are associated with the highest disease burden. Burden of disease is typically measured by Disability Adjusted Life Years (13) and the WHO country assessment (12) provides the following estimates for various conditions for older people:

1. Stroke (35.9 million DALYs)
2. Malignant neoplasms (30 million DALYs);
3. Ischaemic heart disease (22.6 million DALYs);
4. Respiratory diseases (16 million DALYs);
5. Diabetes mellitus (5.6 million DALYs);
6. Mental health conditions such as depression, suicide and dementia (5.3 million DALYs);
7. Hypertensive heart diseases (3.6 million DALYs); and
8. Falls (3 million DALYs).

Thus, it is evident that primary health care physicians require a substantive knowledge of these conditions and their prevention and management. This is how many medical curriculums are organized with a list of key conditions to be covered.

A FOCUS ON RISK FACTORS AND THEIR MITIGATION

However, we consider that the second key focus is the need for primary care physicians to identify and to mitigate and control the risk factors that exacerbate the main diseases. To

[1]Rao X, Lai J, Wu H, Li Y, Xu X, Browning C, et al. (2019). A competency assessment standard and curriculum for General Practitioners in China. (under review).

mitigate these risk factors requires a quite specific skill set. The same analyses have identified risk behaviors amongst the Chinese population that exacerbate the above list of diseases. For example, smoking is a key health risk for most of the above list of diseases/conditions. But there are others that the WHO analysis (8) has identified. These include:

1. Dietary risks
2. High blood pressure
3. Smoking
4. High fasting glucose levels
5. Exposure to air pollution and
6. Physical inactivity

While our focus for this paper is behavioral risk factors that can be mitigated in the primary health care setting, in order to address behavioral risk factor mitigation in China we recognize that multi-level approaches are needed including a systematic approach to chronic illness management within the health system, public health interventions, as well as primary health care physician training in behavior change approaches. In China, as discussed previously, the Deepening Health Reform in China monograph (2), developed by the World Bank, the WHO and various senior Chinese ministries and commissions, highlights a number of proposed levers to improve health outcomes in China, including a Patient-Centered Integrated Care Model, and engaging patients in their care, which build on the experience of Western countries.

In the United Kingdom and Australia, chronic illness management systems have been strongly influenced by the Wagner Chronic Care Model (14) and a focus on patient centered care (15). These approaches include an emphasis on team-based care and better coordination (integration) across primary care settings and hospitals, integrated patient record systems and patient access to their health records, medication management and self-management support.

In Australia, General Practitioners (GPs) are funded by the national health insurance system and government to provide longer consultations and care planning for patients with chronic illnesses (16). A recent review of confirms that Self-Management Support is the most frequent Chronic Care Model intervention that is associated with statistically significant improvements, predominately for diabetes and hypertension (17). Self-Management support requires the ability of the primary care physician to manage behavior change in their patients. This has been long recognized in some countries. For example, the Royal Australian College of General Practitioners have for 20 years developed and revised standards and support resource materials to assist general practice doctors to assist their patients to modify these risk factors through behavior change principles (18). The United Kingdom has also strongly promoted behavior change in its approaches to chronic disease risk reduction (19).

Medication management in primary care in people with chronic illnesses has been a particular focus in Australia and world-wide. Polypharmacy, the prescription of potentially inappropriate conflicting medications has been recognized a potential risk to patients with chronic illness and the typical pattern of multimorbidity. However, the effectiveness of polypharmacy reduction programs (20–22)and the process of de-prescribing (23) has been shown to have quite varied research outcomes, notwithstanding the widespread acceptance of the necessity to reduce it. Polypharmacy in China is a significant problem particularly in older patients (24). Specific issues in China driving polypharmacy include the dominant role of the doctor in the doctor-patient interaction and low patient health literacy, the profit-driven nature of medical interventions in China, and stong pharmaceutical marketing (25). The National Essential Medicine System has shown some promise in improving the rational use of medicines in primary care settings in China (26).

Chronic illness management also needs to address mental health co-morbidities. Since 2006 the Chinese Government policy has promoted the detection and treatment of mental illness in primary care settings through integrated mental services (27). Yet training in mental health for primary care physicians in China is insufficient (28) and patient perceptions including stigma and concerns about the competency of primary care physicians are barriers to treatment (29). Li et al. (30) reviewed the prevalence of co-morbid depression in people with chronic illnesses (COPD, diabetes, stroke, heart disease and cancer) and treatment rates in the US and China. Depression prevalence rates ranged for 40 to 80% across the diseases. Depression prevalence rates were higher in China for diabetes, heart disease and cancer and higher in the US for COPD and stroke. Based on 2009 data, in the US 47% of people with depression were detected by primary care physicians and 35% received treatment. Based on 2003 data treatment levels in China are significantly lower with only 1% of people with depression being treated. While Li et al. (29) focused on the implications of these findings for nurses their general conclusion was that primary care providers needed further skills development in the areas of detecting and managing mental health issues in the context of chronic illness management.

Public health approaches are also an important part of addressing behavioral risk factors at the population level. Smoking is an example of the need for combined regulatory, public health and primary care approaches. For example, to reduce smoking rates, strategies such as increasing excise on tobacco, regulating smoking advertising, banning smoking in public places, public health education and health promotion programs and plain paper packaging have been used in Australia and other western countries to reduce smoking levels (31). In China, these approaches have had limited impact on smoking rates. A Quitline model was introduced in China in 2004 and provided information and counseling calls. However, the effectiveness of the approach was limited by low funding and a lack of targeted approaches for specific at-risk populations (32). Smoke-free legislation in public places was introduced in Guangzhou, China. Where full smoking bans were introduced self-reported smoking decreased in younger age groups (33). A recent analysis argued that in addition to non-price measures, to reduce smoking targets under Healthy China 2030 (34) tobacco excise would need to be doubled (35). However, while public health and more general public policy approaches have been successful in countries such as Australia, these have been complemented and supported by more individual level clinical care approaches provided within the primary health

care setting, an approach that could benefit smoking reduction in China.

Addressing physical inactivity is another important risk factor for poor health and chronic illness prevention and management that requires primary care and public health interventions as well as legislative approaches. In a review of national policies to increase Health Enhancing Physical Activity (HEPA) in seven European countries, Bull et al. (36) reported a number of findings relevant to public health and legislative approaches to inactivity. Several countries had specific physical activity policies and all reviewed countries had legislation about mandatory physical education in schools. Some countries had legislation on transport and the environment relevant to HEPA. Six of the countries had national HEPA guidelines and targets, 5 had surveillance systems, and most used mass media campaigns. Evaluation of the HEPA programs was generally poor with little evidence of implementation processes. The authors concluded there was insufficient policy progress in this area. The Lancet 2016 series (37) on physical activity argued that physical activity goals need to reflect and be consistent with social, environmental, and sustainable development goals and embrace a multi-sectoral, multidisciplinary public health approach.

The Chinese National Fitness Plan (2016-2020) aims to increase physical activity and population health (38). The plan sets targets for physical activity (700 million participating in PA at least once a week, 435 million engaging in regular physical activity). However, Wu et al. (39) argue that in China consensus is lacking concerning the best forms of physical activity given availability and environmental issues associated with outdoor activities. Consistent with recommendations form the aforementioned Lancet series, the authors (38) recommended: a co-ordinated approach across public health authorities, health care, transportation and the environment, the development of mass campaigns, a research agenda to support the implementation of evidence-based programs and the establishment of national surveillance systems. Primary care physicians in China have a significant role to play in this co-ordinated approach similar to their counterparts in Western countries. Physical activity is a key component of primary care chronic disease supported self-management approaches. In order to fulfill this potential Chinese primary care physicians need training in behavior change approaches.

