ZEYUN FENG

SUCCESSFUL AGEING IN CHINA: THE IMPORTANCE OF HEALTH BEHAVIOURS

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General introduction

China is the nation with the largest ageing population on Earth, and ageing in China is accelerating at an astonishing pace, more so than in any other country or timepoint in history [1]. The United Nations estimates that the proportion of China's population aged ≥ 60 years will reach 19.5% in 2025 and 29.9% in 2050 [2]. Ageing is usually accompanied by functional decline [3] and increased vulnerability to chronic diseases [4]. Thus, although the continuing increase in life expectancy is a major achievement, it also entails the challenge of helping people to age successfully. The understanding and encouragement of successful ageing, or the maintenance of high health and quality of life outcome levels, has become vitally important [5].

IMPORTANCE OF HEALTH BEHAVIOURS

Although the variation in human longevity is known to be influenced by genetic factors, recent epigenetic findings have revealed that lifestyle also plays a crucial role in ageing processes [6]. The improvement of health behaviours [e.g. physical activity (PA), healthy eating and smoking cessation] might be a way to meet the challenge of achieving successful ageing.

A growing body of research has shown that PA, a modifiable factor, is associated with various health outcomes, such as improved cognitive [7–10] and physical [11] function, reduced depression [12] and increased quality of life [13] among older adults. Cross-sectional and longitudinal findings suggest that higher PA levels protect against further declines in cognitive function in older populations [14]. In a review, Rejeski and Mihalko [13] demonstrated that PA has beneficial effects on quality of life in older adults; in a systematic review study, Potter and colleagues [11] showed that PA improved physical functioning in older people.

Similarly, dietary patterns have been associated with cognitive [15] and physical [16, 17] function, quality of life [18, 19] and depressive symptoms [20] among older adults. For instance, a recent meta-analysis revealed that greater adherence to a Mediterranean diet has a beneficial effect on older adults' overall cognitive function (a pooled variable including global cognition and episodic, working and semantic memory) [15]. Researchers have also found that combined dietary recommendations (e.g. avoidance of snacking between meals) effectively treat depression [21]. A systematic review of studies published between January 1975 and March 2018 demonstrated that a healthier dietary pattern is associated with higher quality of life among older adults [19]. Evidence regarding associations between dietary patterns and physical function among older adults is less clear. Whereas the Mediterranean diet has been shown to be beneficial for physical function [17], a longitudinal randomised controlled study revealed no association of fruit and vegetable consumption with physical function among older adults [22].

The associations of smoking with negative health outcomes, such as depression [23–25], decreased physical function [26] and worsened quality of life [27, 28], are well documented. Findings regarding the directionality of the association between smoking and cognitive function are mixed. Some researchers have reported that smoking increases the risk of a decline in global cognitive

function [29, 30], whereas others have found no harmful effect of cigarette smoking on cognitive function [31, 32] among older people.

In addition to these traditional health behaviours, social participation is associated closely with various health outcomes, such as increased functional ability [33], the reduction of depressive symptoms [34] and increased quality of life [35], among older adults. Social participation, as a health behaviour, has been incorporated as an essential element of successful ageing models [36, 37]. It can be especially beneficial for older adults for several reasons [38]. Active engagement in social activities allows older adults to experience dynamic atmospheres, which can benefit cognitive function by stimulating neurogenesis, even in later life [33]. Decades ago, Havighurst [39] claimed that 'great changes in social roles occur between the ages of 50 and 75'. Although the scenario has likely changed in modern society [40], social roles are unquestionably affected in later life. For example, the numbers of acquaintances and friends tend to decline over the life course [41]. Older adults are more likely to lose their formal social roles because of retirement [42]. Thus, active social engagement may help to maintain or increase the size of older adults' social networks [41], potentially contributing to improvements in quality of life and health outcomes.

Most studies of PA [7, 9, 43 44], diet [16–18], smoking [26, 28, 45] and social participation [34] have not involved consideration of the tendency of health behaviours to cluster, or the likelihood that multiple health behaviours have cumulative [46, 47], synergistic [48] or overshadowing [49] effects. Furthermore, studies in which multiple health behaviours have been considered [50, 51] have not been able to document potential synergistic or overshadowing effects because of the use of an additive index approach or cross-sectional design.

HEALTH BEHAVIOURS, HEALTH OUTCOMES AND QUALITY OF LIFE VARY ACCORDING TO BACKGROUND CHARACTERISTICS

Health behaviours, health outcomes and quality of life vary with respect to background characteristics, such as age, gender, marital status, educational attainment, residence, socio-economic status (SES) [54–57], chronic conditions [52, 53] and empty-nest status. For example, most empty-nest older adults in China report lower quality of life than do their non–empty-nest counterparts [58], and rural residents in China are more likely than their urban counterparts to experience depression [59], worse cognitive [60] and physical [61] function and lower quality of life [62]. Thus, these factors must be taken into account when investigating associations of health behaviours with quality of life and health outcomes among older adults.

SOCIAL COHESION AND HEALTH BEHAVIOURS

Empirical studies conducted in Western countries have shown that higher levels of social cohesion not only promote better health [63–66], quality of life [67] and well-being [68–70], but also influence people's health behaviours in various ways [71–73]. Chan and colleagues [74] defined social cohesion as 'a state of affairs concerning both the vertical and the horizontal interactions among members of a society, as characterized by a set of attitudes and norms that include trust, a sense of belonging, and the willingness to participate and help, as well as their behavioural manifestations' (p.290). More organized activities are more likely to be offered in more socially cohesive neighbourhoods, providing more opportunities for residents to participate in social activities or PA [75, 76].

RESEARCH GAPS

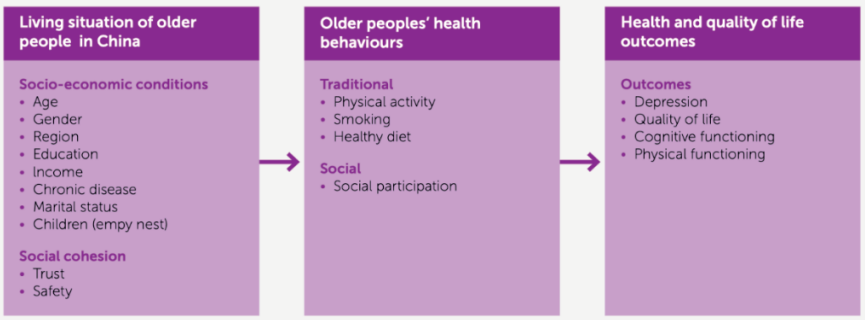
Currently, little is known about nationwide associations of multiple health behaviours with quality of life and crucial health outcomes (cognitive and physical function, depression) among older adults in China. Previous Chinese studies of associations of health behaviours with health outcomes were limited to a single geographic area (Hong Kong) [77] or particular setting (workplaces) [78]. The longitudinal trajectories of multiple health behaviours in China are also poorly understood, as are the effects of different longitudinal health behaviour patterns on health outcomes among older adults in this country.

Substantial information regarding the influence of social cohesion on people's health behaviours is available from Western countries, but less information is available from older Chinese people. Whether the associations observed elsewhere hold among older adults in China remains unknown. As social cohesion is likely to be influenced by economic growth [79], the drastic economic and social development that have occurred in the past few decades in China has likely affected social cohesion. Investigations of associations among socio-economic conditions, social cohesion and health behaviours among older people in China is scarce. Only one study to date has revealed an association between social cohesion and leisure-time PA among older adults in Shanghai [76].

RESEARCH AIM

The overall aim of this thesis was to investigate the (longitudinal) relationships of socio-economic conditions, social cohesion and health behaviours with health and quality of life outcomes among older people in China (Figure 1).

Figure 1. The conceptual model of this thesis



OUTLINE OF THIS THESIS

This thesis is divided into seven chapters. Following this general introduction (**Chapter One**), multivariate associations between key health behaviours and quality of life and health outcomes, considered to be essential elements of successful ageing, among older adults in China are discussed in **Chapter Two**. Regional differences in health behaviours and quality of life and health outcomes are also discussed. Cross-sectional associations were examined using data from the World Health Organization's (WHO's) 2010 Study on global AGEing and adult health (SAGE) Wave 1 China survey and multivariate linear regression analyses.

In **Chapter Three**, an extension of the work described in **Chapter Two**, focusing on chronically ill older adults, is presented. Chronically ill older adults are more vulnerable to worse quality of life and health outcomes than are those without chronic diseases, but whether they benefit from engagement in healthier behaviours is poorly understood. Thus, a cross-sectional study was conducted with WHO SAGE Wave 1 China data on older adults with chronic diseases (angina, arthritis, asthma, chronic lung disease, diabetes, diagnosed depression, hypertension, paralysis and stroke) and multivariate linear regression analyses to evaluate associations of health behaviour with quality of life and health outcomes in this subpopulation.

In **Chapter Four**, associations of social cohesion and SES with various health behaviours among older Chinese people are discussed. This discussion provides a fuller understanding of the role of social cohesion in protecting healthy behaviours among older adults in contemporary China. A cross-sectional study conducted with WHO SAGE Wave 1 China data and multivariate linear and logistic regression analyses is described.

China's economic development has provided a unique setting for scholars to investigate changes in household income and social participation as an important health behaviour. In **Chapter Five**, the longitudinal association between total household income and social participation among older Chinese adults is discussed. This research was conducted using three waves (2011–2015) of data

from the China Health and Retirement Longitudinal Study (CHARLS) and generalised estimating equations. Associations between background characteristics and social participation were also examined.

Little is known about whether different longitudinal patterns of multiple health behaviours are associated with different trajectories of depressive symptoms among older adults. Thus, such longitudinal patterns and associations among older Chinese adults are discussed in **Chapter Six**. These findings were derived using three waves (2011–2015) of CHARLS data; latent class analyses were used to examine patterns of multiple health behaviours, and latent transition analyses were used to examine longitudinal changes in behaviour patterns and pattern associations with trajectories of depressive symptoms over time.

A general discussion of the main findings, methodological and theoretical considerations and recommendations for health professionals and policy makers is provided in **Chapter Seven**.

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2

A healthy diet and physical activity are important to promote healthy ageing among older Chinese people

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ABSTRACT

Objective: To examine the associations between multiple health behaviours and health outcomes among older Chinese adults.

Methods: Data from the World Health Organization's Study on global AGEing and adult health Wave 1 (2007–2010), collected among the older Chinese population, were included in this study. Smoking, diet, and physical activity were analysed by linear regression for any associations with depressive symptoms, quality of life (QoL), cognitive function, and physical function.

Results: A total of 13 367 participants aged >49 years were included in the analyses. After controlling for key socioeconomic factors, healthy diet was significantly associated with higher QoL (b = 0.099) and better cognitive function (b = 0.023). Physical activity was significantly associated with fewer depressive symptoms (b = –0.020), higher QoL (b = 0.086), better cognitive function (b = 0.072), and better physical function (b = –0.155 [higher scores = poorer physical function]). No relationship was found between smoking and any health-related outcome included in this study.

Conclusion: This study demonstrates the importance of healthy diet and physical activity for health outcomes in the older Chinese population.

INTRODUCTION

China's population is growing old at a faster rate than the population of any other country in the world [1,2]. In 2013, China's population included more than 202 million people over the age of 60 years (23 million aged >80 years) and more than 100 million people with non-communicable diseases (NCDs; e.g. heart disease, stroke, and diabetes mellitus) [3,4]. By the end of 2018, the number of people in China aged 60 years had reached 249.49 million (about 17.9% of the total population), and those age 65 years had reached 166.58 million (about 11.9% of the total population) [5]. The prevalence of NCDs in China is expected to grow exponentially over the coming decades [6]. Associations between NCDs and common modifiable unhealthy behaviours (i.e. smoking, unhealthy diet, and physical inactivity) are well established [7], and such unhealthy behaviours are shown to have contributed greatly to the enormous rise in the number of people with NCDs [8]. For example, the incidence of NCDs may be reduced by >80% if people lived healthier lives [9]. Improving health behaviours (e.g. quitting smoking, enhancing physical activity, and eating healthily) is considered to be the way forward to combat this challenge and to promote better health and improved quality of life (QoL) [8,10], and even minor lifestyle changes may improve quality and length of life [11].

Unhealthy behaviours in China

Unhealthy behaviours are a current threat to the health of Chinese people. According to a World Health Organization (WHO) 2017 fact sheet, over 300 million Chinese citizens smoke, comprising almost one-third of the total number of smokers world- wide, and according to the 2010 China Global Adults Smoking Survey, smokers in China represent 28.1% of the Chinese population [12]: The prevalence of smoking among those aged 50 years is slightly lower (26.7%) [13]. Second-hand smoke is also a major issue in China, with 70% of adults exposed to second-hand smoke in a regular week [14]. Estimates show that if the prevalence of tobacco use in China is not reduced, the number of yearly tobacco- related deaths will increase to 3 million by 2050 [15].

Smoking is not the only major health concern, as the majority (69.9%) of older Chinese adults (aged 60 years) are physically inactive [16]. In a national survey by the Chinese Centre for Disease Control and Prevention [17], 75% of the total population reported low levels of physical activity, with the lowest levels found among older age groups. In those aged 60 years, 71% reported no engagement in moderate or vigorous leisure-time physical activity [18].

Unhealthy diet has become another important health threat to China. Almost half (46.8%) of Chinese adults do not meet the WHO's recommended vegetable and fruit consumption level [19], with the highest prevalence of unhealthy diet (57.2%) observed in the group aged 65 years [19]. In 2010, an estimated one-third of all premature deaths in China were caused by poor diet [20]. Poor diets, such as those high in fat, may increases the risk of obesity and depression [21].

As a consequence of unhealthy diet and insufficient physical activity, obesity has become another major health issue in China [22]. The prevalence of obesity and overweight among Chinese adults

increased in the two decades preceding 2019.16 According to a national survey, the prevalence of obesity among Chinese adults aged 20–59 years increased from 8.6% in 2000 to 12.9% in 2014 (estimated increase of 0.32% per year) [23]. A nationally representative study of obesity in the older (aged ≥ 50 years) Chinese population revealed an even higher prevalence of 15.3%.13 In another study of older Chinese adults, obesity (present in 26.3% of participants at baseline) was significantly associated with the risk of cognitive decline [24].

Socio-demographic factors and health behaviours

Available research indicates that socio-demographic factors (i.e. age, sex, marital status, educational level, income, employment, and residence) have important influences on unhealthy behaviours [25,26]. Furthermore, modifiable health-risk behaviours are known to differ among populations and to vary with certain background characteristics [27]. In the Chinese population, older adults are less likely than younger adults to maintain healthy diets [19] and to engage in physical activity [13,28], and the prevalence of overweight/obesity increases with advancing age [23]. Differences in health behaviours also exist between the sexes, with men generally being more likely than women to smoke [12,13,29]. In 2010, smoking rates in Chinese males and females aged 15 years were 52.9% and 2.4%, respectively [12,29], however, the prevalence of current daily smokers was found to decline with increasing age among Chinese men [13], although a less clear trend was observed in Chinese women [13,30]. Men also tend to engage in regular physical activity (leisure-time physical activity in particular) [28], and reported significantly more vegetable consumption, whereas their fruit consumption was significantly less [31], and they were more likely to be overweight/obese [23], than women. Few Chinese studies have examined links between marital status and health behaviours, however, one study revealed that single adults were more prone to unhealthy diets than people with other marital statuses [19]. Mixed empirical findings from other countries have demonstrated that married people tend to regularly consume breakfast and take physical exercise, and are less likely to smoke, compared with their single counterparts [32–34]. However, other research found negative links between marriage and health behaviours. For instance, people tend to consume more calories when they dine together than when they eat alone [35]. Chinese adults with higher educational levels are more likely to consume more vegetables and fruit [19], and have a lower risk of developing obesity [36]. Well-documented Western studies have shown that socio-economically disadvantaged individuals are significantly more likely to smoke [37], to be overweight, and to maintain sedentary lifestyles [38]. Similarly, older Chinese people with lower socioeconomic status (educational level and income) are more likely to smoke [39]. Lower incomes have also been associated with unhealthy diet, but with a higher level of physical activity in the Chinese population [13,19,40]. Unemployed (including retired) older Chinese adults smoke less [41], eat healthier [42], and reported significantly higher levels of leisure-time physical activity [43], or sport/exercise/housework [44], than employed individuals. In rural Chinese areas, the prevalence of smoking [45], unhealthy diet [19], and moderate or vigorous physical activity [18]

was higher than in urban Chinese areas, but rural Chinese adults with higher incomes were less likely to participate in work-related physical activity [40].

Relationship between socio-demographic factors and health outcomes

Socio-demographic factors have been demonstrated to directly affect health outcomes among older Chinese people. For example, age, sex, marital status, educational level, income, employment, and residence were found to be associated with depression [46,47], QoL [48–50], cognitive impairment [36,51–53], and physical function [36] among older Chinese adults. Specifically, older people are more likely to suffer from depression46 and worse cognitive function [54,55]. Females are more prone than males to depression [46], cognitive impairment [56], and the development of physical function impairment [57].Widowed or divorced older people are at greater risk than their married counterparts of developing depressive symptoms [47], poor QoL [50], and poor physical function [57]. Higher educational levels are known to be positively associated with less depression [58], better QoL [59], and better cognitive and physical function [36] among older individuals. Studies have also shown that individuals with higher socioeconomic status are less likely to suffer depressive symptoms,46 and more likely to have better QoL and better functional status [60,61], than those with lower socioeconomic status. Unemployment was found to be a risk factor for depressive symptoms and poor QoL among Chinese people [46,49,50,59]. Regarding the effects of residence, rural residents are more likely than urban residents to suffer depression [46,62], lower QoL [63], worse cognitive function [55], and poor physical function [57], whereas urban older Chinese adults are more likely than their rural counterparts to report chronic conditions (e.g. cardiovascular disease) [64]. Most comorbid associations between depressive symptoms and specific chronic illnesses are reported to be explained by accompanying poor self-reported health and functional status in the Chinese elderly [65].

Although previous studies have shown that unhealthy behaviours are related to various health outcomes, such as depressive symptoms [66], worse QoL [67,68], worse cognitive function [69] ,and poor physical function [70], those studies have ignored the potential cumulative effects of multiple health behaviours [71–74]. In addition, research has suggested a more beneficial and profitable role of interventions targeting multiple health behaviours than of those focused on single health behaviours [74,75]. Therefore, examination of the effects of multiple health behaviours on health outcomes is reasonable and worthwhile. Few studies (including two Chinese studies) have taken this approach [76–80], and the Chinese studies were limited to a single geographic area (Hong Kong) [80] and setting (workplaces) [79], respectively. Previous research has revealed regional variation in residents' health behaviours due to differences in economic, cultural, and social contexts [81,82]. Considering China's size, regional differences in health behaviours and health outcomes between Chinese provinces and urban and rural areas are worth investigating. Published research on health behaviours and health outcomes among older people in China is lacking at the national and provincial levels.

Given the gaps in the existing literature, the aim of the present study was to assess regional differences in health behaviours and health outcomes among older Chinese adults, and to identify associations between multiple health behaviours (smoking, diet, and physical activity) and major mental and physical health outcomes (depressive symptoms, QoL, cognitive function, and physical function) among older Chinese people using nationally representative data from the WHO's Study on global AGEing and adult health (SAGE).

PARTICIPANTS AND METHODS

Study population

The present study included data from the WHO's SAGE Wave 1 China survey, conducted between 2007 and 2010. SAGE Wave 1 China data had been collected using a multistage cluster approach in China, to assemble a nationally representative sample (including eight Chinese provinces), and the individual response rate for Wave 1 was excellent (93%).83 Details of the WHO-SAGE sampling procedure, and ethics approvals and informed consent for the SAGE Wave 1 survey, are described elsewhere [83,84]. In the present study, data from participants aged >49 years were extracted and analysed.

Measures

Socio-demographic characteristics.

The current study included the following characteristics as socio-demographic confounders: age (0=50–59 years, 1=60–69 years, 2=≥70 years); sex (0=male, 1 =female); marital status (0=single [never married, separated/divorced, widowed], 1 married [currently married, cohabiting]); educational level (0 low [no formal education, less than primary school, completed primary school], 1 medium [completed secondary school, completed high school], 2 higher [completed college/university, completed post-graduate degree]); permanent income (quintile); NCDs (0=no, 1=yes); employment status (0=non-working, 1=working); residence (0=urban, 1=rural); and province of residence (Shandong, Guangdong, Hubei, Jilin, Shaanxi, Shanghai, Yunnan, Zhejiang). The classification of educational level was based on the International Standard Classification of Education (ISCED 2011) [85]. Shandong was chosen as the reference province, as it had the highest mortality rate [86].

Health behaviours

Smoking, diet, and physical activity were used to assess health behaviours.

Smokers were defined as those who currently smoke, sniff or chew any tobacco products such as cigarettes, cigars, and pipes, and smoking was assessed by the number of pack-years, calculated by multiplying the number of cigarette packs smoked per day by the duration of smoking in years [87].

Diet was assessed by evaluating fruit and vegetable consumption as an indicator of healthy eating. WHO guidelines were followed [31], using the threshold value of two servings of fruit and three servings of vegetables per day to distinguish healthy (coded as 1, comprising ≥2 servings of fruit and ≥3 servings of vegetables per day) from unhealthy diets (coded as 0, comprising <2 servings of fruit and <3 servings of vegetables per day) [8,88,89].

Physical activity was assessed by asking respondents about their vigorous and moderate physical activity. Vigorous physical activity included sports activities such as jogging, running, swimming, heavy lifting, fitness, gym attendance, and rapid cycling and work activities such as chopping, farm work, and digging with a spade or shovel. Activities such as house-cleaning, washing clothes by hand, stretching, dancing, gardening, and bicycling at regular pace were classified as moderate physical activity. Respondents were asked to report the number of days per week on which they engaged in moderate and/or vigorous physical activity, and the average time spent on these activities per day. The WHO-recommended cut-off point was used to constitute sufficient physical activity (1, ≥150 min/week) or insufficient physical activity (0, <150 min/week) [90].

Health outcomes.

Depressive symptoms, QoL, cognitive function, and physical function were assessed as outcome variables in this study.

Depressive symptoms were assessed as follows: Individual questions assessing the presence of depressive symptoms during the previous 12 months were based on the World Mental Health Survey version of the Composite International Diagnostic Interview [91]. A summary score (range, 0–4) served as the outcome variable. Depression was measured using the 10th revision of the International Classification of Diseases Diagnostic Criteria for Research (ICD-10- DCR) [92]. According to ICD-10-DCR criterion B, individuals reporting any two or more of the following three symptoms (each receiving a score of 1) were depressed: feeling sad/empty/depressed, loss of interest, and fatigue. Additionally, individuals were asked whether they had ever been diagnosed with depression by a health specialist and whether they were taking any medications or receiving any other treatment (including counselling or therapy) for depression in the last 12 months (score of 1) [89].

Quality of life (QoL) was measured using the 8-item WHO quality of life measure (WHOQoL) [83]. Respondents were asked to rate their satisfaction with different domains of their lives, such as finances, health and relationships, and to rate their overall life satisfaction. Each item was rated using a 5-point scale ranging from 0 (not at all/very poor) to 5 (completely/very good). An overall score was computed by summing the 8-item scores and rescaling the result to 0–100, with higher scores representing better QoL [93]. According to Nikmat and Daher (2016) [94], the 8-item WHOQoL is a useful instrument for the assessment of QoL in older populations.

Cognitive function was assessed using five cognitive performance tests (forward and backward digit span, verbal fluency, immediate and delayed verbal recall) to compute the summary variable of cognitive function for each subject. The score ranges for forward and backward digit counts were 0–9 and 0–8, respectively; and the total score (range, 0–17) was calculated by summing

the two scores. The verbal fluency score was defined by the number of animals named correctly [95]. For the immediate verbal recall test, performed in three trials, the interviewer read a list of 10 words aloud and asked the participant to immediately recall as many words as they could in 1 min. Following the third trial, the interviewer administered the other cognitive tests, after which delayed recall ability was assessed by asking the participant to recall the list of words. The final score was the sum of correct responses minus errors. In accordance with other cognitive studies, composite z-scores were calculated to facilitate comparison of cognitive test performance among individuals. Z-scores for each of the five cognitive tests were first computed, then summed for each individual, creating a final composite z-score. Higher scores indicated better cognitive performance [96]. Because of issues of multiple comparison when separately examining cognitive tests, these global scores were used when interpreting the data [97–99].

Physical function measurements were based on the Katz Index of Independence in Activities of Daily Living (Katz ADL) [100]. Six items (difficulty in bathing/ washing body, in dressing, in using toilet, in standing up from sitting down, in getting up from laying down, and in eating) were taken from the ADL items of the WHO Disability Assessment Schedule version 2 (WHODAS-II). Participants rated each item on a 5-point scale ranging from 0 to 4 (0=none, 1=mild, 2=moderate, 3=severe, 4=extreme/cannot do), and a sum score was calculated, for which higher scores represent poorer physical functioning.

Statistical analyses

Data from participants aged >49 years are presented as mean ± SD or n (%) prevalence, and were statistically analysed using SPSS Statistics software, version 24 (IBM, Armonk, NY, USA). Descriptive statistics were used to characterise the study population. Health behaviours among older Chinese people are described according to socio-demographic characteristics. Health behaviours and health outcomes are described for urban and rural areas within the eight Chinese provinces. Linear regression analyses were performed to examine associations among socio-demographic factors (age, sex, marital status, educational level, permanent income, employment status, residence, province, NCDs); health behaviours (smoking, healthy diet, physical activity); and health outcomes (depressive symptoms, QoL, cognitive function, physical function). A P value <0.05 was considered statistically significant.

RESULTS

Data from a total of 13 367 participants were included in the present study (mean ± SD age, 63.16 ±9.44 years; range 50–99 years; Table 1). More than half (53.1%) of the respondents were female, approximately half (49.1%) lived in urban areas, almost two-thirds (61.7%) of individuals reported low educational levels, and about half (49.6%) of participants reported having NCDs. The mean

Table 1 Descriptive statistics for socio-demographic, health behaviours, and health outcomes among a sample of 13 367 persons in China, aged 50 years, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010).

	Total sample *n* (%)	Missing data *n* (%)	Mean ± SD
Socio-demographics			
Age, years (range 50–99)[T]	13367 (100.0)	0	63.16 ±9.44
50-59	5807 (43.4)		
60-69	3968 (29.7)		
≥70	3592 (26.9)		
Sex		0	-
Male	6274 (46.9)		
Female	7093 (53.1)		
Marital status		10 (0.1)	-
Single	2264 (16.9)		
Non-single	11093 (83.1)		
Educational level		72 (0.5)	-
Low	8202 (61.7)		
Medium	4458 (33.5)		
High	635 (4.8)		
Permanent income		61 (0.5)	-
Lowest	2665 (20.0)		
Second	2646 (19.9)		
Middle	2688 (20.2)		
Fourth	2724 (20.5)		
Highest	2583 (19.4)		
Employment status		2019 (15.1)	-
Non-working	6325 (55.7)		
working	5023 (44.3)		
Residence		0	-
Urban	6567 (49.1)		
Rural	6800 (50.9)		
Province		0	-
Shandong	1929 (14.4)		
Guangdong	1569 (11.7)		
Hubei	1572 (11.8)		
Jilin	1702 (12.7)		
Shaanxi	1770 (13.2)		
Shanghai	1792 (13.4)		
Yunnan	1570 (11.7)		
Zhejiang	1463 (10.9)		
NCDs		0	-
No	6738 (50.4)		
Yes	6629 (49.6)		

Table 1 Descriptive statistics for socio-demographic, health behaviours, and health outcomes among a sample of 13 367 persons in China, aged 50 years, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010). (continued)

	Total sample *n* (%)	Missing data *n* (%)	Mean ± SD
Health behaviours			
Smoking		443 (3.3)	-
No	9440 (73.0)		
Yes	3484 (27.0)		
Pack-years[T]		1802 (13.5)	6.53 ± 14.76
Diet		1247 (9.3)	-
Unhealthy	4236 (35.0)		
Healthy	7884 (65.0)		
Physical activity		422 (3.2)	-
Inactive	4244 (32.8)		
Active	8701 (67.2)		
Health outcomes			
Depressive symptoms (sum)	-	438 (3.3)	0.26 ± 0.71
QoL[T]	-	587 (4.4)	3.59 ± 0.58
Cognitive function[T]	-	1309 (9.8)	39.55 ± 9.90
Physical function[T]	-	424 (3.2)	0.69 ± 2.09

SD: standard deviation; NCD: non-communicable disease; QoL: quality of life. [T]Continuous variable.

number of smoking pack-years was 6.53 ± 14.76, and 27% of participants were current smokers. Roughly one-third of participants reported unhealthy diets (35%) and physical inactivity (32.8%).

Health behaviours in various subgroups of participants are summarised in Table 2. Mean smoking pack-years was 14.71 ± 19.19 in males compared with 0.76 ± 5.60 in females. Roughly two-thirds of participants were healthy eaters among non-single (66.7%) and non-working (71.7%) older adults, compared with just over half of single and working older adults (56.8% and 56.7%, respectively); 84% of participants with the highest educational level were healthy eaters, as were 81.5% of participants with the highest income. In terms of physical activity sub-grouped according to age, younger older adults (aged 50–59 years) showed the highest proportion of those being physically active (72.1%), whereas 55.9% of those aged 70 years were physically active. Proportions of physically active participants amongst working and non-working older adults were 74.6% and 65.3%, respectively.

Health behaviours and health outcomes, grouped according to urban and rural areas within the eight Chinese provinces, are summarised in Table 3. Regarding health behaviours, mean values for smoking pack-years were numerically higher among rural residents than among urban residents in most provinces, although the opposite was true in Hubei and Shanghai. Rural residents of Zhejiang showed the highest mean pack-years of smoking (11.51 ± 18.06) and rural residents of Shanghai showed the lowest (1.11 ± 6.40). The proportion of older adults with unhealthy diets in rural areas ranged from 31.6% (Yunnan) to 76.1% (Hubei), and in urban areas ranged from 13.1% (Zhejiang) to 35.7% (Shaanxi). Prevalence of physical activity in rural areas was lowest in Shanghai (11.4%)

and highest in Guangdong (88.1%), and in urban areas, the prevalence of physically active older adults ranged from 49.4% in Shandong to 80.6% in Guangdong. The highest prevalence of physical inactivity was observed among residents of rural Shanghai (88.6%). Regarding health outcomes, the highest mean values for depressive symptoms (indicating more depressive symptoms) were observed among rural residents of Guangdong (0.58 ±1.05) and Shaanxi (0.58 ± 1.04), and the lowest mean value was shown in residents of urban Shanghai (0.03 ± 0.25). Of all the provinces, the lowest mean score of cognitive functioning (indicating lower cognitive function) was observed among rural residents in Jilin (33.89 ± 9.30). Urban residents of Shandong reported the highest

Table 2 Summary of health behaviours among a sample of 13 367 persons in China, aged 50 years, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010).

	Smoking (pack-years)		Diet n (%)		PA n (%)	
	Mean	SD	Not Healthy	Healthy	Inactive	Active
Socio-demographics						
Age (years)						
50-59	6.49	13.04	1721 (32.8)	3531 (67.2)	1575 (27.9)	4080 (72.1)
60-69	6.86	15.26	1317 (5.7)	2367 (64.3)	1165 (30.0)	2714 (70.6)
≥70	6.24	16.68	1198 (37.6)	1986 (62.4)	1504 (44.1)	1907 (55.9)
Gender						
Male	14.71	19.19	2223 (39.0)	3473 (61.0)	1960 (32.3)	4110 (67.7)
Female	0.76	5.60	2013 (31.3)	4411 (68.7)	2284 (33.2)	4591 (66.8)
Marital status						
Single	5.01	14.04	860 (43.2)	1132 (56.8)	822 (38.3)	1326 (61.7)
Non-single	6.84	14.89	3373 (33.3)	6746 (66.7)	3419 (31.7)	7369 (68.3)
Educational level						
Low	6.80	15.55	3039(41.9)	4211 (58.1)	269 (33.9)	5239 (66.1)
Medium	6.49	13.67	1077 (25.7)	3120 (74.3)	1295 (29.9)	3035 (70.1)
High	3.36	10.90	98 (16.0)	513 (84.0)	228 (37.1)	387 (62.9)
Permanent income						
Lowest	7.97	16.66	1271 (54.6)	1058 (45.4)	826 (32.2)	1736 (67.8)
Second	7.85	16.01	1007 (42.8)	1346 (57.2)	748 (29.4)	1799 (70.6)
Middle	6.26	14.53	803 (33.2)	1618 (66.8)	794 (30.7)	1796 (69.3)
Fourth	6.12	13.97	688 (27.4)	1825 (72.6)	902 (34)	1749 (66.0)
Highest	4.44	11.88	452 (18.5)	1994 (81.5)	946 (37.3)	1589 (62.7)
Employment						
Non-working	5.23	14.12	1735 (28.3)	4393 (71.7)	2188 (34.7)	4120 (65.3)
Working	9.12	15.96	2051 (43.3)	2686 (56.7)	1270 (25.4)	3738 (74.6)
NCDs						
No	7.40	15.20	2048 (35.2)	3776 (64.8)	1935 (30.6)	4394 (69.4)
Yes	5.73	14.31	2188 (34.8)	4108 (65.2)	2309 (34.9)	4307 (65.1)

SAGE: Study on global AGEing and adult health; PA: physical activity; SD: standard deviation; NCD: non-communicable disease.

Table 3 Health behaviours and health outcomes among a sample of 13 367 persons in China, aged 50 years, residing in urban and rural areas of eight Chinese provinces, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010).

Province	Health Behaviours						Health Outcomes							
	Smoking (pack-years)		Diet (%)		Physical activity (%)		Depressive symptoms[T]		QoL[a]		Cognitive function[a]		Physical function[T]	
	Mean	± SD	Not healthy	Healthy	Inactive	Active	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
Shandong (ref)														
Urban (0)	1.78	± 8.06	13.2	86.8	50.6	49.4	0.04	± 0.29	3.87	± 0.43	43.81	±10.40	0.41	± 1.64
Rural (1)	9.40	± 18.07	32.2	67.8	26.0	74.0	0.33	± 0.78	3.60	± 0.68	38.76	±8.79	1.44	± 2.94
Guangdong														
Urban (0)	6.96	± 15.61	17.6	82.4	19.4	80.6	0.22	± 0.66	3.67	± 0.47	41.00	±9.39	0.34	± 1.26
Rural (1)	10.59	± 17.79	73.7	26.3	11.9	88.1	0.58	± 1.05	3.58	± 0.56	38.56	±8.94	0.74	± 2.28
Hubei														
Urban (0)	8.38	± 16.25	35.6	64.4	25.0	75.0	0.31	± 0.79	3.54	± 0.54	44.76	±8.97	0.41	± 1.34
Rural (1)	7.08	± 15.00	76.1	23.9	20.7	79.3	0.38	± 0.67	3.40	± 0.55	35.48	±9.15	0.94	± 2.20
Jilin														
Urban (0)	4.59	± 11.89	24.4	75.6	30.7	69.3	0.37	± 0.76	3.77	± 0.51	41.14	±8.45	0.47	± 1.51
Rural (1)	6.93	± 15.21	32.0	68.0	44.8	55.2	0.09	± 0.43	3.18	± 0.59	33.89	±9.30	0.81	± 2.08
Shaanxi														
Urban (0)	8.26	± 15.92	35.7	64.3	24.5	75.5	0.43	± 0.93	3.30	± 0.57	36.06	±8.57	0.66	± 2.07
Rural (1)	10.59	± 16.92	45.1	54.9	18.2	81.8	0.58	± 1.04	3.51	± 0.55	34.93	±9.54	0.44	± 1.88
Shanghai														
Urban (0)	4.86	± 12.50	24.1	75.9	36.9	63.1	0.03	± 0.25	3.73	± 0.46	47.38	±9.94	0.26	± 1.61
Rural (1)	1.11	± 6.40	42.9	57.1	88.6	11.4	0.06	± 0.33	3.84	± 0.62	38.67	±8.08	0.42	± 1.44

Table 3 Health behaviours and health outcomes among a sample of 13 367 persons in China, aged 50 years, residing in urban and rural areas of eight Chinese provinces, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010). (continued)

Province	Health Behaviours						Health Outcomes							
	Smoking (pack-years)		Diet (%)		Physical activity (%)		Depressive symptoms[T]		QoL[a]		Cognitive function[a]		Physical function[T]	
	Mean	± SD	Not healthy	Healthy	Inactive	Active	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
Yunnan														
Urban (0)	2.67	± 10.15	28.5	71.5	38.5	61.5	0.17	± 0.64	3.64	± 0.57	43.21	±9.81	0.93	± 2.72
Rural (1)	5.35	± 13.99	31.6	68.4	23.4	76.6	0.26	± 0.72	3.65	± 0.50	38.12	±9.92	1.60	± 3.05
Zhejiang														
Urban (0)	4.78	± 13.12	13.1	86.9	21.1	78.9	0.09	± 0.46	3.68	± 0.58	39.22	±9.06	0.76	± 2.22
Rural (1)	11.51	± 18.06	47.6	52.4	28.4	71.6	0.33	± 0.67	3.58	± 0.49	40.02	±9.31	0.27	± 1.10

QoL: quality of life; SD: standard deviation. [T]Higher scores represent more depressive symptoms, poorer physical function. [a]Higher scores represent better QoL, better cognitive function.

mean value for QoL (3.87 ± 0.43). Of all the provinces, rural residents of Yunnan showed the worst mean value for physical functioning (1.60 ± 3.05).

After controlling for important socio-demographic characteristics (age, sex, marital status, employment, income, educational level, residence, and chronic illness), healthy diet was positively associated with higher QoL (P < 0.001) and better cognitive function (P =0.016). Among health outcomes, healthy diet had the greatest effect on QoL (d = –3.63). Physical activity was positively associated with fewer depressive symptoms (P = 0.047), higher QoL (P < 0.001), better cognitive function (P < 0.001), and better physical function (P < 0.001); among the included health outcomes, physical activity had the greatest effect on physical function (d = 0.382). Multivariate analyses revealed no statistically significant relationship between smoking (pack-years) and any health outcome among the older Chinese population (Table 4).

Statistically significant associations were also found between socio-demographic variables and health outcomes (Table 4). Depressive symptoms (as the dependent variable) were associated with being female (P < 0.001), rural residence (P < 0.001), and chronic illness (P < 0.001). Older age (P < 0.001), non-single status (P < 0.001), and higher income (P < 0.001) protected against the onset of depressive symptoms.

Better QoL was related to older age (P < 0.001 [60–69 years] and P < 0.001 [≥70 years]), non-single status (P < 0.001), working (P < 0.001), and higher income (P < 0.001). Inverse relationships were found between QoL and rural residence (P = 0.024) and chronic illness (P < 0.001) in this older Chinese population (Table 4). Poorer cognitive function was associated with older age (P < 0.001 [aged 60 years]), being female (P < 0.001), lower educational level (P < 0.001), rural residence (P < 0.001), and chronic illness (P < 0.001). Being non- single (P < 0.001), working (P = 0.020) and having a higher income (P < 0.001) were significantly associated with better cognitive function (Table 4).

Being aged ≥70 years (P < 0.001), rural residence (P < 0.001), and chronic illness (P < 0.001) were associated with poorer levels of physical function, whereas working (P < 0.001) and having a higher income (P < 0.001) were associated with better levels of physical function (Table 4).

Finally, using Shandong as the reference Province, residence in Shanghai Province seemed to protect against the occurrence of depressive symptoms (P < 0.001) and to promote better QoL (P = 0.006). Residing in Shanghai (P < 0.001) and Yunnan P =0.004) was associated with higher levels of cognitive function. Residing in Guangdong (P =0.003), Hubei (P < 0.001), Jilin (P =0.002), Shanxi (P < 0.001), Shanghai (P < 0.001), and Zhejiang (P < 0.001) was significantly associated with better physical function (Table 4).

DISCUSSION

The aim of the present study was to assess the associations between multiple health behaviours (smoking, diet, and physical activity) and major mental and physical health outcomes (depressive

Table 4. Multivariate regression analyses of socio-demographics, health behaviours, and health outcomes among a sample of 13 367 persons in China, aged 50 years, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010).

	Depressive symptoms***				QoL[a]				Cognitive function[a]				Physical function***			
	β	SE	p	Cohen's d	β	SE	p	Cohen's d	β	SE	p	Cohen's d	β	SE	p	Cohen's d
Socio-demographics																
Age																
50-59 (0)																
60-69	-.024	.018	.032	-.013	.043	.013	.000	.021	-.072	.217	.000	-.017	.011	.048	.339	.054
≥70	-.050	.021	.000	.026	.052	.015	.000	.213	-.257	.257	.000	.652	.134	.057	.000	-.489
Gender																
Male (0)																
Female (1)	.056	.017	.000	-.120	-.018	.012	.106	.136	-.067	.209	.000	.202	-.008	.046	.488	-.067
Marital status																
Single (0)																
Non-single (1)	-.046	.021	.000	.128	.033	.015	.001	-.342	.045	.251	.000	-.515	-.004	.056	.716	.265
Educational level																
Low (0)																
medium	.003	.018	.788	.103	.045	.013	.000	-.276	.196	.220	.000	-.667	-.009	.049	.423	.213
High	.006	.035	.611	.204	.052	.025	.000	-.481	.152	.432	.000	-.822	-.030	.094	.005	.199
Permanent income (quintile)	-.075	.007	.000	-	.254	.005	.000	-	.121	.078	.000	-	-.091	.017	.000	-
Employment																
Non-working (0)																
Working (1)	-.018	.019	.173	-.075	.124	.014	.000	-.130	.027	.232	.020	.009	-.130	.052	.000	.018
Residence																
Urban (0)																
Rural (1)	.110	.021	.000	-.113	-.030	.015	.024	.175	-.143	.249	.000	.480	.138	.055	.000	-.156

Table 4. Multivariate regression analyses of socio-demographics, health behaviours, and health outcomes among a sample of 13 367 persons in China, aged 50 years, evaluated with data from the World Health Organisation Study on global AGEing and adult health (SAGE) Wave 1 China (2007–2010). (continued)

	Depressive symptoms***				QoL[a]				Cognitive function[a]				Physical function***			
	β	SE	p	Cohen's d	β	SE	p	Cohen's d	β	SE	p	Cohen's d	β	SE	p	Cohen's d
Province																
Shandong (0)				-				-								
Guangdong	.107	.028	.000	-.210	-.030	.020	.017	-.049	-.026	.337	.036	-.030	-.038	.074	.003	.083
Hubei	.059	.030	.000	-.137	-.075	.021	.000	.260	-.006	.365	.590	-.040	-.045	.079	.000	-.002
Jilin	.086	.033	.000	.056	.016	.025	.143	.308	-.078	.400	.000	.241	-.037	.088	.002	.028
Shaanxi	.144	.029	.000	-.389	-.086	.021	.000	.388	-.140	.348	.000	.474	-.077	.077	.000	.078
Shanghai	-.057	.028	.000	.351	.034	.020	.003	-.383	.100	.337	.000	-.375	-.113	.074	.000	.188
Yunnan	.001	.029	.938	.069	.019	.021	.110	-.098	.033	.349	.004	-.094	.033	.077	.006	-.330
Zhejiang	-.003	.028	.824	.095	.003	.020	.794	-.067	-.002	.343	.880	-.009	-.070	.074	.000	.028
NCDs																
No (0)																
Yes (1)	.103	.015	.000	-.108	-.189	.011	.000	.360	-.049	.182	.000	.136	.080	.040	.000	-.234
Health behaviours																
Smoking (pack-years)	.010	.001	.374	-	.000	.000	.980		-.006	.007	.590	-	-.009	.001	.409	-
Diet																
Not healthy (0)																
Healthy (1)	-.020	.017	.063	.111	.099	.012	.000	-.363	.023	.198	.016	-.305	-.017	.044	.104	.123
PA																
Inactive (0)																
Active (1)	-.020	.017	.047	-.044	.086	.012	.000	-.159	.072	.202	.000	-.186	-.155	.044	.000	.382

QoL, quality of life; SE, standard error; NCD, non-communicable disease. ***Higher scores represent more depressive symptoms or poorer physical function. aHigher scores represent better QoL or better cognitive function. Analyses adjusted for age (years), sex, residence, marital status, employment status, educational level, smoking pack-years, healthy diet, physical activity. Reference groups: male, single, lower education, urban residence, lower income, no NCD, inactive, unhealthy diet, and Shandong Province.

symptoms, QoL, cognitive function, and physical function) among older Chinese people, using nationally representative WHO-SAGE data. The study generated several findings. Overall, healthy diet and physical activity seemed to be the most important health behaviours explaining differences in health outcomes among older Chinese people. Significant associations were found between healthy diet and two health outcomes (QoL and cognitive function). Physical activity was associated with all four outcome variables examined in this study.

Notably, smoking was not found to be significantly associated with any health outcome in the present study. Previous findings regarding associations between smoking and depression have not been consistent; some researchers have found a positive association [101–104], whereas others have argued that smokers actually have a lower risk of developing depression than those in the Chinese population who have never smoked.105 Findings regarding relationships between smoking and cognition have also been controversial. Some studies have revealed an inverse relationship [106], whereas others have shown no association or even a positive association between smoking and cognitive function [104,107]. However, this positive association was observed only in middle-aged Chinese adults, and no significant association was found in older age groups [107]. It should be noted that the above studies investigated smoking as a health behaviour alone and did not include healthy diet or physical activity as additional health behaviours, which may have generated different results. More research is needed to support these findings.

The prevalence of different health behaviours and background characteristics of participants in the present study were similar to those reported previously. More than half (61.7%) of the present study participants had low educational levels, which was similar to, or higher than, the prevalence in other Chinese studies [13,66,108]. In addition, the prevalence of smoking (27.0%), unhealthy diet (35.0%), and physical inactivity (32.8%) in the present study concurred with previously reported levels (26.7%, 35.6%, and 28.3%, respectively) [13]. One remarkable finding of the present study was that residents in rural Shanghai showed the highest prevalence of physical inactivity (88.6%), in contrast with previous findings that rural residents tend to be more physically active [18]. One possible explanation may be the unique urbanisation pattern in rural areas in Shanghai. Previous research has revealed that rapid urbanisation can significantly reduce the level of both occupational and total physical activity among Chinese adults [18], because rapid urbanisation usually brings new ideas, cultures, and technologies, all of which facilitate a sedentary lifestyle [109]. A dichotomous rural-urban classification based on the Chinese government's administrative division has been used to distinguish urban from rural areas in the present study. According to the Urbanization Quality Index (UQI), Shanghai holds the highest average UQI (0.70) among all cities in China [110], which means that Shanghai is the most urbanised city in China, pointing to possible misclassification of 'rural areas' in Shanghai in the present study.

Previous studies have generally shown that urban residents tend to maintain lower levels of physical activity than rural residents,13,40 except one study conducted in Guangdong Province, that showed rural residents aged ≥45 years were more active (80.8%) than urban residents (77.6%), but found that rural residents aged ≥55 years (77.8%) had a lower prevalence of being physically

active than urban residents (80.5%) [111]. In the present study, urban areas had numerically lower proportions of older residents taking physical activity than those in rural areas, except for Jilin, Shanghai, and Zhejiang. Findings of previous studies have shown a higher prevalence of depression in rural China compared with urban areas.48,64 In the present study, the lowest mean scores for depressive symptoms were found in urban Shanghai (0.03 ± 0.25) and Shandong (0.04 ± 0.29), and the highest scores were reported for rural Guangdong (0.58 ± 1.05) and Shaanxi (0.58 ± 1.04).

In the present study, the relationships between health outcomes and sociodemographic variables/health behaviours were analysed by multivariate regression. Unlike in previous studies [46,58], depressive symptoms were not associated with educational level or employment in the present study population. The differences in findings likely reflect the use of different measures to assess depressive symptoms in the aforementioned studies (the Centre for Epidemiologic Studies Depression Scale and the 15-item Chinese version of the Geriatric Depression Scale, respectively), and differences in sample age range (≥18 years [mean, 46.908 years]; and ≥ 70 years, respectively), from that of the present population. Also, the present study revealed no association between physical function and marital status, unlike a previously published study,36 which was conducted with older populations (baseline mean age ≥70 years).

The present study has several strengths. To the best of the authors' knowledge, it is the first study to examine relationships between multiple health behaviours and health outcomes among older Chinese adults using nationally representative data. The scale and size of the WHO-SAGE data are unique and confer a high degree of generalisability of the findings, and the relatively large sample enhances the reliability of the analyses.

The present results may be limited by several factors. First, due to the cross- sectional nature of the data, causality could not be inferred. For example, pointed questions such as 'Did depressive symptoms lead to smoking, or did smoking lead to depression?' and 'Did inactivity result in poorer health, or did poor health lead to reduced physical activity?' could not be answered. The relationships between health behaviours and health outcomes are expected to be dynamic [3,88,112], thus, longitudinal studies are needed to identify whether changes in health behaviours alter health outcomes (or vice versa). Such research will be possible once WHO-SAGE Wave 2 data become available. Secondly, because talking about mental illness, particularly depression, is considered to be taboo in Chinese society [113], the face-to-face approach used in the WHO-SAGE survey may have biased participants' responses about depression. Chinese people tend to express depression in a semantic way, instead of responding to questions about cognitive characteristics such as depressed mood [114], as confirmed in previous empirical studies [65,115]. Other research has also indicated that the prevalence of depression may be underestimated in community-based settings due to self-reporting bias [116]. Although these potential biases may not significantly influence the associations observed in the present study, caution is required when interpreting data on the prevalence of depressive symptoms in this study population. Thirdly, due to limited available data, fruit and vegetable consumption was used to indicate healthy diets in the present study, which alone, cannot provide the whole picture of an individuals' diet pattern

because a healthy diet means more than merely adequate vegetable and fruit consumption. For that reason, future research should aim to collect more information on healthy diets following WHO's guideline, in order to capture a more accurate picture. Fourthly, although this is the first study to assess the associations between region and health outcomes in different Chinese provinces, using nationally representative data, the underlying reasons for these differences were not further investigated. Future studies should explore the reasons for variations in health behaviours and health outcomes between Chinese provinces. Lastly, although three health behaviours were included in the multivariate regression analyses, the influence of differences in clustering of the health behaviours in the study were not examined. Such analyses would be an interesting direction for future research, because different patterns of multiple health behaviours may further explain differences in health outcomes.