The Evidence for the Success of Chronic Disease Risk Factor Mitigation in China

There has been significant Chinese work in clinical trials and systematic reviews of this issue. For example, we examined the therapeutic effects of motivational interviewing on blood pressure control by conducting a meta-analysis of randomized controlled trials (40). The review showed strong effects of the motivational interviewing technique in enabling blood pressure control in the RCTs studied. Similarly, members of our research group reviewed psychological interventions for the management of glycemic and psychological outcomes of Type 2 Diabetes Mellitus in China by conducting systematic review and meta-analyses of relevant Randomized Controlled Trials (41). We have also conducted our own RCTs of treatment effectiveness in the control of T2DM (42, 43) using these techniques and we have found them to be highly effective. There are many such studies that show strong positive effects of this type of intervention and this is why there is such interest in the use of these techniques in the clinical management of high risk behaviors.

CONCLUSIONS

There is widespread agreement about the need to appropriately train general practitioner physicians so that they may deliver high quality and effective care to their patients. There is also strong evidence that there is a global shortage of skilled practitioners and China has particular needs to develop the talent pool to support its ambitious primary care reform agenda. We have argued that primary care physician training needs to be informed by rigorous analysis of the causes and underlying risk factors for high burden of disease conditions. These conditions and their treatments have been well-researched and there is a strong evidence base. We propose that to effectively prevent and mitigate the many chronic conditions and diseases that are caused and exacerbated by lifestyle factors requires high level behavior change skills, mental health detection and management skills and other patient management skills that need to be included in the Chinese primary care physician curriculum.

DATA AVAILABILITY

Publicly available datasets were analyzed in this study. This data can be found here: http://datatopics.worldbank.org/world-development-indicators/

AUTHOR CONTRIBUTIONS

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

FUNDING

This research was funded by The Sanming Project of Medicine in Shenzhen Sanming Project team code: SZSM201511046 and the Australian Research Council Discovery Grant - Aging in China and Australia: Promoting health, productivity and well-being Grant number DP160103023.

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Conflict of Interest Statement: 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.

Yiengprugsawan VS and Browning CJ (2019) Non-communicable Diseases and Cognitive Impairment: Pathways and Shared Behavioral Risk Factors Among Older Chinese. Front. Public Health 7:296. doi: 10.3389/fpubh.2019.00296

Abstract

由于非传染性疾病的流行，人口老龄化给公共卫生和初级卫生保健系统带来了许多挑战。作为全球人口最多的国家，中国正面临越来越多的慢性非传染性疾病，包括与心脏代谢有关的疾病。这份简短的综述调查了非传染性疾病和通过常见危险因素引起的认知障碍之间的联系。识别危险因素对于预防和管理这些慢性病很重要。此外，本评价还确定了初级卫生保健服务在减少非传染性疾病和认知障碍的行为危险因素方面的作用。解决共同的决定因素和途径在中国公共卫生干预和初级卫生保健服务的设计中具有重要意义。监测和管理非传染性疾病的生物标志物和行为危险因素也可能有利于中国老年人的健康。

frontiers in Public Health

MINI REVIEW
published: 23 October 2019
doi: 10.3389/fpubh.2019.00296

Non-communicable Diseases and Cognitive Impairment: Pathways and Shared Behavioral Risk Factors Among Older Chinese

Vasoontara Sbirakos Yiengprugsawan [1,2]* *and Colette Joy Browning* [1,3,4]

[1] *Centre for Research on Ageing, Health and Wellbeing (CRAHW), Research School of Population Health, The Australian National University, Canberra, ACT, Australia,* [2] *Australian Research Council Centre of Excellence in Population Ageing Research (CEPAR), University of New South Wales, Kensington, NSW, Australia,* [3] *School of Nursing and Healthcare Professions, Federation University, Ballarat, VIC, Australia,* [4] *International Primary Health Care Research Institute, Shenzhen, China*

Population aging has brought about a number of challenges to public health and primary health care systems due to increases in the prevalence of non-communicable diseases (NCDs). As a country with one of the largest populations globally, China is confronting a rising number of chronic NCDs including cardiometabolic related conditions. This mini-review investigates the link between NCDs and cognitive impairment through common risk factors. Identifying risk factors is important for the prevention and management of these chronic conditions. In addition, this review also identifies the role of primary health care services in reducing behavioral risk factors for NCDs and cognitive impairment. Addressing shared determinants and pathways is important in the design of public health interventions and primary health care services in China. Monitoring and management of NCD biomarkers and behavioral risk factors may also be beneficial for cognitive health among older Chinese.

Keywords: aging, China, cognitive decline, chronic conditions, lifestyle risk factors

OPEN ACCESS

Edited by:
Marcia G. Ory,
School of Public Health, Texas A&M University, United States

Reviewed by:
Krista Mincey,
Xavier University of Louisiana, United States
Matthew Lee Smith,
Texas A&M University, United States

***Correspondence:**
Vasoontara Sbirakos Yiengprugsawan
vasoontara.yieng@anu.edu.au;
v.yiengpr@unsw.edu.au

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

Received: *09 November 2018*
Accepted: *02 October 2019*
Published: *23 October 2019*

Citation:
Yiengprugsawan VS and Browning CJ (2019) Non-communicable Diseases and Cognitive Impairment: Pathways and Shared Behavioral Risk Factors Among Older Chinese. Front. Public Health 7:296. doi: 10.3389/fpubh.2019.00296

INTRODUCTION

As China's population ages, the country is confronted with rapidly changing health profiles. According to the Global Burden of Diseases, the pattern of causes of deaths has also changed significantly away from communicable diseases and as of 2016, the main causes of death were cardiovascular diseases (41%), cancers (25%), chronic respiratory diseases (10%), and diabetes (4%) (1). In addition to these "Big 4" non-communicable diseases (NCDs), neurological disorders including Alzheimer's disease and other dementias further contributed to 5% of pre-mature mortality. This figure is expected to increase as China's population ages (1, 2).

NCDs are inextricably linked to natural aging processes and various modifiable risk factors, and as a result, chronic conditions generally have common determinants and many shared risk factors, most of which are amenable to prevention and amelioration over the lifecourse (3, 4). NCDs have direct or indirect impacts on activities of daily living resulting from these conditions (5). Furthermore, there has been emerging literature on the potential links between chronic non-communicable diseases and cognitive impairment, notably highlighting common mid-life modifiable risk factors (e.g., mid-life hypertension, diabetes, smoking), improving integrated chronic care management, and reducing impacts on overall quality of life (6–8).

The United Nations Sustainable Development Goals initiative has called for a reduction by one third of premature mortality from NCDs (9). If this is to be achieved in China, risk factor reduction needs to be a focus. An analysis of Chinese Burden of Disease risk factor data (blood pressure, body mass index, high cholesterol, high fasting glucose, smoking, and inactivity) in people aged 30–70 years, found that if risk reduction targets were met by 2030, one million deaths could be avoided (10).