In conclusion, the present findings highlight the important roles of physical activity and healthy diet among older Chinese adults. In addition, there may be variation in health behaviours and health outcomes across regions of China. Health promotion strategies should be tailored at the regional level to consolidate targeting of physical activity and healthy diet among older Chinese people.

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3

Social participation is an important health behaviour for health and quality of life among chronically ill older Chinese people

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ABSTRACT

Background: Health behaviours (physical activity, maintenance of a healthy diet and not smoking) are known to be beneficial to the health and well-being of chronically ill people. With China's ageing population and increased prevalence of people with chronic diseases, the improvement of unhealthy behaviours in this population has become crucial. Although recent studies have highlighted the importance of social participation for health and quality of life (QoL) among older people, no study to date has included social participation along with more traditional health behaviours. Therefore, this study aimed to identify associations of multiple health behaviours (social participation, physical activity, maintenance of a healthy diet and not smoking) with health and QoL outcomes (including cognitive and physical function) among chronically ill older adults in China.

Methods: For this nationally representative cross-sectional study, wave 1 data from the World Health Organization's Study on global AGEing and adult health (China) were examined. In total, 6,629 community-dwelling older adults (mean age, 64.9 years) with at least one chronic disease were included. Multivariate linear regression analyses were used to evaluate associations of health behaviours with health and QoL outcomes while controlling for background characteristics.

Results: Greater social participation was associated with better QoL [$\beta = 0.127$, standard error (SE) = 0.002, $p < 0.001$], cognitive function ($\beta = 0.154$, SE = 0.033, $p < 0.001$) and physical function ($\beta = -0.102$, SE = 0.008, $p < 0.001$). Physical activity was associated with better QoL ($\beta = 0.091$, SE = 0.015, $p < 0.001$) and physical function ($\beta = -0.155$, SE = 0.062, $p < 0.001$). Sufficient fruit and vegetable consumption was associated with better QoL ($\beta = 0.087$, SE = 0.015, $p < 0.001$).

Conclusions: Our findings suggest that social participation is an important health behaviour for quality of life and cognitive function among chronically ill older people in China. Health promotion programmes should expand their focus to include social participation as a health behaviour, in addition to physical activity, maintenance of a healthy diet and not smoking.

BACKGROUND

Humans are living much longer today than they did 100 years ago; this great achievement in human development is accompanied by new challenges [1]. Chronic diseases pose an increasing global problem [2], and older adults are more vulnerable to such conditions (e.g. cardiovascular diseases, diabetes and lung diseases) [3].

China has the largest ageing population in the world, and the rate of ageing in this country has accelerated over recent years [4]. At the end of 2018, the population of China included more than 249.49 million (about 17.9%) people aged ≥ 60 years [5]. Approximately 150 million of these older adults have at least one chronic illness [6]. For decades, research has consistently shown that people with chronic conditions are at greater risk of worse quality of life [7–9] and health outcomes [10] than are those without chronic disease. Thus, the identification of modifiable factors to prevent the deterioration of health and quality of life among chronically ill older adults is crucial in a time of ageing societies.

Considerable evidence shows that healthy lifestyle habits, such as physical activity and maintenance of a healthy diet, can slow the deterioration of cognitive function, quality of life and physical function in chronically ill (older) populations [11–16]. For example, physical activity has been associated with better cognitive function among older adults with hypertension [16], and has been found to enhance the quality of life of patients with type 2 diabetes [12–15] and heart failure [11, 12].

Not only traditional health behaviours (i.e. physical activity, maintenance of a healthy diet and not smoking), but also older people's ability to stay socially active and connected to others is essential for health and quality of life outcomes. Social participation is considered to be a critical element of active ageing [17] and has been incorporated into many theoretical models of successful ageing [18]. It has been associated with longevity [19], self-rated health [6], quality of life [20, 21] and functional ability [22]. Notably, the positive influence of social participation on health was found to be greatest among older adults [23]. For example, the association between social participation and cognitive function was shown to be stronger among older adults than among younger persons [22]. A possible explanation is that active engagement in social activities gives older people opportunities to experience more dynamic environments, which is considered to be beneficial for the maintenance of cognition by stimulating neurogenesis, even at older ages [22].

Less attention has been paid to whether chronically ill older adults can benefit from social participation [24, 25]. Several studies have shown that social participation affects the (health-related) quality of life of older adults with arthritis [26, 27] and post-stroke [28]. Research on chronically ill older Chinese adults, however, is limited. In the first study of its kind, Hu and colleagues [29] found no association between social participation and quality of life among older Chinese adults with diabetes. However, their measurement of social participation focused mainly on formal organisations (e.g. sports clubs), which might have led to underestimation and contributed to inaccurate estimation of this association; in China, joining formal social organisations, such as sports clubs

and culture associations, is not common [29], whereas activities such as public square dancing (guang chang wu in Mandarin) [30], group tai chi practice [31] and group singing in parks [32] are common. Furthermore, Hu and colleagues' [29] findings were not generalisable to the whole country because of the sampling strategy used.

More importantly, although previous research has identified the importance of traditional health behaviours and social participation separately, no study to date has incorporated social participation as a health behaviour in addition to physical activity, maintenance of a healthy diet and not smoking. Thus, the purpose of this study was to investigate the associations of social participation and these traditional health behaviours with health and quality-of-life outcomes among chronically ill older adults in China, using a large nationally representative dataset.

METHODS

Participants and data

Data for this study were taken from wave 1 of the World Health Organization's (WHO's) Study on global AGEing and adult health (SAGE), the most recent data available from China. SAGE is a longitudinal study for which nationally representative data were collected from adults aged ≥ 50 years from six low- and middle-income countries (China, Ghana, India, Mexico, the Russian Federation and South Africa) using a multistage, stratified cluster sampling approach. The effectiveness and high response rate of SAGE are attributable to proper planning and organization from the initiation of the study [33]. All investigators, supervisors and interviewers were trained to administer the survey in the field, introduce SAGE to the sampled households [34]. In China, wave 1 of SAGE was implemented in 16 strata in 8 provinces/municipalities [34]. A five-stage cluster sampling strategy was used to select participants, who were contacted by telephone or in person, and about 200 investigators were involved in wave 1 data collection via face-to-face interviews between 2008 and 2010 [34]. About half of the interviews were computer assisted (CAPI), and half involved manual data recording [35]. Investigators visited the selected households and collected information about household rosters; then, the survey team completed the questionnaires at a central location (e.g. a neighbourhood office) or at respondents' homes [34]. Each respondent received a small gift for his or her cooperation [34]. An excellent response rate was achieved (93%), similar to rates for other surveys (e.g. the China Health and Retirement Longitudinal Study) conducted among older people in China. Detailed information about the SAGE data collection procedures can be found elsewhere [34].

SAGE consists of national longitudinal studies of older people (age ≥ 50 years) in six lower- and upper–middle-income countries. The instruments and threshold age used are compatible with other large longitudinal ageing studies conducted in high-income countries, such as the US Health and Retirement Study (HRS) and the Korean Longitudinal Study on Ageing (KLoSA), enabling sound international comparisons of the ageing process, health and well-being among middle-aged

and older adults [35]. The original wave 1 sample included 13,367 participants from China. We enrolled respondents aged ≥ 50 years with chronic disease (angina, arthritis, asthma, chronic lung disease, diabetes, diagnosed depression, hypertension, paralysis or stroke), leading to a final sample of 6,629 respondents. Most (n = 6194, 93.4%) older persons in the sample were aged 50–80 years; people aged 50–59 years made up the largest group (n = 2270, 34.2%), those aged 60–69 years comprised the second largest group (n = 2154, 32.5%) and only 6.6% (n = 435) of the sample was aged > 80 years. The procedure for sample selection is summarized in Figure 1.

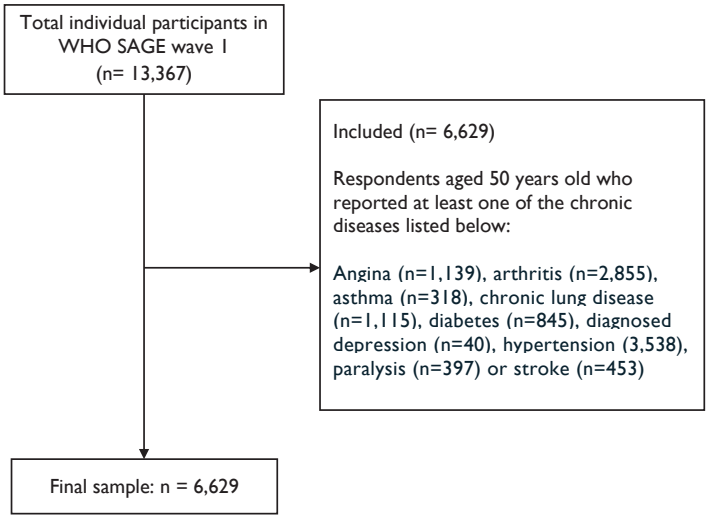

Figure 1. Flow chart on how the final sample (n = 6,629) was derived.

Measures

Chronic Conditions

For self-reporting of chronic conditions, respondents were asked whether they had been diagnosed with any of the following: i) angina or angina pectoris (heart disease), ii) arthritis (or rheumatism, osteoarthritis), iii) asthma (an allergic respiratory disease), iv) chronic lung disease (emphysema, bronchitis, COPD), v) diabetes (high blood sugar), vi) depression, vii) high blood pressure (hypertension), viii) paralysis and ix) stroke. The questions were formatted as: "Have you ever been diagnosed with/told by a health care professional you have…?" Respondents provided yes/no answers. They were considered to have chronic (a) disease(s) if they answered "yes" to any of the questions.

Health behaviours

Social participation was measured using summed scores for the 9-item questionnaire developed for the SAGE [36] (Appendix 1). Items enquire about respondents' frequency of community involvement in the past 12 months, with responses ranging from 'never' (1) to 'daily' (5). The

Cronbach's alpha value for the questionnaire in this study was 0.63. We used adequate fruit and vegetable intake as an indicator of healthy diet (insufficient, fewer than servings fruit and three servings vegetables/day; sufficient, two or more servings of fruit and three or more servings of vegetables/day] [37]. Version 2 of the General Physical Activity Questionnaire was used to measure physical activity [36]. Participants were asked to report the average number of days per week and time in which they engaged in vigorous and moderate physical activity. We recorded physical activity as sufficient or insufficient according to the WHO threshold of 150 min/week [38]. Smoking habits were assessed by asking whether participants were daily smokers (yes/no).

Outcome variables

Quality of life

Quality of life was measured using the 8-item World Health Organization quality of life measure (WHOQoL) [35] (Appendix 2). Respondents were asked to rate their satisfaction with life in general and in different domains (e.g. finances, health and relationships) on a 5-point scale ranging from 0 ('not at all/very poor') to 5 ('completely/very good'). Total scores were calculated by summing the item scores and rescaling the result to 0–100 [39]. According to previous research [40], the 8-item WHOQoL is useful for the assessment of quality of life in older populations. The Cronbach's alpha value of the instrument in this study was 0.86.

Cognitive function

Cognitive function was measured by administering five cognitive performance tests (forward and backward digit spans, immediate and delayed verbal recall, and verbal fluency) [41]. Forward digit span was tested by asking participants to repeat progressively longer number series in the exact order in which they had been presented [41, 42]. Backward digit span was tested by asking participants to repeat such series backwards [41]. Scores (longest spans repeated) for the forward and backward digit spans ranged from 0 to 9 and 0 to 8, respectively (total possible scores, 1–17) [42]. Immediate and delayed verbal recall was measured by asking participants to read 10 words aloud and soon thereafter to recall as many words as possible in 1 minute [41]. The same test was repeated three times. Scores ranged from 0 to 10 [43]. Verbal fluency was assessed by asking respondents to name as many animals as they could in 1 minute [42]. Scores were based on the number of correctly named animals, with repeated names counted only once (range, 2–38) [42, 43]. *Z* scores were calculated for the five test scores, and final cognitive function scores (range, 0–100) were generated by summing these scores [41, 42].

Physical function

Physical function was measured using the activities of daily living items from version 2 of the WHO's Disability Assessment Schedule, based on the Katz Index of Independence in Activities of Daily Living [44]. Total scores was calculated by summing scores for the following items: 1) difficulty in bathing/washing your whole body, 2) difficulty in getting dressed, 3) difficulty with

getting to and using the toilet, 4) difficulty with standing up from sitting down, 5) difficulty in getting up from lying down and 6) difficulty with eating (including cutting up your food). Responses are structured by a 5-point scale ranging from 0 (none) to 4 (extreme/cannot do). The Cronbach's alpha value for this instrument in this study was 0.89.

Potential confounders

Based on data from the literature and the availability of SAGE data, we included age (in years), gender (male/female), marital status, area of residence (urban/rural), educational level and income (by quintile) as potential confounders because they are associated both health behaviours and health outcome variables [45-51].

We dichotomized marital status as non-single (including 'currently married' and 'cohabiting') and single (including 'never married', 'separated/divorced' and 'widowed'), and educational level as higher (completion of secondary school or more) and lower (completion of primary school or less). The Chinese government's administrative division was used to determine if people lived in a rural or urban area. Respondents' incomes were estimated. SAGE-China used the WHO's Bayesian post-estimation method to generate raw continuous income estimates based on income indicators such as a set of household ownership of durable goods (e.g. number of chairs), various dwelling characteristics (e.g. type of floor) and access to services (improved water, sanitation and cooking fuel) [52, 53]. Estimated income was then transformed into quintiles [53], with quintile 1 denoting the lowest and quintile 5 denoting the highest income [52, 53].

Statistical analysis

Descriptive statistics and frequencies were used to describe the study population. Correlation analysis was performed to assess relationships between background characteristics and health behaviours using the outcome measures (quality of life, cognitive function and physical function). Multivariate linear regression analyses were conducted to study associations between health behaviours (physical activity, maintenance of a healthy diet, smoking and social participation) and quality of life and health outcomes while controlling for background characteristics. We used listwise deletion of missing cases in the multivariate analyses. Analyses were performed using IBM SPSS software (version 24; IBM Corporation, Armonk, NY, USA). As the sample was large, the significance level was set at $p < 0.001$. All statistical tests were two sided.

RESULTS

Participants' characteristics

In total, 6,629 participants with a mean age of 64.9 (range, 50–99) years were included in the study (Table 1). More than half (56.0%) of the participants were women. The majority of participants were non-single (81.9%) and had lower educational levels (60.4%). Fewer than half (42.9%) lived in

rural areas. About one-fifth (20.5%) of the respondents were daily smokers, and more than one-third reported inadequate fruit and vegetable consumption and/or insufficient physical activity. The mean social participation index score was 14.6 (standard deviation, 3.58; range, 8–36). The percentages of missing values for the study variables were ≤7.1%.

Table 1 Characteristics of the study population (n = 6,629)

Characteristic		*n*	%	Mean (SD)	Range
Age (years)		6,629	100.0	64.9 (9.28)	50–99
Gender					
	Female	3709	56.0		
	Male	2920	44.0		
Marital status *Missing 6 (0.1%)*					
	Non-single	5426	81.9		
	Single	1197	18.0		
Residence					
	Rural	2846	42.9		
	Urban	3783	57.1		
Education level *Missing 35* (0.5%)					
	Lower	3984	60.1		
	Higher	2610	39.4		
Income level M*issing 30* (0.5%)					
	Quintile 1 (lowest)	1265	19.1		
	Quintile 2	1246	18.8		
	Quintile 3	1333	20.1		
	Quintile 4	1417	21.3		
	Quintile 5 (highest)	1338	20.2		
NCDs					
	Hypertension	3,538	53.8		
	Arthritis	2855	43.1		
	Angina	1,139	17.2		
	Chronic lung disease	1,115	16.9		
	Diabetes	845	12.8		
	Stroke	453	6.8		
	Paralysis	397	6.2		
	Asthma	318	4.8		
	Depression diagnosed	40	0.6		
Health behaviours					
Social participation index *Missing 11 (0.2%)*		6618	99.8	14.6 (3.58)	8–36

Table 1 Characteristics of the study population (n = 6,629) (continued)

Characteristic		*n*	%	Mean (SD)	Range
FV consumption *Missing 333 (5%)*					
	Inadequate	2188	33.0		
	Adequate	4108	62.0		
PA *Missing 13 (0.2%)*					
	Insufficient	2309	34.8		
	Sufficient	4307	65.0		
Daily smoker *Missing 16 (0.2%)*					
	Yes	1358	20.5		
	No	5255	79.3		
Health and QoL outcomes					
QoL *Missing 121 (1.8%)*		6,508	98.2	3.5 (0.6)	1–5
Cognitive function *Missing 471 (7.1%)*		6,158	92.9	38.9 (10.1)	3–94
Physical function *Missing 15 (0.2%)*		6,614	99.8	0.9 (2.4)	0–24

SD, standard deviation; NCD, non-communicable disease; FV, fruit and vegetable; PA, physical activity; QoL, quality of life.

Correlations

Social participation showed weak positive correlations with quality of life ($r = 0.178, p < 0.001$) and cognitive function ($r = 0.197, p < 0.001$) scores, and a weak negative correlation with the physical function score ($r = –0.135, p < 0.001$), indicating that greater degrees of social participation correlated with better quality of life, cognitive function and physical function (Table 2). Adequate fruit and vegetable intake showed weak positive correlations with quality of life ($r = 0.185, p < 0.001$) and cognitive function ($r = 0.153, p < 0.001$) scores, and a weak negative correlation with the physical function score ($r = –0.073, p < 0.001$), indicating that it correlated with better quality of life, cognitive function and physical function (Table 2). Physical activity showed weak positive correlations with quality of life ($r = 0.095, p < 0.001$) and cognitive function ($r = 0.105, p < 0.001$) scores, and a weak negative correlation with the physical function score ($r = –0.197, p < 0.001$), indicating that physically active individuals had better quality of life, cognitive function and physical function (Table 2). Daily smoking did not correlate with quality of life or cognitive or physical function (Table 2).

Table 2 Associations of background characteristics and health behaviours with quality of life and health outcomes

	QoL[a]	Cognitive function[b]	Physical function[c]
Age (years)	-.054***	-.310***	.228***
Gender (female)	-.055***	-.088***	.020
Residence (rural)	-.124***	-.256***	.119***
Marital status (non-single)	.122***	.189***	-.108***
Education (lower)	-.180***	-.374***	.130***
Income			
Quintile 1 (lowest)	-.252***	-.254***	.120***
Quintile 2	-.108***	-.143***	.021
Quintile 3	.016	-.023	.021
Quintile 4	.093***	.154***	-.052***
Quintile 5 (highest)	.242***	.255***	-.106***
Social participation index[d]	.178***	.197***	-.135***
FV intake (sufficient)	.185***	.153***	-.073***
PA (active)	.095***	.105***	-.197***
Daily smoker (yes)	.004	.025	-.034

QoL, quality of life; FV, fruit and vegetable; PA, physical activity.
***$p < 0.001$.
[a]Higher scores represent better QoL.
[b]Higher scores represent better cognitive function.
[c]Higher scores represent poorer physical function.
[d]Higher scores indicate more social participation.

Table 3 demonstrates the associations of health behaviours and quality of life to health outcomes in analyses controlled for background characteristics. Social participation was associated significantly with all health and quality of life outcomes. With all other variables held constant, a 1-unit increase in the social participation index score was associated with a 0.128-unit increase in the quality of life score [$\beta = 0.128$, standard error (SE) = 0.002, $p < 0.001$], a 0.154-unit increase in the cognitive function score ($\beta = 0.154$, SE = 0.033, $p < 0.001$) and a 0.101-unit decrease in the physical function score ($\beta = –0.101$, SE = 0.008, $p < 0.001$). Compared with insufficient intake, sufficient fruit and vegetable intake was associated with a 0.087-unit increase in the quality of life score ($\beta = 0.087$, SE = 0.015, $p < 0.001$). Compared with physical inactivity, physical activity was associated with a 0.091-unit increase in the quality of life score ($\beta = 0.091$, SE = 0.015, $p < 0.001$) and a 0.155-unit decrease in the physical function score ($\beta = –0.155$, SE = 0.062, $p < 0.001$). No significant association was found between daily smoking and any health outcome or the quality of life score (Table 3).

Table 3 Multivariate regression results for relationships of health behaviours to QoL and health outcomes analyses were controlled for background characteristics. QoL, quality of life; SE, standard error; FV, fruit and vegetable; PA, physical activity.

	QoL[a]				Cognitive function[b]				Physical function[c]			
	Unstandardized coefficients		Standardized coefficients		Unstandardized coefficients		Standardized coefficients		Unstandardized coefficients		Standardized coefficients	
	B	SE	Beta	*p*	B	SE	Beta	*p*	B	SE	Beta	*p*
Age (years)	.003	.001	.048	<.001	-.247	.014	-.224	<.001	.047	.004	.179	<.001
Gender (female)	-.035	.016	-.030	.031	-1.544	.270	-.076	<.001	.065	.069	.013	.344
Residence (rural)	.003	.017	.003	.849	-3.153	.271	-.154	<.001	.595	.069	.122	<.001
Marital status (non-single)	.073	.019	.048	<.001	.838	.318	.032	.008	-.118	.081	-.019	.147
Education (lower)	-.065	.017	-.054	<.001	-3.358	.274	-.162	<.001	.0.18	.070	.004	.797
Income (quintile 2)	.154	.023	.103	<.001	.809	.371	.032	.029	-.293	.095	-.048	.002
Income (quintile 3)	.282	.023	.193	<.001	2.092	.375	.083	<.001	-.164	.095	-.028	.085
Income (quintile 4)	.350	.023	.246	<.001	4.771	.378	.195	<.001	-.438	.096	-.075	<.001
Income (quintile 5, highest)	.507	.024	.354	<.001	5.897	.399	.234	<.001	-.581	.101	-.098	<.001
Health behaviours												
Social participation index[d]	**.021**	**.002**	**.128**	**<.001**	**.437**	**.033**	**.154**	**<.001**	**-.068**	**.008**	**-.101**	**<.001**
FV intake (sufficient)	**.107**	**.015**	**.087**	**<.001**	.267	.248	.013	.282	-.032	.064	-.006	.618
PA (active)	**.112**	**.015**	**.091**	**<.001**	.718	.245	.033	.003	**-.786**	**.062**	**-.155**	**<.001**
Daily smoker (yes)	.008	.020	.006	.689	-.536	.325	-.021	.100	-.071	.083	-.012	.393
Constant	2.586	.076	-	<.001	48.880	1.249	-	<.001	-.467	.318	-	.142
Overall adjusted R^2		.160				.293				.113		
Model *F* value		90.38		<.001		185.09		<.001		61.87		<.001
n		6099				5761				6200		

[a]Higher scores represent better QoL.

[b]Higher scores represent better cognitive function.

[c]Higher scores represent poorer physical function.

[d]Higher scores represent more social participation.

DISCUSSION

Previous studies have linked social participation to various quality of life and health outcomes among older adults [20, 21], but not specifically among chronically ill older adults. Moreover, they did not involve the investigation of social participation as a health behaviour in addition to traditional health behaviours (i.e. physical activity, maintenance of a healthy diet and not smoking). In this study, we thus examined the associations of social participation and traditional health behaviours with quality of life and health outcomes among chronically ill older people in China.

We found that the health behaviour social participation was associated significantly with all health and quality of life outcomes examined, which was not the case for traditional health behaviours (smoking, healthy diet, and physical activity). Among all health behaviours, social participation showed the strongest association with better quality of life. In contrast, Hu and colleagues [29] failed to find an association between social participation and quality of life among older Chinese adults with type 2 diabetes. However, they focused mainly on participation in formal organisations, such as sports clubs, which is not common among older Chinese adults and may have contributed to the lack of association [29]. In the current study, we incorporated broader aspects of social participation (e.g. working with other neighbourhood residents to fix or improve something and participation in social events in other neighbourhoods), which are more common among older Chinese adults. Our findings extend our understanding of the importance of social participation as an additional health behaviour in chronically ill older populations. Health promotion and lifestyle programmes for such populations should thus address social participation as well as traditional health behaviours.