While there is good evidence that the prevalence of cognitive impairment among older Chinese is greater than would be expected from age-related health decline (2, 11, 12), information is still limited on the relationships between NCD co-morbidities, common risk factors, and cognitive impairment. This review looks at common pathways for NCDs, Cognitive Impairment (CI), and Mild Cognitive Impairment (MCI) whereby CI is a broad term that can range from mild to severe (13). The purpose of this review is to specifically focus on older Chinese to investigate associations between NCDs, CI as well as MCI, and common risk factors, as well as to identify the role of primary health care services in reducing common behavioral risk factors. Notably, the majority of these studies reported focus on MCI with some examples of CI included. The role of key socio-demographic factors and primary health care in these associations will be also presented in the mini-review.

The review will contribute to a better understanding of the pathways and interrelationships between NCDs, CI/MCI and their risk factors among older Chinese. It will also discuss effective health promotion and prevention strategies targeting modifiable risk factors that may prevent or delay the onset and progress of late-life cognitive impairment.

METHODS

This mini review will cover the range of observational population-based studies conducted between 2010 and 2018 focusing primarily on CI/MCI among non-clinical samples of adults aged 50 years and over in mainland China. Studies that restricted the sample ages to 75+ years and the oldest old were not included in the review. Main searches were conducted in English through international databases such as MEDLINE, PubMed, Scopus, and Web of Science. Key search terms, for example, include "cognitive impairment" "Mild Cognitive Impairment" "MCI" "Alzheimer's" "dementia" "cardiovascular diseases" "hypertension" "diabetes" "blood pressure" "chronic diseases" (**Table 1**).

Definition and Prevalence of CI/MCI Among Older People in China

We focus on CI and MCI as there is evidence that these conditions could lead to an increased risk of developing more severe neurological conditions such as dementia and Alzheimer's disease (2, 11, 12). Commonly used international diagnostic criteria for CI and MCI rely on cognitive function assessments such as the Montreal Cognitive Assessment (MoCA) and the Mini-Mental State Examination (MMSE), both with scores ranging from 0 to 30 points. MCI diagnosis is often based on Petersen's criteria which include memory problems in the absence of dementia (27–29). In the Chinese literature, using MMSE, CI has a cut-off score of 24, while MCI generally has the cut-off score of 26 (30–32). Taking into account the educational differential effect on cognitive performance, MCI among older Chinese was commonly defined by an MMSE score of <17 in the illiterate group, <22 in the primary school group, and <26 in the junior school and above (19). Corresponding cut-off scores for CI were reported at 17, 20, and 24, respectively (23).

According to a meta-analysis of 22 studies among older people aged 60 years and over in China, 12.7% have experienced MCI and the prevalence was lower in more economically advanced Eastern areas (9.6%) compared to Western China (14.7%) (11). A more recent systematic review among 48 studies across 22 provinces in China reported the pooled prevalence of MCI in the older Chinese aged 60 years and over was 14.7%; the prevalence was 16.7% in clinical samples and 14.6% in non-clinical samples (12).

RESULTS

Relationships Between Cardio-Metabolic Risk Factors and CI/MCI

Diabetes and Obesity

There is increasing evidence on the significant relationship between type 2 diabetes mellitus and CI/MCI among older adults in China (14, 15, 33). A cross-sectional study (aged 65+in Northern China) revealed risk factors for MCI to be age at onset and biomarkers of type 2 diabetes severity such as fasting plasma glucose, glycosylated hemoglobin, and immunoreactive insulin (14). An urban population-based study (aged 55+ in Shanghai) further confirmed that T2DM was not only a risk factor for MCI but also associated with the progression to Alzheimer's disease after adjusting for other possible covariates (15). However, another study (aged 60+ in Tianjin) revealed that even in the absence of type 2 diabetes, being overweight and/or obese are risk factors for MCI (16). Similarly a community-based study (aged 55+ in rural Xian) found that the presence of both type 2 diabetes and abdominal obesity was associated with an increased risk of cognitive impairment by more than double (17).

Cardiovascular Diseases, Blood Pressure, and Cholesterol

Cardiovascular diseases and cognitive decline share common risk factors including high blood pressure, which was found to be a predictor for CI/MCI among older adults (32, 34). A cross-sectional study (aged 60+ in Beijing) reported a higher prevalence of MCI among hypertensive individuals and also the prevalence of MCI was lower in those treated than in those not treated (18). Another cross-sectional study (aged 60+ in Tianjin) also reported similar findings with high blood pressure associated with a higher risk of cognitive impairment compared to normal blood pressure participants (95% CI: 1.07–2.54) (19). In addition to hypertension, coronary heart disease, total cholesterol, and low-density lipoprotein cholesterol were found to be independent risk factors for MCI and elevated high-density

TABLE 1 | Description of studies illustrating relationships between cognitive impairment and non-communicable diseases.

Studies	N and age (years)	Areas	Study design	Cognitive impairment (CI/MCI)	Cardiometabolic and lifestyle factors
Gao et al. (14)	*N* = 8213 Aged 65+	Tianjin, Northern China	Cross-sectional (2010)	Mini Mental State Examination MMSE ≤27 Montreal Cognitive Assessment MoCA <26	Fasting plasma glucose (FPG), glycosylated hemoglobin (HbA1c) and immunoreactive insulin (IRI) were associated with increasing risk for MCI with Type 2 diabetes (T2DM).
Li et al. (15)	*N* = 525 Aged 55+	Shanghai	Cross-sectional (2011)	MMSE ≤27 MoCA <26	T2DM was a risk factor for MCI progressive to Alzheimer's disease.
Wang et al. (16)	*N* = 480 Aged 65+	Tianjin, Northern China	Longitudinal (2008–2014)	MMSE<20 (primary education); MMSE<24 (>primary education) MoCA <25 (≤12 years of education); MoCA <26 (>12 years of education)	Being overweight or obese at baseline was associated with an increased risk of both amnestic and non-amnestic MCI. An increased body mass index at 6-year follow-up also increased the risk of non-amnestic MCI.
Li et al. (17)	*N* = 865 Aged 55+	Xi'an	Cross-sectional (2014/2015)	MMSE<17 (illiterate) ≤20 (primary school education) ≤24 (junior school and above)	Significant interaction between abdominal obesity and diabetes associating with an increased risk of cognitive impairment.
Wu et al. (18)	*N* = 2,065 Aged 60+	Wanshoulu District, Beijing	Cross-sectional (2009/2010)	MMSE<17 (illiterate) ≤20 (1–6 years of education) ≤24 (≥7 years of education)	Prevalence of MCI was higher in hypertensive than normal individuals. Among hypertensive patients, the prevalence of MCI was lower in those treated than in those not treated.
Ren et al. (19)	*N* = 1,171 Aged 60+	Tianjin, Northern China	Cross-sectional (2014/2015)	MMSE<17 (illiterate) <22 (primary school) <26 (junior school and above)	In the multivariate analysis, high blood pressure/ stage III hypertension was associated with cognitive impairment.
He et al. (20)	*N* = 227 Aged 65+	Tianjin, China	Cross-sectional (2014)	MMSE scores 18–23: mild CI MMSE scores 10–17: moderate CI MMSE scores 0–9: severe CI	Total cholesterol (TC) was significantly higher in participants with MCI. Elevated HDL (high-density lipoprotein cholesterol) and triglyceride were associated with the occurrence of MCI.
Ma et al. (21)	*N* = 1,159 Aged 60+	Nationwide, Chinese Longitudinal Healthy Longevity Survey	Longitudinal (2009–2014)	Annual cognitive change of MMSE scores	High TC and low-density lipoprotein cholesterol (LDL-C) in late-life were associated with greater cognitive decline.
Zou et al. (22)	*N* = 597 Aged 60+	Chongqing, Southwest China	Cross-sectional (2011/2012)	Complaint of memory decline for at least 6 months; objective memory decline via neuropsychological evaluation, Clinical Dementia Rating (CDR) score of 0.5.	Hypertension, coronary heart disease, TC, and low-density lipoprotein cholesterol (LDL-C) are independent risk factors for MC.
Yin et al. (23)	*N* = 16,629 Age 60+	Nationwide, Disease Surveillance Point System	Cross-sectional (2011/2012)	MMSE<17 (illiterate) ≤20 (primary school) ≤24 (middle school and above)	Chronic respiratory symptoms and self-reported COPD were strongly associated with cognitive impairment in urban areas.
Zhou et al. (24)	*N* = 3,012 Age 60+	Chongqing, Southwest China	Cross-sectional (2001)	MMSE<17 (illiterate) <20 (primary school) ≤24 (middle school and above)	Current smoking and daily alcohol consumption were significantly associated with an increased risk of cognitive impairment.
Pan et al. (25)	*N* = 2,037 Age 45+ women only	China Health and Retirement Longitudinal Study	Longitudinal (2011–2013)	Telephone Interview version of the MMSE – 1) memory tests and 2) orientation, visuoconstruction, and numeric ability.	Longer exposure to second hand smoke exposure was associated with a greater decline in memory over 2 years, especially among women aged 55–64 years
Zhu et al. (26)	*N* = 6,586 Age 65+	Chinese Longitudinal Healthy Longevity Survey	Longitudinal (2005 and 2008–2009)	MMSE<18 (no formal education) <21 (1–6 years of education) <25 (>6 years of education)	High level of participation in leisure activities was associated with about 40% decreased risk of cognitive impairment.