Physical activity was not associated with cognitive function in our study, in contrast to the previous finding of a positive association among older adults with hypertension [16]. In an intervention study conducted with diabetic patients [54], physical activity was related to certain aspects of cognitive function, such as memory and executive function, but was not associated with other aspects (i.e. psychomotor speed and attention/concentration). The inconsistency among findings may reflect the use of different measures of cognitive function. For instance, Frith and Loprinzi [16] used the digit symbol substitution test, whereas we used a more comprehensive measure of cognitive function. Wu et al.'s [54] study might partly explain the lack of association in our study because our measure of cognitive function incorporated aspects of attention and concentration, which were shown to be unrelated to physical activity.

In the present study, we observed no association between smoking and any health or quality of life outcome examined in the bivariate correlation and multivariate regression analyses. Similarly, no association has been reported among patients with diabetes [55,56] and hypertension [57]. Nevertheless, in general, smoking has been associated with decreased quality of life among chronically ill patients, including those with diabetes, asthma and lung cancer [58-60]. The reason for the lack of association in our study remains unknown. Research has suggested that smoking intensity (i.e. years of smoking, number of cigarettes per day) influences associations between smoking

and health outcomes [61, 62]. However, most reports do not provide information on smoking intensity, and smoking status has been classified in different ways, making comparison among studies difficult. For example, Xu and colleagues [57] dichotomized smoking status ('smoking' and 'no smoking'), Danson et al. [60] used three categories (never, former and current smokers) and we used the most commonly employed dichotomized variable ('daily smoker' and 'not a daily smoker'). Differences in controlling for confounders among studies also may have contributed to the variation in associations [62]. For example, Danson et al. [60] study controlled for demographic and clinical variables (e.g. long-term health problems and previous medical conditions), whereas Cataldo et al. [63] controlled only for age, gender and depression. In addition, the higher mortality rate of heavy smokers may have biased the analyses [64].

Study strengths and limitations

Our study has several strengths. First, it demonstrated that traditional health behaviours and social participation influenced quality of life and health outcomes in a large nationally representative sample of chronically ill older adults in China. Second, to minimise confounding bias, we included various potential confounders (e.g. socio-demographic characteristics) in the regression model. Third, although we could not assess causality, our findings show that chronically ill older adults may benefit from social participation.

Nevertheless, our findings should be viewed in light of the study's limitations. As this study was the first to investigate health behaviours of social participation, smoking, physical activity and maintenance of a healthy diet simultaneously with health and quality of life outcomes among chronically ill older adults in China, more research is needed to support our study findings and increase their generalisability. Second, although we followed the WHO's guideline in defining a healthy diet by measuring fruit and vegetable intake, this measure might be too general, which may have influenced the associations in our analysis. More research is needed to confirm associations with more inclusive dietary criteria, such as those for meat, dairy products, eggs, fish, poultry and soybeans, which are more commonly consumed in China [65]. Future research also should consider the impacts of the consumption of (certain amounts) of unhealthy foods, such as fatty and high-calorie foods [66]; diets including large amounts of unhealthy foods should not be considered to be healthy, even when they also include sufficient amounts of fruits and vegetables. Third, due to the cross-sectional design of this study, we could not examine the causality of associations of social participation and health behaviours with quality of life and health outcomes. Social participation and physical function may be reciprocally related [67]. Future studies should investigate whether changes in social participation and health behaviours are associated with improvements in quality of life and health outcomes among chronically ill patients over time; the effects of changes in health and quality of life outcomes on social participation and health behaviours should also be explored. Finally, we do not know whether or how chronic condition severity and combinations affect health behaviours and health outcomes due to data limitations. Research has suggested that hypertension, chronic hyperglycaemia and atherosclerotic macrovascular disease have a combined

effect on cognitive function in patients with type 2 diabetes [56]. Future studies should consider the potential combined effects of multiple chronic diseases, as multimorbidity is common in older adults.

CONCLUSIONS

This study showed that social participation is an important health behaviour for health and quality of life outcomes among chronically ill older adults in China. Expansion of the focus of health promotion programmes and lifestyle interventions to include social participation as an additional health behaviour is thus expected to be beneficial.

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APPENDIX 1

Social participation index

How often in the last 12 months have you…

1. Attended any public meeting in which there was a discussion of local or school affairs?
2. Met personally with someone you consider to be a community leader?
3. Attended any group, club, society, union or organisational meeting?
4. Worked with other people in your neighbourhood to fix or improve something?
5. Had friends over to your home?
6. Been in the home of someone who lives in a different neighbourhood than you do or had them in your home?
7. Socialised with co-workers outside of work?
8. Attended religious services (not including weddings and funerals)?
9. Gotten out of the house/your dwelling to attend social meetings, activities, programmes or events or to visit friends or relatives?

APPENDIX 2

Eight-item World Health Organization quality of life measure (WHOQoL)

1 Do you have enough energy for everyday life?
2 Have you enough money to meet your needs?
3 How satisfied are you with your health?
4 How satisfied are you with your ability to perform your daily living activities?
5 How satisfied are you with your personal relationships?
6 How satisfied are you with the conditions of your living place?
7 How satisfied are you with your life as whole these days?
8 How would you rate your quality of life?

4

Associations of Social Cohesion and Socioeconomic Status with Health Behaviors among Middle-Aged and Older Chinese People

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ABSTRACT:

Background: An understanding of factors associated with health behaviours is critical for the design of appropriate health promotion programmes. Important influences of social cohesion, education, and income on people's health behaviours have been recognised in Western countries. However, little is known about these influences in the older Chinese population.

Objective: To investigate associations of social cohesion and socioeconomic status (SES) with health behaviours among middle-aged and older adults in China.

Methods: We used data from the World Health Organization's Study on Global AGEing and Adult Health. Logistic regression and multivariate linear regression were performed.

Results: Participants who reported greater social cohesion were more likely to have adequate vegetable and fruit (VF) consumption, be socially active, and less likely to smoke daily, but were not physically more active; participants with lower education levels were less likely to have adequate VF consumption and be socially active, and more likely to smoke daily; higher incomes were associated with decreased odds of daily smoking, increased odds of adequate VF consumption, increased likelihood to be socially active, but also less likelihood to have sufficient physical activity (PA). Associations of social cohesion and SES with health behaviours (smoking, PA, and VF consumption) differed between men and women.

Discussion: Our findings are an essential step toward a fuller understanding of the roles of social cohesion and SES in protecting healthy behaviours among older adults.

Keywords: social cohesion; socioeconomic status; physical activity; healthy diet; smoking; social participation; health behaviour

1. INTRODUCTION

China, the country with the largest ageing population on Earth [1], is facing multiple health challenges [2). Health deteriorates as people age with increasing disease risk. Healthy behaviours are expected to slow health deterioration by preventing people from becoming ill, as well as by preventing the worsening of chronic illness [3]. Given the importance of leading a healthy lifestyle among older people in China, investigation of the factors associated with health behaviours is critical, and can be particularly useful for the prioritization of limited resources and targeting of public health interventions in the country.

Socio-economic status (SES), conceptualised as education and income, has been found to be associated with health behaviours [4,5]. Among Chinese adults, for example, less-educated people report lower levels of vegetable and fruit (VF) consumption [6] and higher levels of smoking [7]. People with lower incomes also reported inadequate VF consumption [8]. Diverse mechanisms underlie the relationships between SES disparities and unhealthy behaviours [5]. One classic explanation, termed the 'healthy lifestyle' mechanism, is that adults with higher educational levels tend to avoid unhealthy behaviours (e.g. smoking) and to engage in healthy behaviours (e.g. exercise) because education enables people to be more aware of the health outcomes of their behaviours and to develop stronger self-control [9]. Another explanation is that wealthier adults are able to afford the expenses of gym membership and other leisure time associated with physical activity (PA) [10]. In China, however, associations among income, PA and smoking are complex; people in rural China with lower incomes reported higher levels of work-related PA than did those with higher incomes [11]. Another study showed that women with lower incomes reported higher levels of domestic PA compared with the higher income group [12]. Possible explanations are that poorer rural residents must work for longer periods to earn livings; women with lower incomes are more likely to be stay-at-home housewives and thus participate more in domestic chores. Also, the association between income and smoking is not straightforward. How can we explain the fact that more than half of highly educated doctors in some areas of China are smokers, despite their knowledge of the harmful effects of smoking [13]? This phenomenon indicates that education and income alone are not sufficient to explain people's health behaviours. Factors other than SES disparities must empower people to adopt certain health behaviors; research has suggested that social circumstances [5] and social environmental factors such as social cohesion [14] can greatly influence such behaviors.

Empirical studies have highlighted the significant influence of social cohesion on people's health behaviours in Western countries [15-19]. For example, higher levels of social cohesion are associated with higher physical activity (PA) levels among older adults [16-18]. Social cohesion can promote PA in many ways [19]. More cohesive societies may be more likely to organize local activities, including sports/PA, that provide more opportunities for residents to adopt and maintain healthy behaviours [20,21]. Social cohesion also may reinforce healthy norms [21]; for

example, seeing neighbors jog every day might encourage others to participate in such activities when the perceived safety level (an element of social cohesion) is high [17].

This mechanism may also apply to the maintenance of a healthy diet. Collective efficacy, another aspect of social cohesion, is grounded in mutual trust and describes a community's ability to create change and exercise informal social control [e.g., promote healthy vegetable and fruit (VF) consumption through social norms] [22]. Several scholars have found that greater social cohesion is associated with higher VF intake among adults [23] and adolescents [24], and benefits nutrition among children [25]; little attention has been given to this association in older adults. In a study conducted with 5900 adults living in urban neighborhoods in five European countries, higher levels of social cohesion were associated positively with fruit, but not vegetable, intake [26].

The relationship between social cohesion and smoking appears to be less straightforward, as studies evaluating it have yielded different conclusions; some researchers found that greater social cohesion was associated with lower levels of smoking [27,28,29], whereas Andrews and colleagues [30] found no such association.

Apart from traditional health behaviours, social participation has also been reported recently to be a crucial health behaviour in later adulthood [31]. Studies conducted in Western countries, such as Great Britain [22,32] and the United States [33], have revealed a clear association between social cohesion and social participation among older adults, although evidence on this subject remains scarce and whether this association holds among older adults in China remains unknown.

Numerous attempts have been made to conceptualize social cohesion [34,35]. In general, the term refers to trust levels and the absence of social conflict, interrelated societal characteristics [36,37], but an internationally accepted definition remains lacking. For this study, we adopted Chan and colleagues' [38](pp. 290) definition: "social cohesion is a state of affairs concerning both the vertical and the horizontal interactions among members of a society, as characterized by a set of attitudes and norms that include trust, a sense of belonging, and the willingness to participate and help, as well as their behavioural manifestations." Researchers have proposed several indicators for its measurement [39,40], including trust among citizens [17,18,21,39,40,41,42] and perceived safety [39], which are expected to influence health behaviours.

Despite China's rapid economic growth in recent decades, the income gap (reflected by the Gini coefficient) in the country is ranked highly globally, even higher than that in the United States [43]. It peaked in 2008 and then began to decline in 2010 [43]. According to the Committee on Social Affairs, Health and Sustainable Development (Council of Europe), a substantial body of evidence has shown that income inequality is a major threat to social cohesion [44]. The drastic economic development that have occurred in the past few decades in China has likely affected social cohesion. Thus, the investigation of social cohesion in China during the period of 2008–2010 is of particular interest.

Research investigating associations between social cohesion, SES and health behaviours among older people in China is very limited; only one study revealed an association between social cohesion and leisure-time physical activity (LTPA) among older adults in Shanghai [21]. No study

to date has explicitly examined associations of social cohesion and SES with multiple health behaviours in a national sample of older Chinese people. Although the importance of SES has been well documented in developed nations [5], less evidence is available for developing countries such as China. To fill this gap, we investigated associations of social cohesion and SES with various health behaviours (smoking, physical activity, VF consumption and social participation) among middle-aged and older adults in China using a large nationwide database. As previous studies have revealed substantial gender differences in health behaviours such as smoking in China [45], we also conducted a gender-stratified analysis of these associations.

2. METHODS

2.1. Participants and data

Data from Chinese participants in wave 1 (2008-2010) of the World Health Organization's (WHO's) Study on global AGEing and adult health (SAGE) were used for the current study, which is the most recent available data from China. This period is also of interest because income inequality in China peaked in 2008 and only began to decline in 2010 [43]. SAGE is a nationally representative study of individuals aged ≥ 50 years in six low- and middle-income countries (China, Ghana, India, Mexico, the Russian Federation and South Africa). In China, the wave 1 survey was conducted in between 2008 and 2010 in 8 provinces/municipalities [46]. A multi-stage, stratified cluster sampling approach was used to select participants [46]. Approximately half of the face-to-face interviews were computer assisted (CAPI), and half were assisted by manual data recording [46]. The individual response rate was excellent (93%) [46]. Further details of WHO SAGE sampling have been provided elsewhere [47]. The sample for this study comprised 13,367 participants.

2.2. Measures

2.2.1. Independent variables

Social cohesion scale

Social cohesion was operationalized by using a mean scale based on respondents' answers to five questions about trust and safety developed by WHO SAGE as a social cohesion indicator: neighbourly trust, trust in co-workers, trust in strangers, perceived safety while staying alone at home, perceived safety while walking alone in streets after dark (details shown in Appendix A). The original questionnaire requires respondents to rate the levels of trust/safety on a five-point scale. In our analyses, all answers were inverse coded for convenience of interpretation. Meaning, for trust items, each answer based on a five-point scale, ranged from 1 denoting "to a very small extent" (1) to 5 "to a very great extent" (5); for safety items, answers ranged from "not safe at all" (1) to "completely safe" (5). At least three out of five items needed to be answered. Higher scores indicated higher levels of social cohesion.

SES

Based on previous research [5,48,49], education and income were used to measure SES in our analyses. Individuals' educational levels were recorded as lower (completed primary school or less; 0) and higher (completed secondary school or more; 1). Individuals' incomes were estimated by the WHO-SAGE research team. The Bayesian post-estimation method was used to estimate raw income based on income indicators such as various dwelling characteristics (e.g. type of floor), a set of household ownership of durable goods (e.g. number of chairs), and access to services (improved water, sanitation and cooking fuel) [50].

Socio-demographic characteristics

The following socio-demographic variables were controlled in our analyses: age (years), gender (0, male; 1, female), marital status [0, single (never married, separated/divorced, widowed); 1, married (currently married, cohabiting)], and area of residence (0, urban; 1, rural).

2.2.2. *Dependent variables*

PA

PA was assessed using a dichotomous variable based on self-reported questionnaire responses. Participants were asked to report their vigorous and moderate PA. Vigorous PA included work activities (e.g. chopping, farm work, digging with a spade or shovel), sports, leisure and recreational activities (e.g. jogging, running, swimming, heavy lifting, fitness, gym attendance, rapid cycling). Moderate PA included washing clothes by hand, gardening, house cleaning, stretching, dancing and cycling at regular pace. Participants were asked to recall the level of activities and the time spent on them in a typical week. We used the WHO-recommended thresholds (for individuals aged ≥ 18 years) to classify PA as sufficient (≥150 min/week moderate or ≥75 min/week vigorous PA; 1) and insufficient (0, <150 min/week moderate or <75 min/week vigorous PA; 0) [51].

VF consumption

VF consumption was used as an indicator of healthy eating. We followed the WHO guidelines [51] to distinguish adequate (≥2 servings fruit and ≥3 servings vegetables/day; 1) from inadequate (<2 servings fruit and <3 servings vegetables/day; 0) VF consumption.

Smoking

Smoking behaviour was assessed by asking whether participants smoked daily. This variable was dichotomised as 0 (not a daily smoker) and 1 (daily smoker).

Social participation scale

Social participation was measured using a mean scale for the 9-item questionnaire developed for the SAGE (Appendix B), with questions such as 'How often in the last 12 months have you attended any public meeting in which there was discussion of local or school affairs?'. Responses

ranging from 'never' (1) to 'daily' (5) denote the frequency of respondents' involvement in their communities. Total social participation scores were calculated by summing the item scores.

3. STATISTICAL ANALYSIS

As descriptive statistics, means and standard deviations (SDs) of continuous variables (e.g. age) and numbers and percentages of categorical variables (e.g. gender) were calculated. The strength of associations between social cohesion and health behaviours (categorical variables: PA, VF consumption, smoking) was evaluated by estimating odds ratios (ORs) with 95 per cent confidence intervals (CIs) using a logistic regression model. The association between social cohesion and social participation (a continuous variable) was evaluated by estimating B coefficients and standard errors (SE) using a multivariate linear regression model. Social cohesion and SES variables (income and education) were entered into the models simultaneously while adjusting for key individual background characteristics (age, gender, marital status and area of residence). To produce gender-specific analyses and to account for potential confounders, stratified analyses were performed, while adjusting for age, gender, marital status and areas of residence. To assess the severity of multi-collinearity, we calculated the Variance Inflation Factors (VIF) among independents variables. The VIF score of all covariates did not exceed the recommended value of 10 [52]; which suggested that there were no multi-collinearity problems among independent variables included in our analyses. The significance level was set at $p < 0.01$. All statistical analyses were conducted using IBM SPSS Statistics (version 27, IBM, Armonk, NY, USA).

4. RESULTS

Table 1 shows the characteristics of the study participants. Of the 13,367 participants included, the mean age (SD) was 63.2 (9.44) years; 53.1 per cent of participants were female, 83.1 per cent were not single, 50.9 per cent were from rural areas, and 61.7 per cent had lower educational levels. Overall, the prevalence of smoking was 24.5 per cent, but a much higher proportion of smokers was male (48.9% vs. 3.0% female). The prevalence of inadequate VF consumption was 35.0 per cent, and 32.8 per cent of participants reported insufficient PA. The mean social participation scale score was 1.7 (standard deviation, 0.4).

Table 2 presents the results of the multivariate linear regression model and logistic regression models. In the analysis adjusted for age, gender, marital status and residence, each unit of increase in the social cohesion score was associated with a 30 per cent increase in the likelihood of adequate VF consumption (OR = 1.300; 95% CI, 1.192–1.417; $p < 0.001$); higher social cohesion was as0sociated with lower odds of being a daily smoker (OR = 0.839; 95% CI, 0.754–0.934; $p < 0.01$); also, higher mean score of social cohesion was positively associated with higher levels of

Table 1. Characteristics of the study population (n = 13,367).

		n	%	Mean (SD)
Socio-demographic characteristics				
Age (years) Range 50-99		13367		63.2 (9.4)
Gender (female)		7093	53.1	
Marital status Missing 10 (0.1%)				
	Non-single	11093	83.1	
Areas of residence (rural)		6800	50.9	
SES and social cohesion variables				
Educational level Missing 72 (0.5)				
	Lower	8202	61.7	
Income quintile Missing 61 (0.5)				
	Q1 (lowest)	2665	20.0	
	Q2	2646	19.9	
	Q3	2688	20.2	
	Q4	2724	20.5	
	Q5 (highest)	2583	19.4	
Social cohesion scale Missing 429 (3.2)		12938		3.4 (0.5)
Health behaviours				
Daily smoker *Missing 443 (3.3)*				
	Female	209	3.0	
	Male	2954	48.9	
	Total sample	3163	24.5	
Inadequate VF consumption Missing 1247 (9.3)				
	Female	2013	28.4	
	Male	2223	39.0	
	Total sample	4236	35.0	
Insufficient PA Missing 422 (3.2)				
	Female	2284	33.2	
	Male	1960	32.3	
	Total sample	4244	32.8	
Social participation scale Missing 419 (3.1)				
	Female	6879		1.7 (0.4)
	Male	6069		1.7 (0.4)
	Total	12948		1.7 (0.4)

SD, standard deviation; SES, socio-economic status; VF, vegetables and fruit; PA, physical activity. No data on age, gender, residence were missing. Higher Social participation scores indicate greater social participation.

social participation (B = 0.074, p < 0.001). Regarding education, less-educated respondents were associated with lower odds of having adequate VF consumption (OR = 0.806; 95% CI, 0.730–0.890; p < 0.001), lower educated respondents had a 31 per cent higher likelihood of being daily smokers (OR = 1.314; 95% CI, 1.166–1.480; p < 0.001), and were less likely to be socially active (B = -0.052, p < 0.001) compared to people with higher levels of education. With respect to income, individuals with higher income were less likely to have sufficient PA (OR = 0.606; 95% CI, .552–.665; p < 0.001), less likely to be daily smokers (OR = 0.790; 95% CI, 0.699–0.891; p < 0.001), more likely to have adequate VF consumption (OR = 2.650; 95% CI, 2.396–2.932; p < 0.001) and tend to be more socially active (B = 0.101, p < 0.001) compared to people with lower income.

Analyses controlled for key background characteristics (age, gender, marital status and area of residence) revealed significant gender differences in the associations of daily smoking and PA with social cohesion (Table A3, Appendix C). Higher levels of social cohesion were associated significantly with decreased odds of being a daily smoker among men (OR = 0.805, p < 0.001), but not women. Such levels were associated significantly with sufficient PA only among men (OR = 1.178, p < 0.01). In addition, gender differences were found in the associations of education with adequate VF consumption and daily smoking (Table C1, Appendix C). Lower educational levels were associated significantly with reduced odds of adequate VF consumption among women (OR = 0.723, p < 0.001), but not men. Such levels were associated significantly with greater odds of being a daily smoker only among men (OR = 1.320, p < 0.001). In addition, higher incomes were associated significantly with reduced odds of being a daily smoker only among men (OR = 0.807, p < 0.01)

Table 2. Relationships between social cohesion and socioeconomic status with four health behaviours.

	Sufficient PA	Adequate VF consumption	Daily smoker	Social participation §	
	OR (95% CI)	OR (95% CI)	OR (95% CI)	B	SE
Independent variables					
Social cohesion	1.058 (.975- 1.147)	1.300 ** (1.192-1.417)	.839 * (.754-.934)	.074	.007 **
Education (low)	1.058 (.963- 1.162)	.806 ** (.730-.890)	1.314 ** (1.166- 1.480)	-.052	.008 **
Income	.606 ** (.552- .665)	2.650 ** (2.396- 2.932)	.790 ** (.699- .891)	.101	.008 **
Covariates					
Age	.960 ** (.956- .964)	1.000 (.995- 1.005)	.959 ** (.953- .964)	-.005	.000 **
Gender (female)	.937 (.867- 1.013)	1.510 ** (1.390- 1.640)	.027 ** (.023- .032)	-.003	.007
Residence (rural)	.681 ** (.621- .745)	.455 ** (.415- .500)	1.608 ** (1.431- 1.808)	.122	.008 **
Non-Single	1.078 (.968- 1.200)	1.330 ** (1.188- 1.489)	.787 * (.671- .923)	-.003	.010
Constant	25.762 **	.889	20.600 **		1.679**
R^2	.047 (Nagelkerke)	.153 (Nagelkerke)	.445 (Nagelkerke)		.062
n	12822	12005	12797		12840

*p < 0.01, **p < 0.001. SE, standard error; OR, odds ratio; CI, confidence interval. § continuous variable. PA, physical activity. Reference groups: male, urban residence, single, higher education. Higher Social participation scores indicate greater social participation.

5. DISCUSSION

In general, this study revealed that older Chinese people with greater social cohesion are more likely to have adequate VF consumption and to be socially active, and less likely to be daily smokers, but were not physically more active. Participants with lower education levels were less likely to have adequate VF consumption and to participate in social activities, and were more likely to be daily smokers than those with more education. Higher incomes were associated with a reduced likelihood of being a daily smoker and increased likelihood of having adequate VF consumption and being socially active, but also a reduced likelihood of engageing in sufficient levels of PA. Associations of social cohesion and SES with smoking, physical activity and VF consumption, however, differ between older Chinese men and women. This study serves as a first step in the deepening of our knowledge of the crucial role of social cohesion for health behaviours among older adults in China.