lipoprotein cholesterol and triglyceride were associated with the occurrence of MCI (20–22).

Chronic Obstructive Pulmonary Disease

There is evidence documenting the relationships between chronic obstructive pulmonary disease and cognitive impairment among older Chinese. A nationally representative Chronic Disease and Risk Factor Surveillance study covering 31 provinces across China reported chronic cough, chronic phlegm, and self-reported symptoms in urban areas, but only chronic phlegm in rural areas was associated with cognitive impairment (23). In addition, indoor air pollution, such as exposure to biomass combustions from cooking fuel, could modify the effects of chronic obstructive pulmonary disease on cognitive impairment (23).

Relationships Between Modifiable Health-Risk Factors and Cognitive Impairment

Smoking and Alcohol Consumption

Smoking and alcohol consumption have been found to be major behavioral risk factors for cognitive impairment among older Chinese (24, 25). For example, cross-sectional evidence from (aged 60+ in Chongqing) reported that current smoking and daily consumption of alcohol were associated with a significantly increased risk of cognitive impairment (24). Despite of low female smoking in China, further longitudinal evidence from the national China Health and Retirement Longitudinal Study among Chinese nationwide reported that longer exposure to second hand smoke was associated with higher risk of cognitive decline over 2 years, especially among women aged 55–64 years (25).

Exercise and Incidental Physical Activity

The benefits of being physically active has been widely documented among older Chinese with direct effects across multiple domains of cognitive functions from engaging in modern aerobic and traditional Chinese exercise such as Tai Chi and Qigong (35–37). A systematic review among older Chinese has linked the health benefits of exercise in a range of chronic diseases through lowering elevated blood pressure (hypertension) as well as improving cardiopulmonary and lung functions (38). In addition to exercise, incidental physical or leisure activities such as housework were shown to associate with a 41% decreased risk and thus protective against cognitive impairment based on the 5-year follow-up of the nationwide Chinese Longitudinal Health Longevity Survey (26).

Common Social Determinants of NCDs and Cognitive Impairment

Socio-Economic Status

Low socioeconomic status has been commonly linked to disparity in mild cognitive impairment (11, 19, 39). According to the World Health Organization Study on global AGEing and adult health among older Chinese nationally aged 50 years and over, years of education were shown to be significantly associated with cognition scores at the individual level and median household income and median years of education at the community level (40). Using the same data, another study has confirmed that both education level and wealth were negatively associated with untreated chronic non-communicable diseases among older Chinese (41).

Demographic Status

The role of demographic characteristics, particularly old age and being female is associated with cognitive impairment among older persons across China (11, 19). The gender difference may also be a result of women having less access to education (11, 42). Solitary status, including never married, divorced, and widowed, is also associated with cognitive impairment among older Chinese (43).

Geographical Areas

Multiple epidemiological studies have determined that geographical disparities result in an increase in cognitive impairment among older Chinese in rural areas (39, 44). Residential status has been linked to a faster decline in cognitive function, not only among rural but also rural-to-urban migrants compared to urban residents as reported by a 12-year follow-up of the Chinese Longitudinal Health Longevity Survey (45). Another study using a 9-year follow-up of the same data revealed rural disadvantage also affected not only cognitive health but also other physical health measures (46).

Strengths and Limitations

This mini review brings together recent evidence on cognitive and mild cognitive impairment among older Chinese highlighting the link to shared behavioral lifestyle risk factors of cardio-metabolic conditions. The strength of this mini review draws upon many large epidemiological studies across China including longitudinal studies where possible. Notably, the mini review focuses on observational population-based data with less evidence from clinical studies. Because of the smaller scope of the mini review, which is primarily based on international databases, relevant articles in Chinese may be omitted. This could potentially result in under reporting bias in some geographical areas that have limited exposure to English publications.

The definition and severity of cognitive impairment vary across studies, however, most of these studies use international standardized measures. It has been argued that these measures should have differing cut-offs for older and less educated respondents within the Chinese context (47). Care should be taken in the investigation of aging and cultural influence on cognition (48, 49). In addition to the importance of culturally appropriate tests in interpreting cognitive impairment, other factors such as cultural specific factors such as regional norms among older Chinese could be further explored. Longitudinal studies could provide insight into mechanisms by which cognitive impairment and NCDs interact. Standardized measures would also allow for possible international comparative studies beyond China in future research.

Policy Implications

Under the national Healthy China Initiative, the Chinese government has put in place the plan toward 2025 for the prevention and treatment of chronic non-communicable diseases (50). The first two goals of "…diagnosing diseases in the early stage" and "…advocate a healthy lifestyle" are applicable to both NCD and CI/MCI which share common risk factors. Addressing behavioral risk factors and early detection of NCDs could delay its progression and further complications.

Since the health system reforms in 2009, achieving essential public health services and community-based non-communicable disease management has been rolled out nationwide to improve availability and accessibility of health services (51). Primary health care and community health centers, especially in the rural areas, play a significant role in regular screening for blood pressure or blood glucose in middle-aged and older adults and follow-up management of these conditions (52, 53). In line with advocating a healthy lifestyle through self-care education, behavioral, and psychological approaches embedded within primary health care settings could also provide effective intervention in managing chronic conditions such as diabetes (54). Integration of services at both primary and secondary levels is also vital for chronic care management (5, 55).

In order to implement these reforms in primary health care settings the health care workforce needs to be upskilled (50, 56). The need for more and better trained general practitioners is central to many recent policy statements in China (57). Sun et al. (58) in this *Frontiers Special Topic Chronic Illness and Aging in China* present a strong argument for the training of general practitioners in China in behavior change and chronic illness management in order to prevent and manage behavioral risk factors in chronic illness. Wang et al. (57) in an analysis of community nurse training courses asked nurses to rank the importance and the utility of various topics. Pertinent to the current paper the authors found that while learning about health behaviors was ranked by nurses as 11 out of 20 topics in terms of importance, content utility was ranked at 15. In the subsequent modified curriculum, methods and skills involved in health education and promotion, impacts of unhealthy behaviors and interventions for unhealthy behaviors were included as well as management of chronic disease in the community.

The recent World Bank China Joint Study Partnership Health Policy Summary "Deepening health reform in China" (56) advocates a People-Centered Integrated Care Model to address the burden of chronic illness in China. It proposes an expanded and empowered role for citizens in the management of their health through building health literacy, strengthening patient self-management, and improving shared decision making. This model has the potential to address risk factors and the management of chronic illnesses in China but will require an investment in the training of doctors in the areas of self-management and behavior change and the education of citizens in the prevention of chronic illness.

As well as training the healthcare workforce in people-centered care, risk factor and chronic disease management; and the empowerment of patients in the management of their illness, system level changes are also needed. In addition to workforce strengthening and engaging citizens in their health care, the Deepening Health Reform in China policy statement identifies another six levers of reform including shaping a tiered health care delivery system, improving quality of care, reforming public hospitals, realigning purchaser and provider payment incentives; strengthening the health care private sector and modernizing health service planning [(56) p. xviii].

Given our current knowledge about the relationships between NCDs and cognitive impairment it is important that early public health interventions and primary health care services address risk factors across the lifecourse and that these interventions and services are well-targeted. We argue that attention to prevention through reducing behavioral risk factors such as excess tobacco and alcohol consumption and physical inactivity and the management of abnormal blood pressure and blood glucose all have the potential to impact positively on cognitive and mild cognitive impairment and non-communicable diseases in China.

AUTHOR CONTRIBUTIONS

VY and CB conceptualized the study, drafted the manuscript, and finalized revisions for publication.

FUNDING

This study received support from the Australian Research Council (ARC), Discovery Project Understanding aging in China and Australia (DP16010323), the ARC Centre of Excellence in Population Ageing Research (CEPAR grant numbers CE1101029 and CE1701005), and The Sanming Project of Medicine in Shenzhen, Sanming Project team code: SZSM201511046.

ACKNOWLEDGMENTS

The authors thank the late Emeritus Professor Hal Kendig who passed away before the manuscript submission. Prof. Kendig contributed significantly to the conceptualization of this study. Overall editorial guidance was provided by Peter Sbirakos throughout the process.

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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.

Rao X, Lai J, Wu H, Li Y, Xu X, Browning CJ and Thomas SA (2020) The Development of a Competency Assessment Standard for General Practitioners in China. Front. Public Health 8:23. doi: 10.3389/fpubh.2020.00023

Abstract

本文介绍了中国深圳全科医生胜任力评估标准的制定。该标准将用于开发和提供全科医生培训课程，并能够严格评估参加培训的全科医生的掌握程度。政府政策要求对中国的全科医生进行培训，要求有国际标准的课程来满足患者和社区的需求。采用改进的德尔菲法达成课程共识。建立了一个专家小组和一个由该专家小组组成的14个专家工作组，以审查和评估国家和国际上通用的能力标准，并通过改进的德尔菲方法制定一套标准。四十三名专家参与了该项目。该项目做了详细的课程说明。然后在2017年和2018年使用了此标准，对全科医生进行了试点考核（分别为298人和315人），以评估全科医生是否符合此标准。考试包括两个模块：笔试（模块A）和实践技能操作考试（模块B）。参与者的成功率相对较低，大多数人未成功完成考核。考核将在以后的工作中进一步完善。该项目实现了制定严格的评估标准的目标，以支持临床实践操作中对全科医生的培训和考核。

frontiers in Public Health

BRIEF RESEARCH REPORT
published: 20 February 2020
doi: 10.3389/fpubh.2020.00023

The Development of a Competency Assessment Standard for General Practitioners in China

Xin Rao[1,2], *Jinming Lai*[2], *Hua Wu*[2], *Yang Li*[2], *Xingzhi Xu*[1,2*], *Colette Joy Browning*[1,2,3,4] *and Shane Andrew Thomas*[1,2,3]

[1] International Primary Health Care Research Institute, Shenzhen, China, [2] Health and Family Planning Capacity Building and Continuing Education Center of Shenzhen Municipality, Shenzhen, China, [3] Research School in Population Health, Australian National University, Canberra, ACT, Australia, [4] School of Nursing and Healthcare Professions, Federation University, Ballarat, VIC, Australia

This paper describes the development of a competency assessment standard for General Practitioners in Shenzhen, China. The standard is to be used for developing and delivering the training curriculum for General Practitioners and to enable rigorous assessment of the mastery of the standards by GP trainees. The requirement for the training of General Practitioners in China is mandated by government policy requires an international standard curriculum to meet the needs of patients and the community. A modified Delphi process was employed to arrive at a curriculum consensus. An expert panel and 14 expert working groups derived from the expert panel were established to review and evaluate national and international competency standards for General Practice and develop a set of standards, through a modified Delphi methodology. Forty three experts were involved in the project. The project resulted in a detailed curriculum statement. The curriculum was then used in 2017 and 2018 where pilot examinations of GP trainees ($n = 298$ and $n = 315$, respectively) were conducted to assess the trainee's competencies against the Standards. The examination included two modules, a written test (Module A) and a practical test (Module B). The success rate for participants was relatively low with the majority not successfully completing the assessments. The assessments will be further refined in subsequent work. The project achieved its goal of developing a rigorously evaluated standard to support clinical practice and the training and assessment of GPs.

Keywords: competency standard, curriculum, general practitioners, China, GP training

OPEN ACCESS

Edited by:
Matthew Lee Smith, School of Public Health, Texas A&M University, United States

Reviewed by:
Vesna Bjegovic-Mikanovic, University of Belgrade, Serbia
Ulrich Laaser, Bielefeld University, Germany

***Correspondence:**
Xingzhi Xu
xu_xingzhi1992@hotmail.com

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

Received: *07 June 2019*
Accepted: *23 January 2020*
Published: *20 February 2020*

Citation:
Rao X, Lai J, Wu H, Li Y, Xu X, Browning CJ and Thomas SA (2020) The Development of a Competency Assessment Standard for General Practitioners in China. Front. Public Health 8:23. doi: 10.3389/fpubh.2020.00023

INTRODUCTION

As outlined in other papers by our team (1) in this special issue and by other commentators, the training of large numbers of high quality Chinese General Practice doctors is fundamental to China's efforts to improve its health system (2, 3). China has set ambitious targets for the growth in its General Practice medical workforce (4). This paper describes the development and pilot trial of competency standards for General Practice medical training in Shenzhen, China by the Health and Family Planning Capacity Building and Continuing Education Center of Shenzhen Municipality.