5.1. Associations of Social Cohesion with Health Behaviours

Our finding for the total sample that greater social cohesion decreased the odds of smoking, which is in agreement with previous research [27-29], supports the theory that social cohesion strengthens psychological resources (e.g., self-esteem, optimism) and helps to reduce smoking risk factors, such as distress [29]. Similarly, our finding for the total sample that older people with greater social cohesion are more likely to be socially active is in accordance with findings from Western countries, such as the United States [33]. No comparable data for older adults in China were available. In highly collectivistic societies, people tend to limit their social activities, including only people in their inner circles; they tend to be comfortable participating in social activities with others only when they feel that they can trust them [53]. Our finding implies that the enhancement of older people's perceived safety and trust (vital elements of social cohesion) boosts their social participation. The lack of association between social cohesion and PA in this study is consistent with Legh-Jones and Moore's finding [54] that perceived generalized trust was not associated with PA among adults. However, other researchers have reported a positive association with LTPA [18,21,55]. This inconsistency may reflect the use of different PA measures among studies [19]. To be specific, we included multiple aspects of PA (e.g. gardening, walking, household chores) whereas Lindström [55], Gao [21] and Van Dyck's [18] studies focused on the associations between social cohesion and LTPA specifically. Thus, social cohesion may be more relevant for leisure-time activities (e.g., going shopping, going to the movies, dining at a restaurant) than for other types of PA (e.g., gardening, household chores). Finally, we observed a positive association between greater social cohesion and sufficient VF consumption among older adults. This finding is in line with the findings of a study conducted in Japan, which revealed that people living in more cohesive neighbourhoods more frequently had sufficient VF intakes [56]. Although empirical studies of VF receipt among older adults in China are lacking, older Chinese adults who cultivate VF are likely to more frequently share their products with neighbours they trust as an

indicator of greater social cohesion. Previous findings on this topic are inconsistent. Barnidge and colleagues [57] found no significant association between social cohesion and VF consumption, and a multinational study conducted in Europe [26] revealed an association with fruit, but not vegetable, consumption. This discrepancy may be due to the examination of different study populations using different measures; we included middle-aged and older adults living throughout China, whereas Barnidge et al. [57] focused on older adults (mostly women) in rural settings in the United States and Mackenbach and colleagues [26] examined a general adult population from urban areas in Europe. Furthermore, we followed the WHO guidelines to distinguish adequate and inadequate VF consumption as one variable, Mackenbach and colleagues' [26] study measured fruit consumption and vegetable consumption separately as two variables. Besides, as admitted by Barnidge and colleagues [57], their study potentially brought bias regarding the reporting of VF consumption because they used a single item to measure VF consumption. Our finding, however, is consistent with the expected presence of such an association, and expands our understanding of it in general older adult populations.

5.2. Associations of SES with Health Behaviours

Our finding that older Chinese adults with higher incomes were more likely to be physically inactive is in accordance with previous findings for Chinese adults [11]. Older adults with higher incomes are more likely to own and use (personal) vehicles [58], which decreases their daily engagement in physical activities such as walking and cycling. In addition, this group may be less likely than those with lower incomes to need to engage in physically demanding work, for example, by hiring workers to do household chores. Although we found that higher incomes decreased the risk of being a daily smoker among older Chinese adults, according to Zhang and colleagues' [59], national Chinese surveys have revealed no relationship between household income and smoking behaviour (among men). This inconsistency might be explained by an age difference among study samples; the national surveys were conducted with adults aged ≥ 18 and ≥ 15 years, respectively [60,61]. Although higher education levels have been associated with higher levels of exercise [62], we observed no such association in our overall sample. Age may also explain this discrepancy, as the previous study was conducted with individuals aged 15–69 [62]. In addition, only 31% of participants in Gang et al.'s [62] study had lower educational levels (0–6 years of school), whereas 61.7% of our participants had completed primary school or less. Relationships between education levels and health behaviours need to be examined further.

5.3. Gender specific findings

This study revealed some gender differences related to smoking, PA, and VF consumption. Lesser social cohesion and lower educational levels and incomes were associated with daily smoking only among older Chinese men. These findings could be explained by the difference in smoking patterns between men and women [63,64], and the corresponding small number of female smokers in our sample. Various surveys have revealed low prevalence rates for smoking among Chinese

women [60]. For example, this rate was 2.4% in the 2010 Global Adult Tobacco Survey [65], likely because smoking is an accepted social norm for men, but not women, in China [66]. Greater social cohesion was associated with sufficient PA only among men in this study. In traditional Chinese culture, women are responsible for housework and are thus more likely than men to engage in domestic forms of PA (e.g., cooking and cleaning) [67]. Thus, social cohesion may have less influence on Chinese women's PA.

Lower educational levels were associated with inadequate VF consumption only among women in this study. A study conducted in Korea revealed an association between lower educational levels and lower VF intake, and specifically low consumption of yellow/orange vegetables in men and red fruit/vegetables in both men and women [68]. Due to differences in study samples and the measurement of VF consumption, comparison of our findings with those of Hong and colleagues [68] is difficult. Evidence regarding gender differences in the associations of social cohesion and SES with health behaviours in China is lacking. While this study provided a first insight into these gender differences, more studies are needed to gain an in-depth understanding of whether and how the mechanisms underlying older adults' social cohesion and health behaviours differ according to gender.

5.4. Public Policy Implication

The findings of this study provide valuable insight for policy development to promote healthy ageing among older adults in China. For instance, investment in the creation of safe neighbourhoods is expected to benefit older adults' health behaviours. Vest and Valdez [69] found that people who described their neighbourhoods as unsafe were almost three times more likely to be physically inactive than were people describing their neighbourhoods as extremely safe. Health policies should thus aim to create safe, walkable, and accessible neighbourhoods by increasing urban public space (e.g., community gardens and parks) to encourage older adults' outdoor (physical and social) activities and social interactions [70]. Furthermore, our findings highlight the importance of considering gender differences when designing health promotion strategies aiming to improve older Chinese adults' health behaviours.

5.5. Study Strengths and Limitations

This study contributes to the literature in several ways. First, China's unprecedented development has created a unique context for social scientists, as the rapid changes that have occurred have had profound impacts on the country's population. Specifically, scholars believe that economic growth can influence social cohesion [71]. This study is the first in which data from a large population-based sample were used to investigate the associations of social cohesion and SES with various health behaviours among older Chinese people. Second, we minimized bias by controlling for various potential confounders, such as sociodemographic factors, in our regression models.

Notwithstanding, several limitations of this study warrant mention. First, we could not assess causality or changes in social cohesion, SES, or health behaviours, due to the cross-sectional study

design. We encourage researchers to explore longitudinal relationships among these factors when wave 2 SAGE data become publicly available. In addition, bundling of health behaviours should be considered, as a previous study showed that people tend to gain weight when they quit smoking due to the consumption of more food/snacks as rewards for smoking withdrawal [72]. Second, we used VF consumption as an indicator of healthy diet due to limited data availability, although VF consumption alone cannot fully reflect individuals' dietary patterns. Thus, we urge researchers to collect more detailed dietary information according to the WHO guidelines, to augment our ability to assess these patterns. Third, the lack of global consensus on the definition of social cohesion—a well-known problem in this research field—makes the comparison of research findings difficult [41]. Fourth, we did not examine alcohol consumption in this study because face-to-face interviews have been shown to generate socially desirable answers to questions on this topic, with underreporting of alcohol consumption [73]. Lastly, due to data limitation, the measurement of social cohesion was limited to trust and safety indicators. More research is needed to develop an internationally accepted definition of social cohesion and means of operationalising this concept.

6. CONCLUSIONS

In the general older Chinese population, greater social cohesion was associated with adequate VF intake, active social participation, and not being a daily smoker among middle-aged and older adults in China, but was not associated with physically more active. Higher educational levels and incomes were associated with favorable health behaviours, except that higher incomes were associated with insufficient PA. Significant male-female differences, however, were found in the associations between social cohesion being a daily smoker, PA and adequate VF consumption. Our findings are an essential step toward a fuller understanding of the roles of social cohesion and SES in protecting healthy behaviours among older adults in China. Policymakers and health professionals designing health promotion strategies should aim to enhance social cohesion among middle-aged and older adults in China, which may vary between Chinese older men and women.

APPENDIX A

Table A1. Social cohesion scale.

How much you trust different groups of people…				
To a very small extent	To a small extent	Neither great nor small extent	To a great extent	To a very great extent
First, think about people in our neighbourhood. Generally speaking, would you say that you can trust them…?				
1	2	3	4	5
Now, think about people whom you work with. Generally speaking, would you say that you can trust them …?				
1	2	3	4	5
How about strangers? Generally speaking, would you say that you can trust them …?				
1	2	3	4	5
Questions about safety in the area where you live.				
Not safe at all	Slightly safe	Moderately safe	Very safe	Completely safe
In general, how safe from crime and violence do you feel when you are alone at home?				
1	2	3	4	5
How safe do you feel when walking down your street alone after dark?				
1	2	3	4	5

APPENDIX B

Table A2. Social participation scale.

How Often in the Last 12 Months Have You…
1. Attended any public meeting in which there was a discussion of local or school affairs?
2. Met personally with someone you consider to be a community leader?
3. Attended any group, club, society, union or organisational meeting?
4. Worked with other people in your neighbourhood to fix or improve something?
5. Had friends over to your home?
6. Been in the home of someone who lives in a different neighbourhood than you do or had…them in your home?
7. Socialised with co-workers outside of work?
8. Attended religious services (not including weddings and funerals)?
9. Gotten out of the house/your dwelling to attend social meetings, activities, programmes or events or to visit friends or relatives?

APPENDIX C

Table A3. Associations between social cohesion and socioeconomic status with health behaviours among males and females

	Sufficient PA		Adequate VF consumption		Daily smoker		Social participation §	
	Males	Females	Males	Females	Males	Females	Males	Females
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	B (SE)	B (SE)
Social cohesion	1.178* (1.044- 1.329)	.976 (.874- 1.091)	1.251 ** (1.106- 1.416)	1.357 ** (1.202- 1.531)	.805 ** (.716- .904)	.984 (.732- 1.323)	.067 (.011) **	.080 (.010) **
Low education	.941 (.826- 1.073)	1.184 (1.034- 1.356)	.866 (.759- .989)	.723 ** (.620- .841)	1.320 ** (1.163- 1.498)	1.413 (.938- 2.129)	-.050 (.012) **	-.055 (.012) **
Income	.595 ** (.519- .682)	.616 ** (.541- .700)	2.506 ** (2.175- 2.887)	2.806 ** (2.430- 3.240)	.807* (.708- .920)	.652 (.461- .923)	.124 (.012) **	.081 (.011) **
Age	.969 ** (.963- .975)	.952 ** (.946- .958)	1.010* (1.003- 1.017)	.990* (.983- .996)	.948 ** (.942- .954)	1.037 ** (1.020- 1.055)	-.004 (.001) **	-.006 (.001) **
Residence (rural)	.840 (.736- .960)	.568 ** (.501- .644)	.493** (.432- .563)	.426 ** (.373- .486)	1.704 ** (1.503- 1.933)	1.076 (0.778- 1.488)	.152 (.012) **	.098 (.011) **
Non-Single	1.072 (.894- 1.286)	1.051 (.916- 1.205)	1.277 (1.061- 1.537)	1.265 * (1.092- 1.466)	.878 (.708- .920)	.951 (.677- 1.338)	.035 (.017)	-.023 (.012)
Constant	9.387 **	55.798 **	.512	2.640 *	41.854 **	.002**	1.607 (.056) **	1.734 (.051) **

*p < 0.01. **p < 0.001. SE, standard error; OR, odds ratio; CI, confidence interval. § continuous variable. PA, physical activity; Higher Social participation scores indicate greater social participation.

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5

The longitudinal relationship between income and social participation among Chinese older people

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ABSTRACT

The vital role of active social participation in older people's lives is widely acknowledged. The maintenance of adequate levels of social participation is an essential element of successful ageing. Low income may inhibit older people from engageing in social activities. Given its recent rapid economic growth, China provides a unique setting for the study of changes in income and social participation among older people over time. In this study, the longitudinal relationship between income and social participation among Chinese older people was investigated using a nationally representative dataset from three waves of the China Health and Retirement Longitudinal Study (CHARLS). At baseline, a total of 3863 participants with a mean age of 60.4 years (range: 50-89) were included in our study; 49.9% of the participants were female, and 64.4 % lived in rural areas. Generalized estimating equations were used to analyze the longitudinal relationship between income and social participation, with and without adjustment for background variables (age, gender, marital status, educational level, empty-nest status, area of residence, and multimorbidity). The results of unadjusted and adjusted analyses clearly showed a longitudinal association between income and social participation. People from the highest income group were almost two times more likely to participate in social activities than were those from the lowest income group. People with a higher educational level are also more likely to participate in social activities compared to people with a lower educational level. Being married and living with children decreased the odds of social participation. Social participation is also less likely among older aged and those living in rural areas Our findings indicate that higher income levels are associated positively with social participation over time among older people in China.

1. INTRODUCTION

The vital role of active social participation in older adults' lives is acknowledged widely and is receiving increasing research attention [1]. Social participation can be conceptualized as "a person's involvement in activities that provide interaction with others in society or the community" [2]. An extensive body of literature confirms that social engagement is associated positively with better health [3,4], quality of life [5], life satisfaction [6,7], well-being [7,8,9], and less depressive symptoms [10] in later life. The maintenance of adequate levels of social participation is an essential element of successful ageing [9,11]. Low levels of social participation, on the other hand, increase the risk of mortality, with an effect comparable to those of smoking and alcoholism and potentially greater than that of physical inactivity [12]. Thus, the identification of factors associated with active social participation among older adults is essential.

Evidence suggests that poverty and low incomes inhibit people's engagement in social activities [13,14,15,16,17,1819]. Notably, poverty is a multi-dimensional and complex phenomenon, but income is a crucial aspect of it [20]. The available theoretical and empirical evidence is, however, mainly derived from Western populations. For example, a longitudinal study using registry data showed that poverty had adverse social consequences among older Swedish people [15]. Impoverished people may not be able to afford the expenses of social activities, such as club membership fees, material items required for leisure activities, and the costs of dining out or hosting dinner parties due to a lack of income [21,22]. Poverty entails a greater risk of exclusion from social life [22], which in combination with the shame associated with the inability to live a decent life leads ultimately to reduced social participation [23]. Although researchers believe that the mechanisms underlying associations between poverty and social consequences are similar across countries, this assumption is open to debate until comparable longitudinal studies are conducted internationally [15]. A cross-sectional study conducted in 24 European countries showed that income had a stronger negative influence on individuals' social participation in more unequal societies [14]. Furthermore, given that the patterns of and perspectives on social participation can differ markedly among settings, more research is needed to understand the association between income and social participation in non-Western countries.

China has had the second-largest economy in the world since 2010 [24]; together with rapid population ageing [25] and economic inequality [26], China's unprecedented economic growth and the accompanying pattern of social development provide a fascinating setting for scientists' study of the relationship between changes in income and social participation over time. During 1981–2013, China's national poverty headcount dropped at a rate of approximately 12.84% per year [27]. The average household income in the country has increased dramatically in the 21st century [28]. However, this rapid economic growth has had social consequences [29], such as imbalances in economic development (e.g., between rural and urban areas) [30]. This inequal development has contributed to Chinese adult children's movement away from their natal areas (i.e., villages, townships, and cities), leaving their ageing parents as "empty nesters" at home [25,31].

Research has shown, however, that Chinese empty-nester older adults are more socially active than are their non–empty-nester peers [32]. A possible explanation is the traditional Chinese cultural expectation that older people spend time with their families at home, such as by taking care of young children, before taking part in social (e.g., community) activities outside of the family sphere [32]. Marital status may also influence social activity levels, as people living with spouses may be less likely to engage in social activities outside of the home than are older persons with no spouse, although the findings on this topic are mixed [33,34].

Social participation also differs with respect to other background characteristics. With increasing age, older adults may lose their spouses/partners and friends, which increases the risks of having narrower social networks and experiencing social isolation [35,36]. More-educated people have reported higher levels of social participation [37] and the positive influence of education is known to persist into old age [38], although gender differences in these effects exist. Females are usually more socially active than males [37]. Similarly, urban older adults in China reported significantly more social participation than did their rural counterparts [39,40]. Furthermore, social participation has been reported to differ between people with and without (multi)morbidity [41]. Chronic conditions tend to be associated with functional disability, which has been shown to be among the greatest obstacles to social participation among older adults [36]. Because (multi) morbidity, empty-nest status, marital status, and other relevant background characteristics, such as age, gender, level of education, and rural or urban residence, impact people's ability to participate in social activities [18,33,40], they must be taken into account to avoid bias in examinations of the relationship between income and social participation.

Longitudinal studies investigating this relationship among Chinese older adults with consideration of background variables are lacking. Not until very recently have researchers begun to assess the relationship between pension amounts and social participation among Chinese older adults [42]; they failed to find an association, but they did not examine total income. According to the 2010 Chinese census, nearly half of older adults' (age ≥ 65 years) incomes comes from family members; 25% comes from pensions and 20% comes from labor [43]. In addition, Zhu and Walker [42] did not take relevant characteristics of Chinese older people into account; thus, the contribution of their finding to our understanding of the influence of total income on Chinese older adults' social participation is limited. Thus, we conducted this study to investigate the longitudinal relationship between total household income (adjusted for household size) and social participation among Chinese older adults while taking (multi)morbidity, empty-nest status, and relevant background characteristics into account. The following research questions were investigated to achieve this goal:

(1) Is higher household income associated with social participation among older Chinese adults over time (with and without adjusting for covariates)?
(2) In addition to household income, what is the relationship between background characteristics and social participation among older Chinese adults?

2. METHODS

2.1. Participants and data

This study was conducted with data from the China Health and Retirement Longitudinal Study (CHARLS), which had a nationally representative sample of non-institutionalized Chinese people aged ≥ 45 years [44]. The baseline survey (wave 1) was conducted between June 2011 and March 2012 with 17,708 participants, and follow-up surveys were conducted every year thereafter [45]. CHARLS was designed to have a better understanding of the social determinants and consequences of ageing. It includes a variety of information about demographics, economic status, physical and psychological health, and social participation among older adults in China [46]. The initiative of creating a Harmonized CHARLS dataset was to facilitate a more accessible and user-friendly version of the datasets, also, to increase the comparability of ageing-related studies around the world, such as Harmonized Health and Retirement Survey (HRS) in the United States, Harmonized JSTAR (Japan), and Harmonized SHARE (Europe and Israel) [46]. Currently, there are 4 waves of data available in CHARLS: the year 2012 (wave 1), the year 2013 (wave 2), the year 2014 (wave 3: life history study), the year 2015 (wave 4). The harmonized CHARLS dataset contains the newest available waves of CHARLS data (wave 1, wave 2, wave 3, wave 4) [46]. In wave 1, 2 and 4, community residents were asked to report their demographics, family information, social connections, health status, household income, individual income. Therefore, we included waves 1, 2, 4 of the Harmonized CHARLS data in our analysis. Wave 3 was not included in our analysis because it contains life history data only and does not contain variables such as household income and social participation, which therefore does not fit our criteria for analysis. CHARLS has been described in detail elsewhere [45]. For more detailed information about the Harmonized CHARLS data, please refer to: www.g2ageing.org.

In line with the World Health Organization's Study on Global Ageing and Adult Health, we used 50 years of age as the cut-off for this study of older persons [47]. After the elimination of cases with missing values for background characteristics, total household income and social participation, the final sample comprised 3863 older people.

2.1.1. Exclusion criteria

i) people age < 50 years; ii) respondents with missing data on background characteristics at baseline; iii) respondents with missing data on household income variable (all three waves); and iv) respondents with missing data on social participation (all three waves). The reasons for exclusion are summarized in Figure 1.

2.1.2. Ethical approval

The CHARLS team obtained ethical approval for the research from the Ethics Committee of Peking University. All participants provided written informed consent [45].

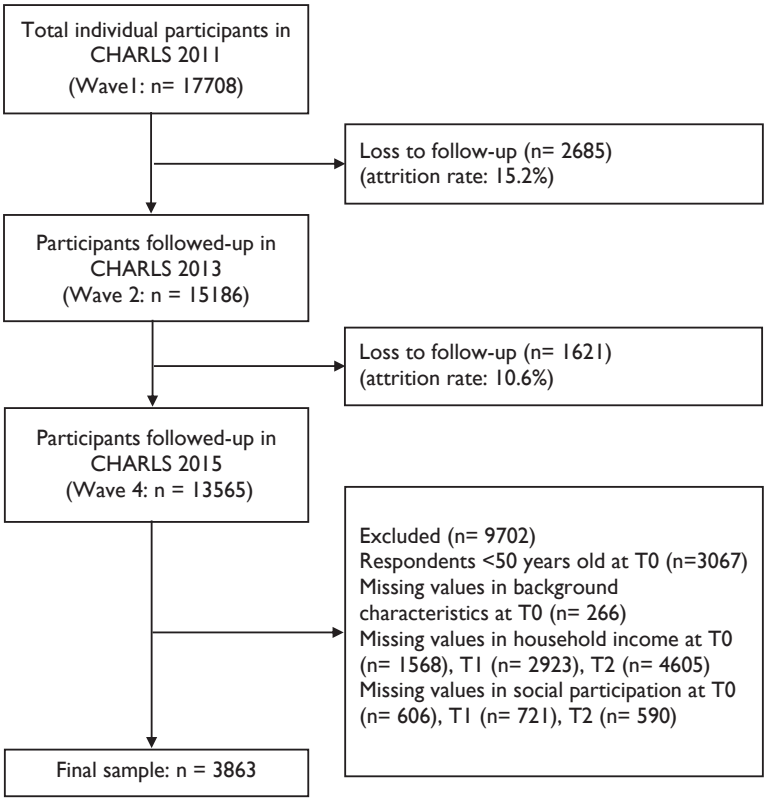

Figure 1. Flow chart on how the final sample (n= 3863) was derived.

2.2. Variables

2.2.1. Social participation

In CHARLS, the notion of social participation was operationalized by asking participants whether they had interacted with (a) friend(s); played mah jong, chess, or cards or gone to a community club; gone to a sporting event or participated in a social group or other type of club; engaged in the activities of a community-related organization; conducted volunteer or charity work; or attended an educational or training course in the past month. The social participation variable was dichotomized, with 0 indicating no participation in a social group or activity and 1 indicating participation in any of the social activities in the past month.

2.2.2. Household income per capita

In China, labor income, pension, and income transfer from family members are the most common types of income for older adults [42]. The total household income variable included a wide range of income sources, such as labor (e.g., wages), capital (e.g., self-employment, assets, and rental), pensions, government subsidies (i.e., welfare), and other household members, for the past year.

Following Wang and Tapia Granados [48], we calculated annual household income per capita by dividing the household income by the number of people in the household, followed by quintile ranking (lowest, lower, middle, higher, highest) based on wave 1 data, with the lowest income quintile serving as the reference group. Adjustment for the number of household members is important because a large proportion of older adults had more than one child due to the lack of strict enforcement of the national one child policy in rural China [49].

2.2.3. Covariates

Sociodemographic characteristics included in the analysis were age, gender (0 = female, 1 = male), marital status (0 = single [separated, divorced, widowed, or never married], 1 = married [married or partnered]), residence (0 = urban, 1 = rural), and level of education. Age (in years) was calculated according to the respondents' birth years. For the classification of educational levels, which is based on a simplified version of the 1997 International Standard Classification of Education codes [50] (www.uis.unesco.org); 1 indicated a low educational level (less than lower secondary education), 2 indicated a medium educational level (upper secondary and vocational training), and 3 indicated a high educational level (tertiary education).

2.2.3.1. Empty-nest status

Following Duan et al. [51], we defined empty-nester older adults as those who lived alone or with spouses/partners, but with no child (code = 1), and non–empty-nester older adults as those who lived with (a) child(ren) (code = 0).

2.2.3.2. (Multi)morbidity

Respondents were asked if they had ever had high blood pressure, diabetes, cancer, lung disease, heart problems, stroke, psychiatric problems, arthritis, dyslipidemia, liver disease, kidney disease, stomach/digestive disease, asthma, or memory-related disease. We constructed a (multi)morbidity variable with 0 indicating no chronic disease, 1 indicating one of these diseases, and 2 indicating multimorbidity (two or more diseases).

2.3. Statistical analysis

Descriptive statistics were calculated for all variables; continuous variables are reported as means with standard deviations (SDs), and dichotomous and categorical variables are reported as numbers and percentages. To investigate the longitudinal relationship between household income and social participation over time, we used a longitudinal linear regression approach, generalized estimating equations (GEEs) [52,53] with an exchangeable correlation structure. In GEE models, the associations between different variables at different time points were tested simultaneously [53]. This means that a regression coefficient obtained in GEEs is a 'combined (pooled)' coefficient which incorporates both within-subject (longitudinal effects) and between-subject relationships (cross-sectional effects) [54]. In other words, the obtained coefficients in GEEs are the average

value of individual regression lines, which reflect the 'population average' longitudinal relationship between the parameters involved in the model [53,55].

In our study, the relationships between household income and social participation were analyzed not only with the correction for time (three waves), but also adjusted for baseline potential confounders such as levels of education.

We first calculated crude odds ratios (ORs), and then adjusted for baseline covariates (individual sociodemographic characteristics, [multi]morbidity, and empty-nest status). Also, collinearity diagnostics revealed that the Variance Inflation Factor (VIF) did not exceed the recommended value of 10 [56]. Therefore, there were no collinearity problems among variables included in our study. The total number of observations involved in our analysis were 11589 observations (3863 individuals were repeatedly measured across three waves).

All statistical tests were two sided, with $p < 0.01$ considered to represent significance. The data were analyzed using SPSS software (version 24; IBM, Armonk, NY, USA).