A key consideration in ensuring high quality service delivery by Chinese General Practice doctors is the development and implementation of rigorous clinical practice standards reinforced by a well-designed and executed training curriculum (5, 6). Recently, some commentators have

addressed the issue of development of Chinese clinical practice standards and there has been some criticism of the quality of the standards development methodologies employed and the subsequent quality of the standards derived from them (7–9). The criticism has centered on the failure in many studies to satisfactorily address conflict of interest considerations and lack of reliance upon strong evidence tools such as systematic reviews to inform the content of the standards. International protocols for the development of standards particularly emphasize these two issues as central to the quality and credibility of high-quality clinical standards (10, 11).

In order to meet the needs of the Chinese people and indeed people of any nationality, rigorous, and high-quality approaches are required to ensure that doctors are well- trained and have access to evidence-based clinical standards.

The development of medical and nursing curriculums and clinical standards has often employed variants of Delphi technique as a means of rigorously developing agreed positions (12–15). Delphi procedures especially for curriculum development vary widely in their implementation with modifications from the original specification. We employed the same modifications employed by other curriculum developers who used this technique namely extensive discussion of content. Because a curriculum is expandable requests for additional content could be accommodated in most instances. We also had the advantage of extensive prior analysis of international curriculums and national and local epidemiology to guide the discussions. The Delphi technique, when properly applied, permits the structured management of conflict of interest issues and requires a systematic approach to the resolution of potential differences in opinions about the matters under discussion. However, the Delphi technique itself is not without some criticisms (16, 17) relating mostly to inconsistency and variability in the application of protocols. We would suggest that this may relate to the asking of answerable research questions for which there is adequate empirical evidence combined with the use of standardized and rigorous evidence evaluation protocols.

Globally, there has recently been a strong focus on the development of high-quality General Practice curriculum and practice standards (18–20). The content of international standards for General Practice/Family Medicine curriculums is, of course, an important focus, and guide for the development of the General Practice/Family Medicine discipline in China. However, each country has its own unique cultural, epidemiological and demographic circumstances (21). The curriculum and practice standards for one country do not necessarily wholly relate to the needs of another. The global burden of disease studies (22, 23) amply illustrate the variability in such circumstances between China and other countries. Sources such as the country reports from the WHO World Health Organization China country assessment report on aging and health (24) provide detailed data about the Chinese patterns of burden of disease that require attention in the Chinese medical curriculum. In Europe, members of the European Union have nevertheless made some efforts to harmonize the core content of General Practice training curriculums throughout the participant union countries. The Council of the European Academy of Teachers in General Practice and Family Medicine (EURACT) set themselves the task of specifying the common core content for a short clerkship in General Practice (25). The Council comprises the national representatives of EURACT. A Delphi consultation technique was used to derive an agreed list of 15 core areas for undergraduate General Practice/Family Medicine medical education curriculums.

In view of the strong emphasis placed by the Chinese government upon the necessity for rapid expansion and upgrade of general practice and the primary health care system, there is a strong awareness of the need for the development of modern, evidence-based general practice curriculums to ensure that the practitioners have the necessary skills and knowledge to deliver high quality care.

The goal of this research was to develop and trial rigorous evidence-based competency standards for General Practice medical training in Shenzhen, China. The research sub-questions that were specifically addressed to achieve this goal were:

1. What GP competency standards currently exist and what is their content?
2. What are the key patient groups in Shenzhen/ China?
3. What are the patients' health care needs?
4. What are the key clinical skills required for General Practitioners to address these needs?
5. What assessment tools should be used to test mastery of the knowledge and skills required to achieve the GP standards amongst trainee practitioners?

METHODS

Expert Participants ($n = 43$)

The development of the curriculum assessment standards in this project was led by the Standards Unit within the Shenzhen Health and Family Planning Commission, the Shenzhen Health and Family Planning Capacity Building and Continuing Education Center. An expert panel and 14 groups comprising 43 expert participants were established to review and evaluate national and international competency standards for General Practice and develop a set of standards, through a modified Delphi methodology, to be applied in the training and assessment of General Practitioners in Shenzhen, China.

The experts were representatives from a range of local agencies and international experts including the Shenzhen Health and Family Planning Commission, the Shenzhen Health and Family Planning Capacity Building and Continuing Education Center, the Shenzhen International General Practice and Community Health Service Center, the Shenzhen Health Bureau General Practitioners Branch, the Shenzhen Hospital of Peking University, the General Practice Department of Shenzhen Hospital of Hong Kong University, and the US-based International Primary Care Education Alliance (IPCEA) and professors from Monash university and Australian National University. The experts had substantial clinical, teaching, curriculum development and management experience in primary care. The same 43 participants participated in all rounds of

the study. At the commencement of the study agreement to participate in all rounds was obtained from the participants.

The foundation for the evidence base used in the Delphi methodology employed in this project was the NICE and NHMRC guideline protocols which emphasize:

- Forming the questions
- Deciding what evidence to include
- Identifying the evidence
- Selecting appropriate studies and documents
- Synthesizing evidence
- Assessing risk of bias
- Assessing certainty of evidence
- Documenting the evidence and final decisions.

The consultation protocols specified in these standards documents were followed meticulously. All decisions were documented in detail and provided to participants for further review to ensure that all matters had been fairly and inclusively dealt with. There was a very high commonality of views on all matters because of the evidence-based approach employed in the development process. For example, the epidemiology, disease burden, and demography of the community are facts informed by evidence for which detailed evaluation and evidence grading protocols were employed. The health needs of the community are knowable through this evidence. Such evidence based approaches provide additional rigor and certainty in the identification, analysis, and review of evidence to inform the consensus process.

Trainee Trial Participants ($n = 613$ Participants)

As outlined below, two rounds of trials of the standards using examinations in the form of Objective Structured Clinical Examinations (OSCEs) were conducted (Rounds 3 and 4). In Round 3 the first pilot of the standards was conducted. The pilot involved an examination of 298 GP trainees seeking GP accreditation enrolled in the Shenzhen Health and Family Planning Capacity Building and Continuing Education Center. In Round 4 a second pilot involving 315 GP trainees seeking GP accreditation was conducted.

Project Process and Methodology

An extensive consultation process following modified Delphi methodology was undertaken in the project. **Figure 1** summarizes the processes followed in the development of the Shenzhen GP training and assessment standards:

Each of the phases is now described. All meetings were face to face.

Preparatory Phase (3 Months)—Analysis of Existing Local and International GP Standards

In the preparatory phase the activities focussed on the research question "What GP competency standards currently exist and what is their content?" The Standards Unit and the expert panel members reviewed GP competency standards from a range of Chinese and international bodies. These standards included those developed by:

- The Royal Australian College of General Practitioners (RACGP) (26, 27)
- The UK Royal College of General Practitioners (RCGP) (28)
- The Accreditation Council for General Medical Education Family Medicine Milestone Project (ACGME) (29)
- The Shenzhen Health and Family Planning Capacity Building and Continuing Education Center
- The World Organization of National Colleges, Academies and Academic Associations of General Practitioners/Family Physicians (WONCA) (30).