3. RESULTS

Table 1 presents background characteristics of the study participants. At baseline, the mean age of the 3863 participants was 60.4 (SD = 7.03) years; 49.9% of the participants were female, 64.4 % lived in rural areas, and most (87.9%) respondents were married. Only 11.0 % of the respondents had finished high school or vocational school. About half of the respondents were empty-nesters, and 43.6% reported having two or more diseases. The percentage of respondents in the highest income category was greater at T1 (22.9%) than at T0 (19.5%), but had decreased at T2 (20.3%). Similarly, the percentage of socially active participants was greater at T1 (52.3%) than at T0 (47.1%), but had decreased at T2 (45.9%; Table 1).

Table 2 shows the results (crude odds ratios) of GEE models for the longitudinal associations between household income and social participation. Table 2 clearly shows that higher household income is positively associated with higher levels of social participation among older Chinese adults over time (without adjusting for covariates). Individuals in the lower income quintile had 1.155 times higher the odds of being socially active than among those in the lowest income quintile (95% confidence interval [CI] = 1.082–1.233, $p < 0.001$). The odds of participation in social activities were 1.217 times greater among people with incomes in the middle category than among those in the lowest income category (95% confidence interval [CI] = 1.137–1.302, $p < 0.001$). The odds of participation in social activities were 1.550 times greater among people with income in the higher income category than among those in the lowest income category 95% confidence interval [CI] = 1.451–1.656, $p < 0.001$). Overall, higher income levels were associated significantly with active social participation over time, with the highest quintile of income showing the strongest association (OR = 1.969, 95% confidence interval [CI] = 1.842–2.105, $p < 0.001$).

Table 1
Participant characteristics (*n* = 3863, 2011–2015).

	T0	T1	T2
Background characteristics			
Age in years, mean (SD, range)	60.4 (7.0, 50-89)		
Females, number (%)	1926 (49.9)		
Married, number (%)	3397 (87.9)		
Rural residence, number (%)	2487 (64.4)		
Level of education, number (%)			
Low	3440 (89.0)		
Medium	378 (9.8)		
High	45 (1.2)		
Empty-nest, number (yes, %)	1985 (51.4)		
(Multi)morbidity, number (%)			
No	1078 (27.9)		
1 disease	1100 (28.5)		
≥2 diseases	1685 (43.6)		
Total household income per capita, number (%)			
Lowest quintile	689 (17.8)	855 (22.1)	1202 (31.1)
Lower quintile	818 (21.2)	776 (20.1)	871 (22.5)
Middle quintile	828 (21.4)	624 (16.2)	454 (11.8)
Higher quintile	776 (20.1)	725 (18.8)	552 (14.3)
Highest quintile	752 (19.5)	883 (22.9)	784 (20.3)
Social participation (active, %)	1819 (47.1)	2021 (52.3)	1774 (45.9)

SD, standard deviation; T0, baseline; T1, 2-year follow-up; T2, 4-year follow-up.

Table 2
Effects of income on social participation in 2011–2015, as determined by a standard generalized estimating equation (*n* = 3863).

Total household income per capita	Crude odds ratio (95% CI)
Lowest quintile (ref)	-
Lower quintile	1.155 (1.082-1.233) **
Middle quintile	1.217 (1.137-1.302) **
Higher quintile	1.550 (1.451-1.656) **
Highest quintile	1.969 (1.842-2.105) **

CI, confidence interval. Significance levels: *$p < 0.01$, **$p < 0.001$.

Table 3 shows the GEE models' results for the longitudinal associations between household income and social participation (adjusted for baseline covariates). After adjusting for age, gender, marital status, residence, level of education, empty-nest status, and (multi)morbidity status, results show that higher levels of household income were still clearly associated with active social participation over time. The odds of participation in social activities were 1.158 times greater among people with incomes in the lower income category than among those in the lowest income

category (95% CI = 1.082–1.240, $p < 0.001$). The odds of participation in social activities were 1.168 times greater among people with incomes in the middle quintile than among those in the lowest income category (95% CI = 1.088–1.254, $p < 0.001$). The odds of participation in social activities were 1.469 times greater among people with incomes in the higher category than among those in the lowest income category (95% CI = 1.369–1.576, $p < 0.001$). The odds of participation in social activities were 1.726 times greater among people with incomes in the highest 20% than among those in the lowest income category (95% CI = 1.604–1.858, $p < 0.001$).

Table 3
Effects of income on social participation in 2011–2015, as determined by a standard generalized estimating equation ($n = 3863$).

		Social participation OR (95% CI)
Background characteristics		
Age in years, mean (SD)		0.990 (0.987-0.993) **
Gender (male)		0.983 (0.932-1.037)
Marital status (married)		0.848 (0.779-0.923) **
Residence (rural)		0.888 (0.838-0.941) **
Level of education		
	Low (ref)	-
	Middle	1.582 (1.440-1.737) **
	High	1.894 (1.539-2.331) **
Any child co-residence (yes)		0.913 (0.863-0.966) *
(Multi) morbidity		
	No (ref)	-
	1 disease	0.989 (0.924-1.058)
	≥2 diseases	1.069 (1.003-1.139)
Total household income per capita		
	Lowest quintile (ref)	-
	Lower quintile	1.158 (1.082-1.240) **
	Middle quintile	1.168 (1.088-1.254) **
	Higher quintile	1.469 (1.369-1.576) **
	Highest quintile	1.726 (1.604-1.858) **

OR, odds ratio; CI, confidence interval; SD, standard deviation. Significance levels: *$p < 0.01$, **$p < 0.001$. Analyses were adjusted for baseline age, gender, marital status, residence, educational level, empty-nest status, and (multi)morbidity.

Results displayed in Table 3 also reveal the associations between baseline background characteristics and social participation among older Chinese adults. At baseline, a one-unit increase in age was associated with a one percent decrease in the likelihood of being socially active (OR = 0.990, 95% CI = 0.987-0.993, $p < 0.001$). Less participation in social activities was reported by married people (OR = 0.848, 95% CI = 0.779–0.923, $p < 0.001$) and people living in rural areas

(OR = 0.888, 95% CI = 0.838–0.941, $p < 0.05$). The odds of being socially active were 1.582 times greater among people with middle education levels than among those with low levels of education (95% CI = 1.440-1.737, $p < 0.001$); the odds of being socially active were 1.894 times greater among people with high education levels than among those with low levels of education (95% CI = 1.539–2.331, $p < 0.001$); the odds of being socially active were 1.582 times greater among people with middle education levels than among those with low levels of education (95% CI = 1.440-1.737, $p < 0.001$). Participants living with children tended to be less socially active than empty-nesters (OR = 0.913, 95% CI = 0.863–0.966, $p < 0.01$). Gender and multimorbidity were not associated with social participation.

4. DISCUSSION

To our knowledge, this study is the first to investigate the longitudinal association between total household income and social participation among Chinese older people with consideration of empty-nest status, (multi)morbidity, and background characteristics. Its results contribute to our understanding of the longitudinal effects of income status on social participation among Chinese older people.

We found that higher total household incomes were associated with active social participation over time (in both adjusted and unadjusted GEE models), in line with the finding from a recent longitudinal study that poverty negatively influenced older Swedish adults' social participation, although that association was weak [15]. No longitudinal Chinese data are available for direct comparison with our results. We do note, however, that as Chinese culture is strongly collectivistic, the core unit of survival is the group [57]. In collectivist cultures, people depend on each other; individualistic cultures (e.g., those in Western countries) are characterized by more detachment from groups, more distance among people in groups, and greater self-reliance [58], with the main foci of individual uniqueness and independence [59]. The relationship between income and social participation has been the primary focus of only one cross-sectional Chinese study [42], which revealed no such association among Chinese older adults. In addition to our longitudinal design, our study extends Zhu and Walker's [42] research in several ways. First, those researchers focused only on pensions, which typically comprise about 25% of older adults' total incomes (although substantial rural/urban differences exist) [43]. In the present study, we included various main sources of income. Furthermore, Zhu and Walker [42] did not take empty-nest status and multi(morbidity) into account. These factors may significantly influence older adults' social participation [32,41] and deserve careful consideration, as they may introduce bias into the observed association between income and social participation. The present study demonstrated that income has a critical effect on the social engagement of older adults in a highly collectivistic culture over time.

Nevertheless, caution is warranted when interpreting our findings because not all social activities cost money. For example, since the last decade, public square dancing (*guang chang wu*) has become one of the most popular group-oriented activities in China, and it is openly supported by the Chinese government [60]. The majority of dancers are from low- and middle-class families [61]. Thus, for those in the lowest- and lower-income groups, lower incomes themselves might not be the most fundamental reason for the lack of social participation. Impoverished people's lesser social engagement may be related more to the "side effects" of being poor, such as depression [62,63]. We encourage the performance of additional studies to further explore the obstacles to social activity participation among poor people.

Besides, the decline in the proportion of respondents in the highest income category between T1 and T2 in this study seems to be at odds with China's rapid economic growth and overall increase in pensions over time [64]. Several possible explanations can be offered for this finding. First, despite the increase in pensions, people receive less money overall after retirement [65], many participants (likely including many blue-collar workers) may have reached retirement age at T2. Notably, the pension amount varies greatly among programs in China. For example, the Public Employee Pension program, established for civil servants and people working for public services, provides an average pension replacement after retirement of 80–90% of the pre-retirement wages, whereas the Basic Old Age Insurance program, which was established for formal employees in urban areas and began to include rural migrant workers in 2010, provides only 59.2% of employees' pre-retirement wages as pension [65]. Furthermore, the retirement age varies according to gender and occupation. For example, the official retirement age for men is 60 years; it is 50 years for women with blue-collar jobs and 55 years for those with white-collar jobs [65]. Finally, people's total household incomes may have been reduced by investment losses, which were included in the calculation of total household incomes in this study.

We found that significant differences were observed among some background characteristics (age, marital status, residence, level of education, empty-nest status) and social participation among older adults in China.

As reported in previous studies [35,36,66], older age was associated with inactive social participation among older Chinese adults in this study. Ageing would enhance the risk of shrinking social networks because of the death of peers in the later years of life [35,36]. Also, social participation may not be a priority of older adults anymore [67].

As expected, and in line with the results of a cross-sectional Chinese study [32], we found that living with children negatively impacted Chinese older people's social participation over time. In traditional Chinese culture, older adults are expected to engage in family activities, such as taking care of young children [32], which limits non–empty-nesters' time for social activities outside the home. In addition, research has shown that the majority of older Chinese non–empty-nesters have lower incomes and depend financially on their children, which also restricts engagement in social activities [32].

In this study, married status was associated negatively with social participation among Chinese older adults. Previous research has yielded mixed findings, reflecting the complexity of this relationship; a positive association [33] and a lack of association [34] among older adults have been reported. Married people may be more likely to participate in social activities because participation with their spouses/partners is more attractive than participation alone [33], but conversely they may need to care for their spouses at home [68]. There is no simple explanation for the observed negative association between marriage and social participation in this study. In traditional Chinese culture, ageing individuals are expected to take on a contributory family role [69]. The emphasis on family needs over individual needs has been long embedded in Chinese culture [70]. For instance, caregiving to close family members, such as spouses, in older age is quite common, and indeed obligatory, in China [71]. A recent Chinese study showed that family responsibility [e.g., taking care of a spouse or (grand)child] can be a barrier to older adults' social participation [42]; caregiving usually requires considerable time and effort [73,74].

The negative association of rural residence with social participation observed among Chinese older people in this study is consistent with previous reports of less social participation among older rural residents than among their urban counterparts in China [39,40]. Under China's household registration system (*hukou*), rural and urban residents form distinct social classes [40]. Infrastructure, public facilities, community services, and volunteer organizations are much better developed and more accessible in urban China [75]. As a consequence, opportunities for older adults' social participation differ substantially between rural and urban locations [40]; consistently, Lancee & Van de Werfhorst [14] argued that the availability of resources determines participation. In addition, older rural residents in China are usually less financially secure; the average pension for this group in 2010 was approximately USD 13.6/month, which is not nearly sufficient to cover daily needs [76]. Because of this lack of income security, Chinese older people in rural areas must continue to work in old age [40], and likely allocate their time to work instead of social/leisure activities [77]. This situation is likely to be context related, as full-time employment was associated negatively with social participation in Germany [78], whereas no association was found in the Netherlands [79].

In line with findings from high-income countries [79,80,81], higher educational levels were associated significantly with social participation in this study. According to Gesthuizen [38], the influence of education is quite persistent, and may influence people's attitudes toward life into old age. Relative to lower levels, higher education levels are also associated with greater tolerance of social norms and interest in social matters among older adults [38]. In addition to being more likely to engage in healthy behaviours such as social participation, highly educated people are more likely to have stronger social support networks, which encourages their involvement in social activities [80].

4.1. Implications and suggestion for future research

We found that higher income levels were associated positively with active social participation over time among older Chinese people. This finding has important implications for income-related policies seeking to improve social participation. We suggest that policies be developed to protect or increase pension income for older Chinese citizens, especially more vulnerable individuals who live in rural areas and have lower levels of education. Although China has made great efforts to optimize its pension system, the average benefit level is still too low to ensure older people's basic living needs [82]. In general, pension income accounts for only about one-fourth of an older person's total income. As a consequence, a majority of older people, and especially those in rural areas, remain financially dependent on their family members [83]. However, different pension realities coexist in China. Thus, we need to acknowledge that the balancing of pension benefit levels and the coverage amount is challenging. Alternatively, the government could create jobs for older adults or re-evaluate the retirement age, creating more flexibility for those who are still willing to work. This study serves as a first step in understanding the pivotal role of total income among Chinese older adults. We encourage further research to inform the development of policies to enhance older adults' income in sustainable ways.

4.2. Strengths and limitations

The present study has several strengths. First, it is the first study to examine the relationship between income and social participation among Chinese older people over time. Perspectives on and patterns of social participation can differ markedly between collective and individualistic societies; our findings extend our understanding of the longitudinal effects of income on social participation in a strongly collectivist society. Second, our calculation of total household incomes included a wide range of income types for Chinese older adults, which provided a complete picture of participants' actual income status. Third, in addition to its longitudinal design, our study was conducted with a large and geographically diverse sample. Moreover, we included critical potential confounders (e.g., multimorbidity and empty-nest status) in the analytical model to minimize potential bias.

This study has several limitations. First, income might have been underreported, which might introduce bias into the analysis. Significant underreporting of income (e.g., to tax authorities) has been detected among high-income individuals [84] and self-employed people (by approximately 25%) [85]. However, we used a broad measure of income to minimize the potential risk of underreporting, and we believe that this risk did not affect our general conclusions. Second, we use a dichotomized social participation variable constructed by RAND; although this variable includes six domains of social activity, it may not represent all social activities in China. In addition, we did not measure the frequency of social participation, which should be incorporated into future research. Further, GEEs pooled together both longitudinal and cross-sectional associations into one regression coefficient, which is a strength of this statistical technique. The coefficients obtained from a GEE analysis includes both a between-subject and a within-subject part. The latter

reflects the relationship between changes. However, this feature of GEEs also limits the interpretation of the results in the meantime because we are not able to separate the between-subject and a within-subject parts. Another limitation is that we lacked information on the severity of diseases included in the assessment, which might have influenced the levels of social participation. In addition, participants may have underreported chronic diseases that carry social stigma (e.g., psychiatric problems) in the face-to-face interviews.

5. CONCLUSIONS

Taken together, the findings of this study indicate that higher levels of total household income were associated positively with social participation over time among older adults in China. In addition, social participation was affected significantly by background characteristics (e.g., non-married status, urban residence, higher educational level, and empty-nest status).

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6

Longitudinal Health Behaviour Patterns Among Chinese Adults Aged ≥ 50 Years and Their Associations with Trajectories of Depressive Symptoms Over Time

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ABSTRACT

Background: Whether different longitudinal patterns of multiple health behaviours are associated with different trajectories of depressive symptoms is not well understood.

Purpose: To identify distinct longitudinal patterns of multiple health behaviours and their associations with trajectories of depressive symptoms among people aged ≥ 50 years in China.

Methods: We used longitudinal data from the Harmonized China Health and Retirement Longitudinal Study (three waves, 2010–2015; *n* = 8439). We performed latent class analyses to identify distinct patterns of multiple health behaviours at three timepoints. We estimated longitudinal random-effects models to predict differences in depressive symptoms trajectories by health behaviour class.

Results: The best-fitting model had five latent classes, all of which showed strong behavioural stability over time: 1) socially active, moderately physically active non-smokers (29.4%); 2) socially inactive, physically active non-smokers (22.3%); 3) socially and physically inactive non-smokers (17.9%); 4) socially inactive, moderately physically active smokers (14.6%); and (5) socially active, moderately physically active smokers (14.2%). All classes characterized by low social participation (classes 2–4) were associated with significantly higher predicted depressive symptom scores compared with the other classes (1 and 5).

Conclusions: Longitudinal behavioural patterns involving low probabilities of social participation were associated with more depressive symptoms. This overshadowing effect suggests that the damage caused by being socially inactive may render the effects of co-existing (un)healthy behaviours meaningless. The stability of the patterns of multiple health behaviours across survey waves suggests that interventions are needed earlier in life.

BACKGROUND

Depression has become the single greatest cause of disability and a major contributor to disease burden globally, affecting 264 million people [1]. Depression is not only detrimental to individuals' well-being, but also incurs substantial medical costs [2] and affects families and society as a whole [3]. The risk of depression is greater among older adults in China than among people in other East Asian countries [4]. Depressive symptoms have been associated with modifiable unhealthy behaviours, such as physical inactivity [5]. Given that people in China tend to feel ashamed to seek help for depressive symptoms [6], strategies that involve lifestyle modification may be particularly promising in efforts to counter later-life depression in the Chinese context.

In the past two decades, researchers have begun to recognize that health behaviours do not occur in isolation; instead, they are interrelated and cluster together [7–10]. Consequently, the number of studies focusing on multiple health behaviours has increased rapidly and such research is considered to represent the future of preventive medicine [11]. The investigation of multiple health behaviours is important for several reasons. First, clustered behaviours posing health risks may have synergistic effects on health outcomes [8, 12] that are more potent than the behaviours' individual effects [9]. Second, the phenomenon of "health behaviour overshadowing," in which the detrimental effects of certain unhealthy behaviours are so profound that they render other health behavioural dimensions largely meaningless, seems to be overlooked [13]. For example, Shaw and Agahi [13] found that the harmful effects of physical inactivity were not evident among smokers.

Although several studies have involved the combined consideration of multiple health behaviours, most researchers have used an additive approach (e.g., [14, 15]). Typically, an additive index is employed, with one point added for unhealthy behaviour in each of the dimensions considered. This approach entails the implicit assumptions 1) that every type of (un)healthy behaviour has a similar effect on the outcome considered and 2) that (un)healthy behaviours are independent of each other, i.e., that the effect of a particular unhealthy behaviour is not contingent on other health behavioural dimensions. Consequently, potential synergistic or overshadowing effects cannot be detected. Hence, an approach that considers particular patterns or clusters of health behaviours is called for. In a few studies, associations of patterns or clusters of multiple health behaviours with depression and mental health have been examined. For example, Oftedal et al. [16] used latent class analysis (LCA) to identify patterns of multiple health behaviours and found that people with high-risk behaviours in all aspects (insufficient physical activity, long daily sitting time, high-risk drinking, high-risk dietary behaviours) had the greatest odds of experiencing mental distress. However, studies of this type [16–18] have provided only snapshots of such associations because of their cross-sectional designs. Not only the influence of patterns of multiple health behaviours on depressive symptoms, but also the longitudinal effects of these patterns, needs to be examined concurrently because some behaviours show no observable health benefit unless they are maintained for certain periods of time [19]. For example, although physical exercise appears to effectively relieve depressive mood, this benefit may require long-term maintenance of

this behaviour [20]. In addition, no previous study of health behaviour patterns has included the examination of social participation, which is arguably an important health behaviour because it increases community engagement and social interaction [21], in turn protecting against depressive symptoms in older adults [22, 23]. Furthermore, trajectories of health behaviour development over time may differ among ethnic groups [24]. Little is known about the longitudinal trajectories of multiple health behaviours, or the effects of different longitudinal health behaviour patterns on depressive symptoms, in middle-aged and older adult Chinese populations.

The identification of particular longitudinal combinations of health behaviours that have detrimental effects on depressive symptoms is of practical relevance. For example, policymakers can weigh the relative importance of various health behaviours and prioritize their focus on particular risky behaviour combinations, which ultimately provides valuable information to aid health professionals' development of optimal health promotion strategies. Thus, the aims of this study were to identify distinct longitudinal patterns of multiple health behaviours (smoking, physical activity, and social participation), and associations of different patterns with trajectories of depressive symptoms, in a population-based sample of people aged ≥ 50 years in China. We focused on smoking, physical activity, and social participation because they are known to be associated separately with depressive symptoms [5, 25], but little is known about whether their longitudinal combinations are associated with depressive symptom trajectories. As three health behaviours were considered at three timepoints in this study, with a vast number of health behaviour combinations potentially observed, we adopted the data-reduction technique of LCA to identify the most meaningful longitudinal behaviour patterns, which best represented all possible combinations in the sample [16].

METHODS

Data Source and Study Population

We used data from the Harmonized China Health and Retirement Longitudinal Study (CHARLS), a population-based survey of non-institutionalized middle-aged and older individuals in China [26]. The baseline (wave 1) survey was conducted between May 2011 and March 2012 with 17,708 participants, and follow-up surveys were conducted in 2013 (wave 2) and 2015 (wave 4) [27]. Trained interviewers conducted face-to-face interviews. The CHARLS sampling strategy has been described in detail elsewhere [27]. In this study, we analyzed Harmonized CHARLS data from waves 1, 2, and 4. As wave 3 was a special life-history survey that did not include the collection of data on health behaviour or mental health variables, wave 3 data were not included in our analysis. More detailed information can be found at www.g2ageing.org.

Exclusion criteria

Respondents were excluded from the present analysis for the following reasons: age < 50 years at baseline; inconsistent age information across waves (e.g., younger reported age than in a previous

wave); missing value for any covariate of interest (age, gender, residence, educational level, marital status, number of children, co-residence with a child) in at least one wave; and missing 10-item Centre for Epidemiologic Studies Depression Scale (CES-D 10) score in at least one wave. The procedure used for sample selection is summarized in Fig. 1.

We applied the age threshold of 50 years to focus on middle-aged and older adults, based on previous studies [13, 28] and in accordance with the World Health Organization's Study on Global Ageing and Adult Health [29]. The final sample comprised 25,317 observations for 8439 respondents.

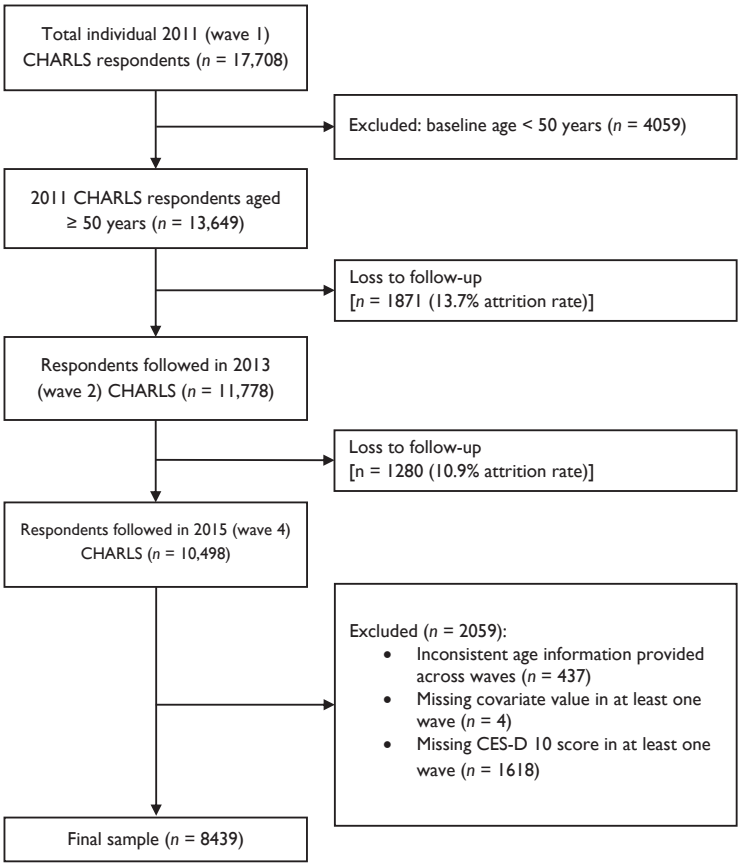

Fig. 1. Flow chart of sample selection. CHARLS, China Health and Retirement Longitudinal Study; CES-D 10, 10-item Centre for Epidemiologic Studies Depression Scale.

Measures

Manifest items

Physical activity, social participation, and smoking served as manifest items in the LCA. The manifest items were used to identify the underlying (latent) health behaviour patterns.