It should be noted that these documents are quite voluminous. For example, the RACGP document is 85 single spaced pages and the UK document is 98 single spaced pages. The detailed analysis of their overlapping and differential content is provided in supporting documentation available from the corresponding and first authors. The content analysis informed, but did not substitute for, the expert judgments of the 43 expert participants. A detailed questionnaire developed by the Standards Unit was circulated to 43 experts who were asked to assess the suitability of the content of the standards for General Practice in China. The results of the questionnaire guided the subsequent face to face discussions.

Round 1—Identification of Key Patient Groups, Health Care Needs, and Associated Clinical Skills Required to Treat Them (14 Months)

In Round 1 of the process the activities focussed on the questions "What are the key patient groups in Shenzhen?" "What are their health care needs?" "What are the key clinical skills required for General Practitioners to address these needs?" The activities in this phase included a review of the local international and local GP standards. Fifteen face to face meetings of the expert groups were held to arrive at an initial draft of the first component of the standard. The component of the standard that was achieved through this round was the general consulting skills and knowledge domains that need to be held by GPs.

Round 2—Development of Standards for Key Patient Groups, Common Symptoms, and Required Clinical Skills (14 Months)

The research questions addressed by this phase were "What are the key patient groups, medical issues, and basic skills that graduate GPs should be able to competently address?" This round focused on the development of a list of the top ten priority patient groups to be seen by GPs in Shenzhen. Local, national and international administrative and research data sets were interrogated to identify common symptoms, common diseases and severe and critical injuries within the Shenzhen community and how these related to other local and international jurisdictions (i.e., epidemiological benchmarking). The demographic and epidemiological

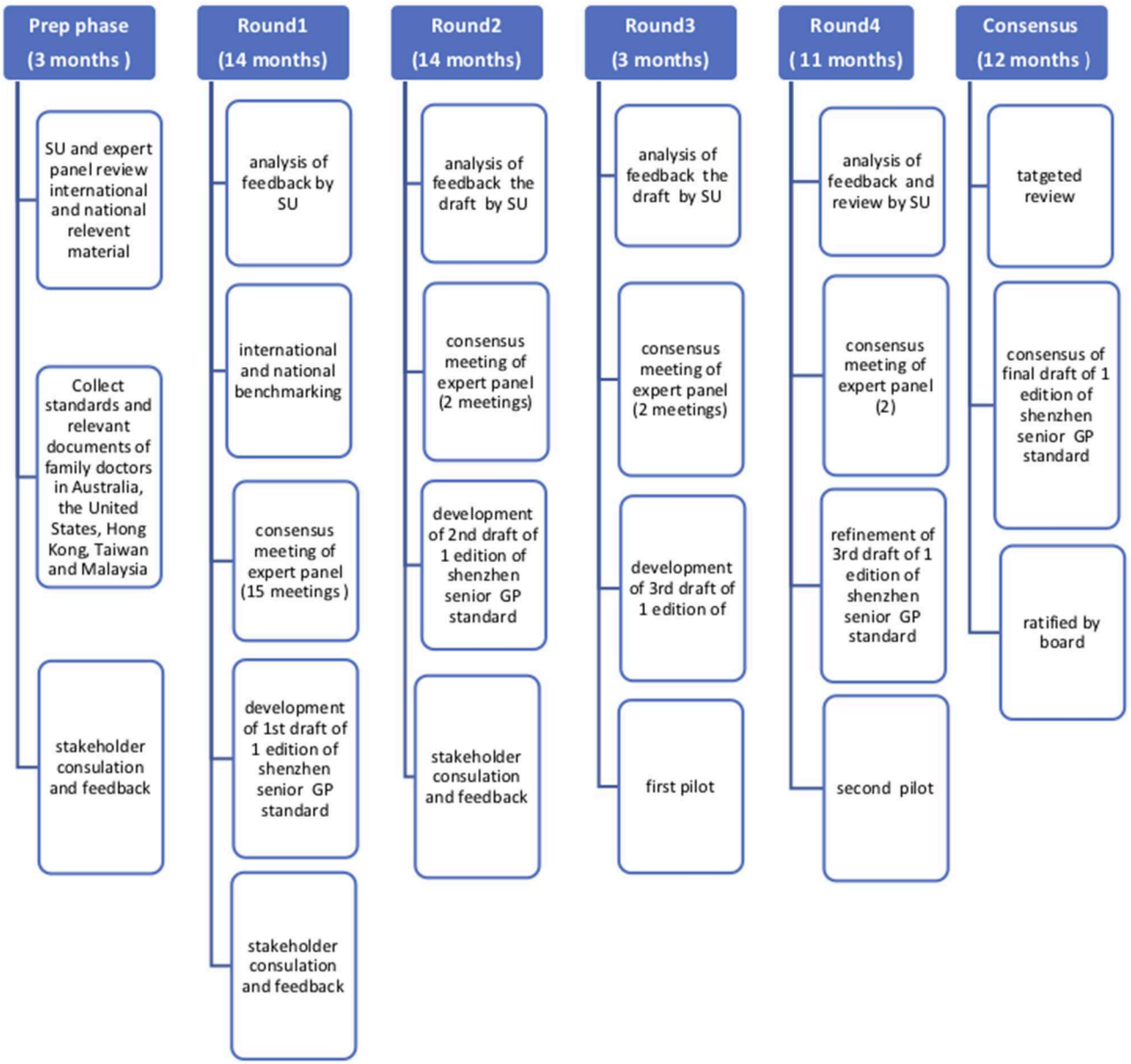

FIGURE 1 | Flowchart depicting the projects steps and activities.

data were also used to inform consideration of the basic clinical skills needed to prevent and treat the prevalent conditions. A draft list of key symptoms, conditions and basic operational skills was developed. Forty-three experts evaluated these domains which were developed through expert consensus (Draft 2 of the standards). Draft 2 of the standards comprised the general consulting skills and knowledge domains, the ten priority patient groups, key symptoms, severe conditions, and basic clinical skills and key symptoms. Two full panel face to face meetings with preparatory document review were conducted involving all the expert participants.

Round 3—Development and First Trial of a Tool to Assess Mastery of the GP Standards by GP Trainees (3 Months)

In Round 3 the research aim addressed was "What written and practice modules in the form of Objective Structured Clinical Examinations (OSCEs) (31) should be used to test mastery of the knowledge and skills required to achieve the GP standards amongst trainee practitioners." The expert panel rated the domains from Draft 2 and provided further feedback. Based on this feedback, Draft 3 of the GP standards was compiled by the supporting Standards Unit. In this round the first pilot of the GP standards was conducted. The pilot involved an examination

of 298 GP trainees enrolled in the Shenzhen Health and Family Planning Capacity Building and Continuing Education Center. The examination included written and practice modules in the form of Objective Structured Clinical Examinations (OSCEs) examining general consulting skills and knowledge domains, the ten priority patient groups, key symptoms, severe conditions and basic clinical skills and key symptoms. Two full panel face to face meetings with preparatory document review were conducted involving all the expert participants.

Round 4—Refinement and 2nd Trial of the Tool to Assess Mastery of the GP Standards by GP Trainees (11 Months)

In Round 4 the Expert Panel evaluated Draft 3 of the standards using the results of the first and a second pilot involving 315 GP trainees was conducted. The examination included written and practice modules in the form of Objective Structured Clinical Examinations (OSCEs). Two full panel face to face meetings with preparatory document review were conducted involving all the expert participants.