Physical activity

Respondents were asked whether they performed vigorous physical activity (VPA) or moderate physical activity (MPA) for at least 10 minutes every week ("yes" or "no"). "Yes" responses prompted the interviewers to ask respondents on how many days they performed at least 10 minutes of VPA and MPA in a usual week (0–7). VPA was defined to include activities that made respondents breathe much harder than normal, such as heavy lifting, digging, plowing, aerobics, fast bicycling, and cycling with a heavy load. MPA was defined to include activities that made respondents breathe somewhat harder than normal, such as carrying a light load, bicycling at regular pace, or mopping the floor. In this study, we dichotomized the physical activity variable, classifying respondents as physically active (MPA/VPA on ≥5 days/week) and physically inactive (MPA/VPA on <5 days/week).

Social participation

In the CHARLS, the social participation variable was operationalized by asking participants whether they had done any of the following in the month prior to the survey: 1) interacted with (a) friend(s); 2) played ma-jong, chess, or cards or gone to a community club; 3) gone to a sporting event or participated in a social group or other type of club; 4) engaged in the activities of a community-related organization; 5) conducted volunteer or charity work; and 6) attended an educational or training course. The social participation variable was dichotomized to reflect whether an individual is socially active, with 0 indicating that the respondent did not participate in any listed social group or activity and 1 indicating that the respondent participated in any of the listed social activities in the past month [30].

Smoking

We used respondents' current smoking habits to evaluate smoking status in this study. A value of 0 was assigned to respondents who never smoked or were ex-smokers, and a value of 1 to the respondents who were current smokers. Notably, wave 2 information on smoking was missing for 2098 respondents, the majority of whom reported the same smoking status in waves 1 and 4. Thus, we coded smoking status in wave 2 as in waves 1 and 4 in these cases.

Time-varying and time-invariant covariates

Based on previous studies, the availability of CHARLS data, and known associations with health behaviours and depression [31–34], age, gender, residence, level of education, marital status, number of children, and co-residence with a child were included as potential confounders. Time-varying covariates were age (interview date – birth date), residence (urban /rural), marital status (single [separated, divorced, widowed, or never married]/not single [currently married or cohabiting]), co-residence with at least one child (no/yes), and number of living children (0/1/2/3/≥4). Time-invariant covariates were gender (male/female) and educational level (higher [upper secondary school or more]/lower [less than lower secondary school]).

Distal outcome

Depressive symptoms, assessed using the CES-D 10 [30], made up the distal outcome in this study. The respondents were asked how often they had experienced each of the following in the past week: 1) "I was bothered by things that do not usually bother me," 2) "I had trouble keeping my mind on what I was doing," 3) "I felt depressed," 4) "I felt hopeful about the future," 5) "I felt everything I did was an effort," 6) "I felt fearful," 7) "My sleep was restless," 8) "I was happy," 9) "I felt lonely," and 10) "I could not get 'going'." Item responses were provided on a four-point scale ranging from 0 ("rarely or none of the time") to 3 ("most or all of the time"). Responses to the positively worded items 4 and 8 were reverse coded before analysis. Total CES-D 10 scores range from 0 to 30, with higher scores indicating higher levels of depressive symptoms. The CES-D 10 has demonstrated sufficient reliability and validity among community-dwelling older adults in China [35], and showed good reliability for all three CHARLS waves in this study (Cronbach's α, 0.777–0.807).

Statistical Analysis

The analysis performed for this study consisted of multiple steps. First, we performed LCA to identify distinct longitudinal health behaviour profiles. LCA identifies mutually exclusive and exhaustive unobserved classes in a population via a set of manifest items [36–38], whereby between-class variation is maximized and within-class variation is minimized [39]. Specifically, we aimed to identify latent profiles underlying manifest information about physical activity, smoking, and social participation across the three CHARLS waves. We began with a two-class solution model, and added classes until we observed no further improvement of model fit. Identification of the optimal number of classes was based on the lowest values of the Bayesian information criterion (BIC), which favors more parsimonious models, as it penalizes model complexity relatively strongly [40]. The BIC is the most widely used statistic in LCA model selection [41]. Each empty model was estimated 500 times with different initial values. We did not exclude respondents with missing information on health behaviour variables because the expectation-maximization algorithm used in LCA enables latent class model estimation even when manifest item information is missing [40]. The underlying assumption that information is Missing At Random (MAR) [42] holds, because, as described earlier, CHARLS questions on physical activity were by design only asked to a randomly selected subsample [30].

After determination of the optimal number of latent classes, the latent class with the greatest posterior probability, i.e., the class that corresponded most strongly to the observed health behaviour pattern, was stored for each respondent [43, 44]. We then estimated longitudinal random-effects models of depressive symptoms by wave, whereby we allowed the effect of wave to vary as a function of the recorded latent health behaviour class. These models, adjusted for the potential confounders, were used to examine associations between health behaviour classes and levels of depressive symptoms.

To identify transition probabilities across time, we performed Latent Transition Analysis. A two-class LTA model was selected by entropy (see Supplementary Table 1), to describe the latent class transition across waves. Furthermore, based on the results of Likelihood Ratio Test, we imposed measurement

invariance in our LTA model [45]. Next, we compared the model of LTA with LCA by comparing the BIC of those two models (Supplementary Table 2). The fit statistics indicated that the LCA model was a more parsimonious model than the model of LTA but also provided a better fit; notably, individual-level clustering was controlled for in the LCA model to adjust the standard errors of repeated measures: since repeated measure were nested within individuals, controlling for intra-individual variability took into account that repeated measures were not independent from each other.

LCA was performed using the poLCA package in R version 3.6.1 (R Foundation for Statistical Computing). Random effects modeling was performed using Stata software version 15.1 (Stata Corporation, Collage Station, TX, USA). We performed the LTA model, comparing the LCA model and the LTA model using Mplus version 8.3 (Muthén & Muthén, 2012-2019).

RESULTS

Sample Characteristics

The respondents were aged 50–100 (mean, 61.1; standard deviation, 7.3) years at baseline. More than half (50.8%) of the respondents were female at baseline. The proportion of physically inactive respondents increased and that of current smokers decreased over time. The proportion of socially inactive respondents and the mean CES-D 10 score had declined at the time of wave 2 and then increased again at the time of wave 4 (Table 1).

Identified Latent Classes

Models with two to six latent classes were estimated. A five-class solution best fit the data (BIC, 63,092.80 vs. 63192.59 [four-class solution] and 63120.32 [six-class solution]); goodness-of-fit indices are provided in Supplementary Table 3. None of the five classes identified (Fig. 2) was characterized by a pronounced change in health behavioural pattern over time.

Members of class 1 (29.4% estimated prevalence), characterized as socially active, moderately physically active non-smokers, had a very low probability of smoking, high probability of being socially active, and moderate (50%) probability of being physically active. Class 2 members (22.3% estimated prevalence), characterized as socially inactive, physically active non-smokers, had low probabilities of participation in social activities and smoking, but a high probability of being physically active. People in class 3 (17.9% estimated prevalence), characterized as socially and physically inactive non-smokers, had low probabilities of being current smokers, being physically active, and participating in social activities. Those in class 4 (14.6% estimated prevalence), characterized as socially inactive, moderately physically active smokers, had a high probability of smoking, moderate (60–70%) probability of being physically active, and low probability of being socially active. Members of class 5 (14.2% estimated prevalence), characterized as socially active, moderately physically active smokers, had very high probabilities of smoking and being socially active, and a moderate probability of being physically active.

Table 1. Sample characteristics (*n* = 8439)

Characteristic	Wave 1	Wave 2	Wave 4
Covariates			
Age (years), mean (SD)	61.1 (7.3)	63.1 (7.3)	65.2 (7.4)
Gender (female), *n* (%)	4287 (50.8)		
Educational level, *n* (%)			
Less than lower secondary school	7612 (90.2)		
Upper secondary school or more	831 (9.8)		
Residence (rural), *n* (%)	5453 (64.6)		
Marital status (married/partnered), *n* (%)	7368 (87.3)	7221 (85.5)	7028 (83.2)
Number of living children, *n* (%)			
0	187 (2.2)	150 (1.8)	80 (0.9)
1	1157 (13.7)	1008 (11.9)	859 (10.2)
2	2721 (32.2)	2646 (31.4)	2634 (31.2)
3	2129 (25.2)	2192 (26.0)	2213 (26.2)
4+	2245 (26.5)	2443 (29.0)	2653 (31.5)
Co-residence with a child, *n* (%)	4559 (54.0)	3852 (45.6)	4216 (50.0)
Manifest items			
Physical activity, *n* (%)			
Inactive	1506 (42.7)	1521 (49.2)	2117 (51.7)
Active	2025 (57.3)	1571 (50.8)	1980 (48.3)
Missing[a]	4908	5347	4342
Social participation, *n* (%)			
Inactive	4535 (53.7)	4057 (48.1)	4621 (54.8)
Active	3901 (46.2)	4381 (51.9)	3821 (45.2)
Missing	4	1	1
Current smoker, *n* (%)			
Yes	2697 (32.0)	2374 (29.5)	2367 (28.1)
No	5740 (68.0)	5279 (70.5)	6065 (71.9)
Missing	2	386	7
Distal outcome variable			
CES-D 10 score (range 0–30), mean (SD)	8.6 (6.4)	8.0 (5.8)	8.4 (6.5)

No data on age, gender, residence, educational level (all time-invariant), or marital status were missing. [a]Data collected for a randomly selected subsample (half of the total sample).
SD, standard deviation; CES-D 10, 10-item Centre for Epidemiologic Studies Depression Scale.

Table 2 describes the probabilities of latent class transit from class to class across waves. Results of LTA showed that transition probabilities of classes across waves were quite low. For instance, the probability of transitioning from class 1 (wave 1) to class 2 (wave 2) was 0.094; probability of transitioning from class 2 (wave 2) to class 1 (wave 4) was 0.007 (Supplementary Table 4). Overall, these results indicated behaviour patterns were quite stable across time.

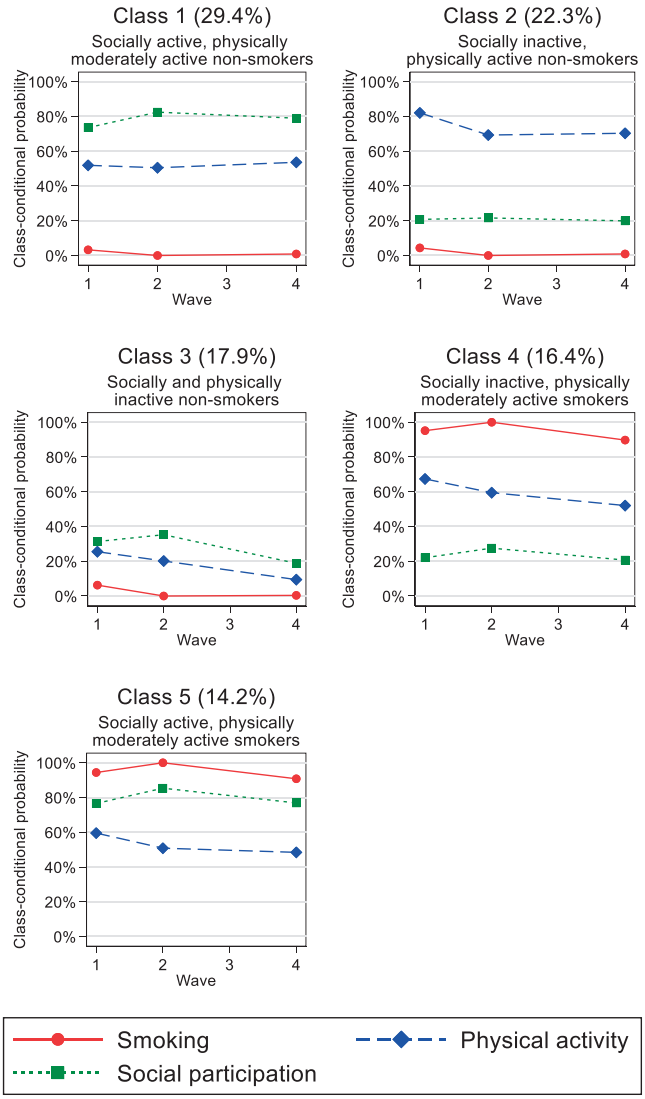

Figure 2. Five multiple health behaviour patterns and their trajectories across three CHARLS waves. Class-conditional probability denotes the probability that a class member answered "yes" to a question about behaviour (e.g., a member of class 1 has nearly 0% probability of being a smoker and 50% probability of being physically active). CHARLS, China Health and Retirement Longitudinal Study.

Relationships Between Classes and Depressive Symptoms

In the adjusted longitudinal random-effects models, the predicted CES-D 10 score across CHARLS waves was lowest for class 1, slightly higher for class 5, and highest for classes 2–4 (Fig. 3, Supplementary Table 4). CES-D 10 scores differed significantly between classes 2–4 and class 1 in all waves, and between classes 2–4 and class 5 in waves 1 and 4; no difference was observed among classes 2–4 in any wave (Supplementary Fig. 1).

Table 2. Transition probabilities of the two-class LTA model across waves

	Latent classes status	
Probability of transitioning to → ***Conditional on wave 1 (Rows) latent classes status ↓***	***wave 2 latent classes (Columns)***	
	Class 1	Class 2
Class 1	0.906	0.094
Class 2	0.024	0.976
Probability of transitioning to → ***Conditional on wave 2 (Rows) latent classes status ↓***	***wave 4 latent classes (Columns)***	
	Class 1	Class 2
Class 1	0.901	0.099
Class 2	0.007	0.993

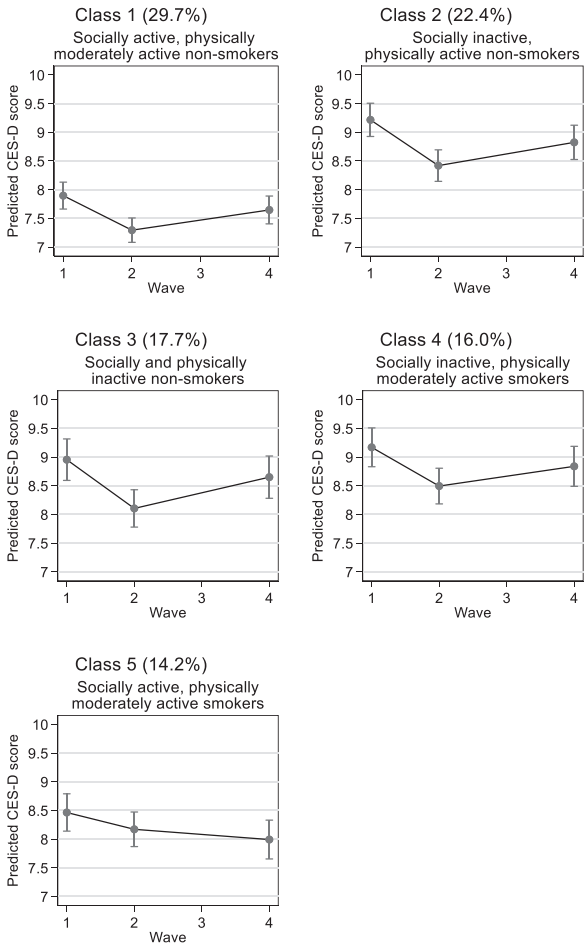

Figure 3. Predicted CES-D 10 score trajectories by health behaviour class. Analyses were adjusted for age, age squared, gender, residence, educational level, marital status, and co-residence with children. Bars represent robust standard errors. CES-D 10, 10-item Centre for Epidemiologic Studies Depression Scale.

DISCUSSION

In this study, five distinct longitudinal patterns of (un)healthy behaviours were identified in a population-based sample of people aged ≥ 50 years in China. All of these patterns were stable over time. Three of the behaviour patterns were associated with significantly higher CES-D 10 scores, reflecting more depressive symptoms, than were the other two patterns. These findings deepen our knowledge of the most representative longitudinal combinations of multiple health behaviours among middle-aged and older adults in China, which is an essential first step in understanding whether and how longitudinal behavioural patterns shape depressive symptom trajectories. Policymakers and health professionals may prioritize their focus on particular behaviour combinations associated with more depressive symptoms when developing optimal health promotion strategies.

In accordance with previous findings that some people engage simultaneously in risky and healthy behaviours [46, 47], all of the patterns identified in this study are combinations of risky (e.g., smoking) and healthy (e.g., being socially active) behaviours. For example, people in class 4 had a high probability of smoking and were moderately likely to be physically active, but unlikely to be socially active. Relationships among health behaviours are complex [46], involving psychological, physiological, and social factors [48]. However, explanation of the mechanisms underlying clustered health behaviours falls beyond the scope of the current study and requires deeper investigation.

Although middle-aged and older adults can benefit from positive health behaviour changes [49, 50], we observed stability of all detected health behaviour patterns across four years in this study. This result is consistent with the finding that health behaviour stability was more common than instability in a 25-year study conducted with U.S. adults aged ≥ 25 years [51]. Empirical findings indicate that many behaviours posing health risks are initiated during earlier life stages [52, 53], and that healthy and unhealthy behaviours stabilize in adolescence and adulthood [47, 51, 54]. Thus, we suggest that health behaviour interventions among adolescents and young adults are needed before unhealthy behaviours become stabilized.

Our finding that different longitudinal patterns of multiple health behaviours were associated with different depressive symptom severities is in line with Verger and colleagues' [17] cross-sectional findings. We observed that patterns entailing high probabilities of being socially inactive were associated significantly with more depressive symptoms, reflecting the overshadowing effect [13]; the harmful effects of being socially inactive might be especially detrimental to depression status in a way that overshadows the impacts of co-existing health behaviours. The vital role of social participation in the amelioration of depressive symptoms has not been documented as well as those of other health behaviours among older adults from a longitudinal perspective. Thus, our findings contribute to the bridging of this research gap and indicate the potential importance of social participation for the reduction of depressive symptoms among middle-aged and older adults in China. More research is needed to improve our understanding of the overshadowing effect of social participation relative to other (un)healthy behaviours.

Study Strengths and Limitations

Significant strengths of this study are the use of LCA and LTA to model middle-aged and older adults' multiple health behaviours and the use of a longitudinal design, which enabled the identification of distinct and highly representative patterns of health behaviours among all possible combinations over time. In addition, the assessment of depressive symptoms in this sample using the CES-D 10 helps to diminish the well-known issue of underreporting regarding mental illness among Chinese adults [55], given the strong social stigmatism of mental illness in Chinese culture. The CES-D 10 questions are nonintrusive and easier for respondents to answer, improving the ability to detect actual depressive status [56].

The findings of this study should be viewed in light of several limitations. First, respondents' self-reporting for all health behaviour variables may have introduced bias [3]. Researchers have reported that respondents may provide socially desirable answers to questions regarding health behaviours [8]. Second, all health behaviour variables were dichotomized in this study, which may have influenced the findings to some extent [57]. More detailed measurement, such as the consideration of smoking intensity (i.e., the amount/frequency of cigarettes/tobacco smoked) or social participation intensity, might yield different patterns [13, 51]. Third, heavy smokers are known to have higher risks of earlier death [58], but our study did not include heavy smokers who had died before the age of 50 years or between CHARLS waves. Thus, our findings might underestimate the influence of heavy smoking on depressive symptoms. Finally, we could not infer the causality of the associations between longitudinal health behaviour patterns and depressive symptom trajectories; further research is needed to clarify the causality of these relationships.

CONCLUSIONS

Our empirical findings indicate that health behaviour patterns entailing high probabilities of social inactivity are associated with more depressive symptoms among middle-aged and older adults in China. Furthermore, the impacts of social inactivity may overshadow the effects of co-existing (un)healthy behaviours. Thus, social participation plays a vital role in the reduction of depressive symptoms in this population. In addition, the stability of the patterns of multiple health behaviours over time suggests that behavioural interventions are needed earlier in life. These findings should be considered when developing health promotion strategies that aim to reduce depressive symptoms among middle-aged and older adults in China.

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Supplementary Table 1. Fit statistics for latent classes at each wave

Number of classes	BIC	Entropy	LL	BLRT(p)	LMR(p)
Wave 1					
1	27064.920	-	-13518.899 [a]	-	-
2	27073.379	**0.729**	-13505.048 [a]	-13518.899 (<.001)	-13518.899 (<.001)
3	27109.042	0.194	-13504.798	-13505.048 (0.436)	-13505.048 (1.000)
Wave 2					
1	25764.379	-	-12868.628 [a]	-	-
2	25782.407	**0.426**	-12859.561 [a]	-12868.628 (<.001)	-12868.628 (<.001)
3	25814.799	0.411	-12857.676 [a]	-12859.561 (.333)	-12859.561 (.052)
Wave 4					
1	27333.968	-	-13653.423 [a]	-	-
2	27338.117	**0.757**	-13637.416 [a]	-13653.423 (<.001)	-13653.423 (<.001)
3	27372.975	0.604	-13636.764 [a]	-13637.416 (.500)	-13637.416 (.341)

Note: BIC=Bayesian information criterion; BLRT= bootstrapped likelihood ratio test, LL= log-likelihood; LMR=Lo-Mendel-Rubin likelihood ratio test; [a] repeated log-likelihood.

Supplementary Table 2. Fit statistics for model of LCA and LTA

	LCA*	LTA
LL	-31324.909 (repeated twice)	-32515.307
No. of parameters	49	11
Entropy	0.659	0.985
BIC	63092.808	65130.061

Note: BIC=Bayesian information criterion; LCA= Latent class analysis; LTA=Latent transition analysis; LL= log-likelihood. * Individual clustering was controlled in LCA model to adjust for stand errors.

Supplementary Table 3. Criteria to assess model fit for LCA number of classes

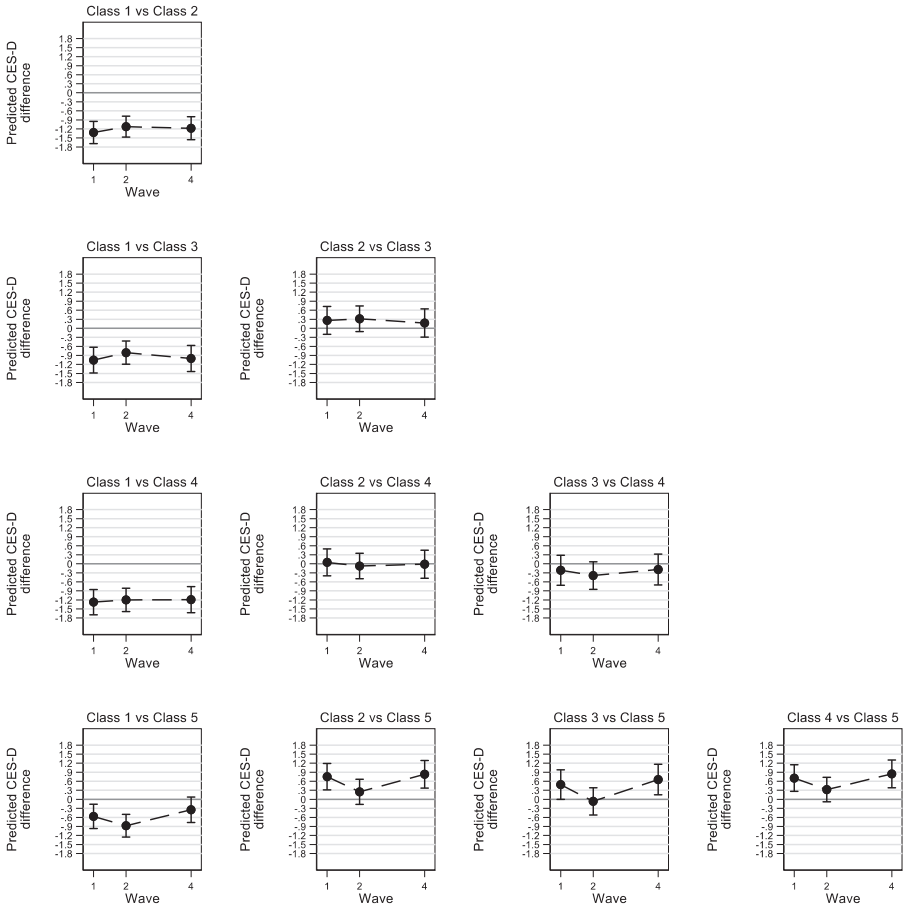
Number of classes	G^{2a}	DF	χ^{2b}	AIC	BIC
2	858.2892	492	1013.167	64917.93	65051.7
3	589.1912	482	643.4836	63548.31	63752.49
4	511.9645	472	518.0512	62918.00	63192.59
5[c]	396.1818	462	388.1353	62747.81	**63092.80**
6	367.4376	452	329.3294	62704.92	63120.32

[a]Reflects the likelihood ratio/deviance; [b]reflects goodness of fit; [c]best-fitting model.
DF, degrees of freedom; AIC, Akaike information criterion; BIC, Bayesian information criterion.