Final Consensus Round—Finalization of the Standards, Curriculum, and Assessment Tools (12 Months)

The final Consensus round involved targeted review and refinement and final ratification by the Panel of the standards and the assessment tool to assess mastery of the GP standards by GP trainees. All documents were finalized in this phase and it involved extensive document review by the expert participants. The documents were submitted to government for final ratification. This was achieved and the program was then used to train the doctors. The November 10, 2017 edition of the Shenzhen Southern Metropolis Daily carried a lead article reporting the graduation of 24 Family doctors using the curriculum was announced. The doctors received senior accreditation and each received a cash reward of RMB 50,000 in recognition of their performance.

RESULTS AND DISCUSSION

The project ran for 47 months. The project timing was longer than planned but it included the development of the standards and two full trials of the tools developed to assess mastery of the standards by trainees. The key results for each round are now presented and discussed.

Results of the Preparatory Round

In the Preparatory Round the Expert Panel participated in 15 workshops, reviewed the content of the existing local and international standards and developed new standards with a focus on China relevant standards and outcome indicators. From the Round 1 review and consultation process five domains of general consulting skills and knowledge were agreed as being core areas for Chinese General Practice (Draft 1 of the standards). Thus, the research questions "What are the key patient groups, medical issues, and basic skills that graduate GPs should be able to competently address?" were addressed.

TABLE 1 | Key domains in the 2019 shenzhen general practice curriculum standards key domains content.

Key domains	Content
General consulting skills and knowledge skills	Professional ethics and professional quality assurance
	Communication skills
	Clinical diagnosis and treatment in general practice
	People-centered, family-oriented and community-based health care
	Ability to utilize and coordinate health-resources
Ten priority patient groups:	1. Older people
	2. Women's health
	3. Men's health
	4. Patients with chronic and NCD health problems
	5. People with disabilities
	6. Migrant workers
	7. Multicultural residents
	8. Doctors
	9. Patients with critical illness and trauma
Key symptoms, conditions, severe, conditions and basic, clinical skills	40 common symptom clusters in the community
	78 common diseases in the community (**Appendix 1**)
	27 severe and critical conditions in the community (**Appendix 2**)
	33 basic operational skills in General Practice (**Appendix 3**)

Table 1 shows the final key domains of the 2019 Shenzhen General Practice Curriculum Standards derived from the expert panel consensus and consultations.

The five domains were

1. Professional ethics and professional quality assurance,
2. Communication skills,
3. Clinical diagnosis and treatment in General Practice,
4. People-centered, family-oriented, and community-based health care,
5. Ability to utilize and coordinate health-resources.

These five domains were the headings used to group the standards content.

Results for Round 2—Development of Standards for Key Priority Patient Groups, Common Symptoms, and Required Clinical Skills

The research questions for this phase were "What are the key patient groups, medical issues, and basic skills that graduate GPs should be able to competently address?" In **Table 1**, the 10 Key priority groups are listed along with the key symptoms,

TABLE 2 | Outcomes of the round 3 and round 4 pilot examinations.

Pilot/Module	Pass rate	Difficulty co-efficient	Discriminant analysis	Reliability (Cronbach's alpha)
Pilot 1 2017 $n = 298$				
Module A	0.24	0.55	0.24	0.65
Module B	0.34	0.54	0.33	0.60
Pilot 2 2018 $n = 315$				
Module A	0.14	0.41	0.31	0.65
Module B	0.48	0.53	0.46	0.87

conditions, and basic clinical skills required to address them. **Appendix 1** comprises the key symptoms identified in the research. **Appendix 2** lists the severe and critical conditions in the Shenzhen community and **Appendix 3** lists the basic operational skills identified in the Shenzhen community. These lists provided the basis for both the proposed curriculum and the assessment tools developed to assess appropriate competencies.

Results for Rounds 3 and 4—Development and First and Second Trials of a Tool to Assess Mastery of the GP Standards by GP Trainees

In 2017 and 2018 pilot examinations of GP trainees ($n = 298$ and $n = 315$, respectively) were conducted to assess the trainee's competencies against the Standards. The examinations included two modules, a written test (Module A) and a practical test (Module B). Outcomes of the examinations are shown in **Table 2**. For Pilot 1 2017, the pass rate in Module A was 24% and for Module B it was 34%. In Pilot 2 in 2018, the pass rate for Module A was 14% and for Module B it was 48 per cent. Thus, the assessment modules were proven to be quite rigorous. It could be argued that the low pass rates were a function of poor quality teaching. This explanation is considered unlikely because the instructors were nationally and internationally accredited with significant and lengthy experience in accredited Chinese, US and Australian General Practice and Family Medicine programs. In the future the tools will be improved and refined with further use and development.

Study Strengths and Limitations

This study used a widely representative group of Chinese and international medical experts in General Practice and Primary Health Care, using a structured Delphi process to develop the General Practice standards specification. As outlined in the study description, the Delphi method is now a widely used method for generation of consensus statements about clinical standards and curriculum specifications although it does have some shortcomings. The process of curriculum generation has also been informed by rigorous review of other international curriculums and existing national and local Chinese curriculum standards. A rigorous iterative process has been employed in the refinement of the final curriculum statements.

The curriculum has been trialed in a large group of GP trainees ($n = 613$) and the assessment tools associated with the curriculum trial have been refined. The assessments have been found to be quite rigorous with high standards as reflected in the relatively low pass rate for those who sat the assessments.

The study limitations included the very substantial resources required to implement the project and the longer than expected project duration (initially a 3-year period was proposed but an additional year was necessary). The documented limitations of Delphi methods may apply to this project.

CONCLUSIONS

This research involved a lengthy development process based upon Delphi procedures involving a large expert group of 43 participants. The curriculum that has resulted from the process has been tested and refined with two sizeable cohorts of trainees (in 2017, $n = 298$ and in 2018, $n = 315$). It will be further refined and developed as it is implemented as part of standard quality improvement processes. While the need for substantially increased numbers of General Practice doctors is recognized in policy and in resource allocation, it is important that the Chinese trainees when they graduate are able to meet internationally recognized standards of practice. An important aspect of this project is the development of standard curriculum and rigorous standardized assessment processes that meet local and national needs. That said, curriculums need to be dynamic and adapt to meet changing circumstances. In China, these circumstances include rapidly changing demography and strong growth in chronic illness and age-related conditions as well as meeting the needs of young people and men and women. We thank the many clinicians and researchers who assisted with this epic task.

DATA AVAILABILITY STATEMENT

All datasets generated/analyzed for this study are included in the article/**Supplementary Material**.

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'S NOTE

This paper provides an overview of a major program of activity undertaken in Shenzhen with the purpose of developing General Practice standards, an associated curriculum and assessment tools to assess mastery of the standards and clinical skills. The documentation of these components is voluminous. Queries concerning the availability of these documents and associated resources should be addressed to the corresponding author.

AUTHOR CONTRIBUTIONS

All authors participated in the design of the study and contributed to the drafting of the paper.

FUNDING

This research was funded by the Sanming Project of Medicine in Shenzhen Sanming Project team code: SZSM201511046 (Thomas team) Health and Family Planning Capacity Building and Continuing Education Center of Shenzhen Municipality.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2020.00023/full#supplementary-material

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