Supplementary Table 4. Associations of variables with CES-D 10 scores, as determined by random-effects models (full results on which Fig. 2 is based)

Variable	Coefficient	SE
Age (years)	0.35***	0.08
Female gender	2.09***	0.13
Rural residence	1.42***	0.11
Lower education	1.27***	0.16
Married/partnered	–1.55***	0.16
Co-residence with child	0.08	0.08
Number of children		
0	0.24	0.34
1	–0.33*	0.15
2 (ref)	0	–
3	0.29*	0.12
4	0.54***	0.14
Comparison of classes over CHARLS waves		
Class 1, wave 1 (ref)	–	–
Class 1, wave 2	–0.60***	0.12
Class 1, wave 4	–0.25	0.13
Class 2, wave 1	1.32***	0.19
Class 2, wave 2	0.52**	0.18
Class 2, wave 4	0.93***	0.19
Class 3, wave 1	1.06***	0.22
Class 3, wave 2	0.21	0.20
Class 3, wave 4	0.75***	0.22
Class 4, wave 1	1.27***	0.21
Class 4, wave 2	0.60**	0.20
Class 4, wave 4	0.94***	0.22
Class 5, wave 1	0.57**	0.21
Class 5, wave 2	0.27	0.20
Class 5, wave 4	0.10	0.22
Constant	-4.97	2.69

The full model was adjusted for age, gender, residence, level of education, and marital status.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
SE, standard error; CHARLS, China Health and Retirement Longitudinal Study.



Supplementary Fig. 1. Predicted between-class differences in the CES-D10 score by CHARLS wave, with 95% confidence intervals. CES-D 10, 10-item Centre for Epidemiologic Studies Depression Scale; CHARLS, China Health and Retirement Longitudinal Study.

7

General Discussion

CHAPTER 7

General Discussion

Although increased life expectancy is a significant achievement of modern human society [1], it presents the challenge of a need to support successful ageing, especially in countries with massive ageing populations, among which China is the most prominent [2]. Maintaining health-promoting behaviours, a good quality of life (QoL), and health outcomes are essential elements of successful ageing [3,4]. Nevertheless, there are scant studies regarding the (longitudinal) relationships of factors such as socioeconomic status, social cohesion, and health behaviours on QoL and health outcomes in elderly Chinese people. Considering China's unprecedented economic development in the past few decades, such research is urgently needed to help China's ageing population age successfully. This thesis, therefore, investigated those associations with nationally representative datasets. Our findings are of both great scientific and practical importance. In addition to contributing to the development of a fuller understanding of the role of social cohesion and socioeconomic status in older adults' health behaviours and, in turn, their health and QoL outcomes, the present work reveals complex associations between longitudinal patterns of health behaviours and the trajectories of depressive symptoms. Furthermore, policymakers can use the present findings to help inform prioritization of health promotion strategies by targeting particularly risky behavioural patterns.

This chapter first presents our main research findings and their contributions to the current literature. Next, theoretical and methodological considerations are discussed. Then, the implications of this study for health-related policies and recommendations for public health and further research are discussed. Finally, we close this chapter with a general conclusion.

Main findings and contributions 13

Associations of health behaviours with QoL and health outcomes

The study presented in **Chapter 2** revealed that, after controlling for key background characteristics, *fruit and vegetable consumption* (VF) was associated with better cognitive function and a better QoL among older adults in China. Our findings are generally in agreement with studies conducted with older adult populations in Western countries [5,6]. Our not finding a significant association between VF consumption and physical function among older Chinese people is consistent with a prior study by Neville and colleagues [7] that reported no association between VF and physical function among older people in the UK. Studies investigating healthy diet via adoption of a Mediterranean diet, instead of VF, did show associations between dietary behaviour and physical function. For example, Struijk and colleagues [8] reported that a Mediterranean diet was positively associated with older people's physical function. Different criteria regarding what constitutes a healthy diet might explain this apparent inconsistency. That is, Neville and colleagues [7] followed the UK Food Standards Agency's dietary guidelines (e.g., at least 150 ml fruit juice or 80 g serving of fruit), whereas Struijk and colleagues [8] employed a Mediterranean Diet Score that is more

wide-ranging than simple VF. The Mediterranean diet attributes they used encompassed nine items, including the consumption of fish and other seafood, which are known to be positively related to health and bodily functioning (e.g., see [9]). In our study, we assessed VF specifically (i.e., at least five vegetable/fruit portions per day).

Notably, as reported in **Chapter 2**, we found that *physical activity* was significantly associated with QoL and all included health outcomes (fewer depressive symptoms, better cognitive function, and better physical function) among older adults in the general population of China. These findings are in line with other studies [10,11,12] showing the importance of physical activity in older populations. Our analysis of associations between physical activity, QoL, cognitive functioning, and physical functioning among chronically ill older adults in China (**Chapter 3**) also showed that physical activity was positively related to QoL and physical functioning. Although others have reported a positive relationship between physical activity and cognitive functioning in older adults with hypertension [13] and diabetes [14], we did not observe a significant relationship of physical activity and cognitive functioning among the chronically ill older adults in our study. Different measurements of cognitive function might explain the inconsistency of findings between studies. Frith and Loprinzi [13] used only a digit symbol substitution test as in index of cognitive function, whereas Wu and colleagues [14] assessed limited aspects of cognitive function, principally executive function and memory, but did not assess other aspects of cognitive function, such as concentration, attention, or psychomotor speed. In our research, we used a more comprehensive approach. It may be that physical activity supports particular aspects of cognitive functioning that would be missed with more targeted assessments. Future research is needed to increase our understanding of the relationship between physical activity and cognitive functioning.

Although smoking has been generally associated with worse health outcomes [15,16,17,18] and a lower QoL [19,20] in older adults in the general population as well as in chronically ill older populations [21,22,23], our studies reported in **Chapter 2** and **Chapter 3** did not reveal significant associations of smoking with QoL or any of the health outcomes examined. Others have reported no harmful effects of smoking on cognitive function in older adults as well [24,25]. The lack of association of smoking with most of our study outcomes might be related to our inclusion of multiple health behaviours, such as social participation, that may have more predictive power than smoking. Most of the studies reporting an association between smoking and worse health and lower QoL investigate smoking as single health behaviour only. Also, smoking frequency, smoking duration (in years), and intensity of smoking (e.g., cigarettes per day) were not always clearly presented in the aforementioned studies. Thus, it is difficult to make direct comparisons among studies because smoking intensity and frequency may contribute to the significance of associations of smoking with QoL and health outcomes. In other words, results may be affected by how smoking is measured. For instance, Pandeya and colleagues [26] found that smoking duration was significantly associated with all health outcomes included in their study, whereas smoking intensity was associated only with two health outcomes (gastroesophageal junction adenocarcinoma and esophageal squamous cell carcinoma). Notably, there is a strong gender distinction

in China for smoking, with smoking being an accepted social norm for Chinese men but not for women [27]. Therefore, it is possible that smoking associations with QoL and health outcomes would be evident in a gender-specific analysis.

The study reported in **Chapter 3** demonstrated that *social participation* was significantly associated with QoL and all health outcomes analysed (depressive symptoms, cognitive function, and physical function) in chronically ill older adults, which highlights the importance of social participation as a health behaviour. Indeed, others have also shown a positive relationship of social participation with QoL and health outcomes [28,29]. By contrast, Hu and colleagues [30] reported no association of social participation with QoL in older adults with type 2 diabetes in China. However, they focused mainly on formal social participation, such as in sports clubs, which is not very common among older adults in China. Our study incorporated a broader concept of social participation, including common social activities, such as visiting with friends and relatives.

Associations between social cohesion and health behaviours

The influence of social cohesion and health behaviours on QoL and health outcomes was examined in the study reported in **Chapter 4**. Earlier research in places other than China have suggested that social environmental factors [31] and social circumstances [32] may influence individuals' health behaviours greatly as well as QoL and health outcomes. Such research, however, has been lacking in China.

Our finding linking greater social cohesion to less smoking among older adults in China is in line with previous studies conducted in Western countries [33,34,35]. There are not substantial data with older Chinese populations with which to compare our findings. Our examination of social cohesion, reported in **Chapter 4**, is the first to investigate the relationship between social cohesion and smoking in China, where smoking is an accepted social norm among men [27], and the effects of social norms on health behaviours have long been recognized [36,37]. For example, it is common for a man to offer a cigarette to another man to show respect and hospitality in Chinese culture, and the rejection of such an offer would be perceived as impolite [38]. Members of one's social networks, such as family members and friends, can influence Chinese people's smoking behaviour [27]. Notwithstanding, we found that even with smoking being broadly socially acceptable, higher social cohesion was associated with a lower likelihood of older Chinese adults being smokers, suggesting that social cohesion may be an important protective factor against smoking among older adults in China.

The study reported in **Chapter 4** demonstrated a significant association between social cohesion and social participation, indicating that enhancing older adults' perceived trust and safety (critical elements of social cohesion) may augment social participation levels. Our finding is in agreement with empirical studies from Western countries [39,40]. For instance, Richard et al. [39] observed a significant association between perceived safety of one's dwelling with social participation among older adults in Canada. There are not yet comparable studies available for older adults in China. Our study therefore contributes to a deeper understanding of the importance of social

cohesion in influencing social participation levels among older adults in China, with the data in **Chapter 3** highlighting the importance of social cohesion for QoL and health outcomes.

Furthermore, we observed a positive association between social cohesion and VF (**Chapter 4**). Evidence related to this association has been mixed. For example, Barnidge and colleagues reported no significant association between social cohesion and VF, whereas Mackenbach and colleagues' [41] cross-country study found an association of social cohesion with fruit consumption but not with vegetable consumption. These inconsistencies among findings might be explained by different measurements of VF and different study populations. To be specific, while our analyses focused on people over the age 50 years in both rural and urban settings within China, Barnidge and colleagues' study [42] examined adults over the age of 18 years living in rural areas of the USA, and Mackenbach and colleagues [41] investigated adults over the age of 35 living in urban areas in Europe. Therefore, age and residence might contribute to inconsistencies among these studies because elderly people living in rural residences tend to have lower VF than those living in urban areas [43]. Additionally, we treated VF as one dichotomized variable, whereas Mackenbach and colleagues' [41] examined VF as two separate independent variables, and Barnidge et al. [42] used a single item to measure VF. Thus, the data we report in **Chapter 4** expands knowledge regarding the role of VF in QoL and health outcomes among middle-aged and senior adults in both rural and urban areas of China.

The lack of association found between social cohesion and physical activities in our study reported in **Chapter 4** is consistent with Legh-Jones and Moore's [44] prior finding that physical activity was not associated with perceived generalized trust in adults. However, a significant association between social cohesion and leisure-time physical activity has been observed in several studies [45,46,47]. It is possible that social cohesion may be more relevant for leisure-time physical activities (e.g., going shopping) than for other forms of physical activity, such as household chores. Our approach of measuring physical activity by incorporating multiple aspects of physical activity rather than focusing only on leisure-time activities could explain the lack of association in our analysis. Regarding implications for health intervention strategies, efforts to enhance people's perceived safety and trust may have the benefit of promoting healthier lifestyles, and thereby lead to better QoL and health outcomes.

Also, our study presented in **Chapter 4** revealed gender differences related to associations between social cohesion and some health behaviours (smoking, PA, and VF consumption). To be specific, lesser social cohesion was only significantly associated with daily smoking in older Chinese men. One possible explanation is different smoking patterns between men and women in China [48,49] given that national surveys have demonstrated a distinctly lower smoking prevalence among Chinese women compared with men [50]. This distinction is likely related, at least in part, to smoking being an acceptable social norm for men, but not women, in China [51]. Similarly, greater social cohesion was significantly associated with sufficient PA in older Chinese men, but not women. Because traditional Chinese culture presumes that women should be primarily

responsible for housework (e.g. cleaning and cooking) [52], Chinese women are more likely to engage in domestic PA than men, regardless of social cohesion levels.

Associations of socio-economic conditions and health behaviours with QoL and health outcomes

Considering China's rapid economic development in recent decades, we investigated the association between *income* and *social participation* specifically in older adults in China. Our study reported in **Chapter 4** demonstrated that older adults with a higher income tended to be more socially active than their counterparts with a lower income. Our study reported in **Chapter 5** further revealed that higher household income per capita was associated with higher social participation over time. This finding has crucial implications regarding income-related policies seeking to improve social participation. This study was the first longitudinal study to our knowledge to have investigated the association between total household income and social participation among older adults in China, with consideration of (multi)morbidity, empty-nest status, and key background characteristics.

We observed *regional differences* regarding health behaviours as well as both QoL and health outcomes among older adults in China (**Chapter 2**). For instance, lower proportions of older adults were physically active in urban areas than in rural areas in five (Shandong, Guangdong, Hubei, Shaanxi, Yunnan) of eight provinces included in the study, with the opposite pattern being observed in the remaining three provinces (Shanghai, Jilin, and Zhejiang). These findings are generally in line with prior regional data showing that urban residents are more likely to be physically inactive than residents in rural areas [53,54]. Future health (intervention) studies should consider regional differences within China.

With respect to other background characteristics, including socio-economic conditions, the findings reported in **Chapter 2** corroborate prior research indicating that being female [55], living in rural areas [56], and being chronically ill are associated with more depressive symptoms. Rural residence was also significantly associated with poorer cognitive function and physical function in both our general-population (**Chapter 2**) and chronically-ill (**Chapter 3**) older adult samples, consistent with prior studies [57,58]. Also, we found that lower education was associated with poorer QoL and worse cognitive function among chronically-ill older adults (**Chapter 3**), although educational level was not found to be significantly associated with QoL in our general-population sample (**Chapter 2**). A prior large-scale study also showed a positive association between higher educational level and QoL among community-dwelling older adults [59].

Still, little is known about the pathways through which education influences people's QoL [60]. It may be that education becomes especially relevant when people encounter adverse life events, such as chronic disease in old age. Indeed, having a health-compromising condition can impact different people's QoL differently [60]. It may be that having more education can be a protective factor that enables people to deal with adverse circumstances, such as chronic disease, while still enjoying life. If so, lower educational attainment may be associated with vulnerability while coping

with chronic conditions. Our finding showing that a non-single status was associated with better QoL among both general-population (**Chapter 2**) and chronically-ill (**Chapter 3**) older adults in China fits with prior studies showing a positive impact of marriage [61,62]. Married older adults may benefit from the social relationships they have with their spouses [61,63]. Indeed, researchers have argued that marriage might form a protective mechanism against mental stress and the development of depressive symptoms in later life [62]. Notwithstanding, marital quality and marital satisfaction should be considered (in addition to marital status) when examining associations of being married with QoL [61,64].

Longitudinal health behavioural patterns and associated trajectories of depressive symptoms

Little is known about how longitudinal patterns of health behaviours are associated with trajectories of depressive symptoms in Chinese older adults. Importantly, the identification of these associations can help health policymakers weigh the importance of different behavioural patterns as they work to optimize health promotion and intervention strategies. Therefore, in **Chapter 6**, in which we investigated distinct longitudinal behavioural patterns and their associations with trajectories of depressive symptoms among older adults in China from 2010 to 2015. This longitudinal study led us to identify five distinct longitudinal behavioural patterns in China, each of which encompassed a combination of risky (e.g. smoking) and health-promoting (e.g. physically active) behaviours, consistent with prior studies showing that people tend to maintain risky and healthy behaviours simultaneously [65,66].

Although older adults can still benefit from switching to healthier behaviours [67,68], we found that all identified latent health behaviour classes tended to be stable across waves (study time points), with low probabilities of inter-class transition (**Chapter 6**). This finding agrees with a 25-year longitudinal study conducted with older adults in the USA [69]. Indeed, unhealthy behaviours have been shown to be largely stabilized during adolescence and to extend into adulthood [69,70]. Therefore, health behaviour interventions may be most effective early in one's life, before unhealthy behaviours have become stabilized.

Notably, in the study reported in **Chapter 6**, we observed evidence of an overshadowing effect of social participation. That is, all identified behavioural patterns involving low probabilities of being socially active were significantly associated with the presence of more depressive symptoms (higher CES-D 10 scores), indicating that detrimental effects of being socially inactive might overshadow the harmful effects of other co-existing unhealthful behaviours. Unlike other traditional health behaviours, the influence of social participation on depressive symptom risk in older people has not yet been well documented longitudinally. Our finding therefore contributes to a better understanding of the importance of social participation in influencing depressive symptom development in older adults. Furthermore, these findings have the potential to provide practical benefits to health policy makers. In particular, our findings suggest that health professionals should prioritize their focus on particular behaviour combinations associated with more depressive

symptoms. Doing so would be helpful for optimizing health resources, especially in China, where health resources are inadequate in some areas.

Theoretical reflection

Conceptualizing social cohesion

There is not yet an internationally accepted consensus definition of social cohesion because there is variability with respect to interests and perspectives [71]. Social cohesion has been described as consisting of two interrelated characteristics of society: levels of trust and the absence of social conflict [72,73]. Considerable attention has been given to Lockwood's definition of social cohesion, which focuses on negative aspects of a society and, accordingly, is measured based on indices of family disorganization and urban rioting [74]. Chan and colleagues [74] argued that Lockwood's definition of social cohesion reflects "one end of two extremes", namely social dissolution and civic corruption. By contrast, Chan's definition is more neutral and balances positive and negative indicators associated with social cohesion. There have been other definitions that either do not consider the conditions and content for social cohesion or that are defined in a very general way [74]. Therefore, we adopted Chan and colleagues' [74] definition of social cohesion in this thesis, which is as follows:

> Social cohesion is a state of affairs concerning both the vertical and the horizontal interactions among members of a society, as characterized by a set of attitudes and norms that include trust, a sense of belonging, and the willingness to participate and help, as well as their behavioural manifestations. (p. 290)

Even though Chan's definition is an important step towards a more "rigorous yet intuitive" conceptual foundation of social cohesion, they also stressed that a large body of empirical research is still needed to form a sound theory of social cohesion [74].

Successful ageing

According to Dillaway and Byrnes [75], Rowe and Kahn's well-known model is widely used because it combines a wide range of successful ageing factors, including psychological, physiological, and social factors. Rowe and Kahn's successful ageing model is composed of three elements: high cognitive and physical functioning; active engagement with life; and low probability of disease and disability [3]. Because it is unrealistic to expect a majority of people to be disease-free in their old age [76], Young and colleagues [4] introduced a more inclusive and multidisciplinary definition of successful ageing, as follows:

> a state wherein an individual is able to invoke adaptive psychological and social mechanisms to compensate for physiological limitations to achieve a sense of well-being, high-assessed quality of life, and a sense of personal fulfilment even in the context of illness and disability.

Young and colleagues' model of successful ageing suggests various pathways of successful ageing and acknowledges that successful ageing is still possible in people with diseases and functional limitations. We further appreciate the inclusivity of Young and colleagues' model of successful ageing because people have different starting points of their lives, including being born with disabilities or (genetic) diseases that are out of their control [4].

The conceptual model of this thesis (Fig. 1) consists of three main elements: living situation of older people in China [background characteristics and socio-economic conditions (age, gender, region, education, income, chronic disease, children, empty nest, social cohesion)], health behaviours (VF, smoking, physical activity, social participation), and QoL and health outcomes (physical function, cognitive function, depressive symptoms). Based on previous theoretical frameworks of successful ageing [3,4,76] and empirical evidence [77,78], this thesis incorporates multiple health behaviours (including social participation) (Bowling et al., 2005), as well as social cohesion, into its conceptual model. Sociopsychological models of successful ageing have emphasised social functioning, including social participation in society, as a crucial domain of successful ageing [76]. In line with the work of Young et al. [4], successful ageing is possible in people manageing chronic illness in our model. Although we incorporated essential concepts in our theoretical model (e.g., adding social participation as a health behaviour and taking social cohesion into account), the model is limited by not having included all aspects that are important for successful ageing. An age-friendly community and solidarity in the neighbourhood are, for example, also known to be important in promoting successful ageing in the community [79,80]. Unfortunately, many communities lack the expertise to evolve into age-friendly communities [80]. Future research is needed on how to build and maintain age-friendly communities that support successful ageing.

Methodological considerations

Measurement limitations

Despite the contributions of this thesis, several limitations need to be noted. First of all, because engagement of behaviours was self-reported via a face-to-face interview, there may have been some reporting bias because respondents may want to provide socially desirable answers [81]. Consequently, the prevalence of unhealthful behaviours in our study might be underestimated, which could have indirect influences on observed associations with QoL and health outcomes. We do not know to what extent these potential underreporting biases might have influenced the results. Further study should explore approaches to validate the reliabilities of self-reported health behaviours across cultures.

Secondly, in **Chapters 2, 3, and 4**, due to data limitations, we used VF to indicate a healthy diet. However, healthy diet is a broader concept [82] that includes other types of dietary patterns, such as the Mediterranean diet. Literature related to dietary patterns is highly heterogenous, which makes comparisons across studies difficult. A recently developed International Diet-Health Index (IDHI) [83] may help to solve many of these issues and facilitate meaningful comparison among studies/countries. The IDHI employs a standardized index that can be used in any country

and reflects overall diet, including both risk-reducing and risk-increasing factors [83]. Researchers should be encouraged to use the IDHI in future diet-related research.

Thirdly, heavy smokers have an elevated risk of dying before the age of 50 years old [84]. Therefore, our data may underestimate the impact of smoking on health outcomes.

Suggestions for further research

Although this thesis demonstrates the importance of multiple health behaviours and social cohesion in successful ageing, we did not look into how to improve these elements among older adults in China. Therefore, we suggest future research designed to elucidate how health behaviours may be improved in older adults in China be pursued. Additionally, we did not examine longitudinal associations or health behavioural patterns with QoL and other health outcomes, such as cognitive function and physical function. Considering the evidence in the literature indicating that cognitive function, physical function, and QoL are key elements of successful ageing [3,4], we encourage researchers to further investigate longitudinal associations of health behaviours with QoL, cognitive function, and physical function.

Overall conclusion

The research reported in this thesis demonstrated associations of multiple health behaviours with QoL and health outcomes among older adults in China. This work also underscored the importance of social cohesion and its relationship with multiple health behaviours among middle-aged and older adults in China, which may differ between men and women. Additionally, our data indicate that social participation is a vitally important health behaviour with the potential to influence the trajectories of depressive symptoms in older adults. Furthermore, this thesis provides crucial evidence that different patterns of health behaviours are associated with distinct trajectories of depressive symptoms among middle-aged and older adults in China. These empirical findings may aid health professionals and policy makers in their efforts to optimize health-promoting strategies, particularly in China. Further studies should focus on enhancing health-promoting behaviours and social cohesion among older adults in China in effective ways.

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SUMMARY

The phenomenon of population ageing is accelerating at an astonishing rate in China, more rapidly than in any other nation in history. Population ageing brings challenges associated with helping people age successfully over an extended lifespan. Thus far, limited studies have been conducted in China with respect to how various health behaviours are related and crucial elements of successful ageing, including sustaining cognitive and physical functions, mitigating depressive symptoms, and optimizing quality of life (QoL). This thesis aims to investigate longitudinal relationships of socio-economic conditions, social cohesion, and health behaviours with QoL and health outcomes among senior citizens in China with analyses of nationally representative datasets.

Two datasets are used in this thesis: the SAGE (Study on global AGEing and adult health) dataset and the CHARLS (China Health and Retirement Longitudinal Study) dataset. Cross-sectional studies described in **Chapter Two, Chapter Three, and Chapter Four** used wave 1 data from the World Health Organization's (WHO's) SAGE dataset, which represents the most recent data available from China. Longitudinal studies described in **Chapter Five and Chapter Six** used harmonized data (wave 1, 2, and 4) from the CHARLS, which had a nationally representative sample of non-institutionalized Chinese people 45 years old and older.

The cross-sectional study in **Chapter Two** examined associations of health behaviours with QoL and health outcomes. In total, data from 13,367 participants were included in our analysis. We found that physical activity was positively associated with all health outcomes examined as well as with a better QoL. Meanwhile, adequate vegetable and fruit consumption (VF) was found to be associated with a better QoL and better cognitive function among older adults in China. Regional differences in health behaviour trends as well as in QoL and health outcomes were observed. Smoking was not significantly related to QoL or to any of the health outcomes examined. Altogether, the findings of this study underscored the importance of the elderly engageing in physical activity and eating a diet with adequate vegetables and fruits.

Chapter Three presents a cross-sectional study, which can be seen as an extension of the work presented in **Chapter Two**, but with a specific focus on chronically ill older adults. Notably, this Chapter included social participation as an additional health behaviour. A total of 6,629 participants with at least one chronic disease were enrolled. Social participation was found to be associated with better QoL, physical functioning level, and cognitive functioning level among chronically ill older adults in China. In this more focused cohort, physical activity was found to be associated with better physical function and QoL, but not with cognitive function, whereas a healthy diet was not associated with better QoL. These findings suggest that social participation may be an essential health behaviour, particularly among older adults with chronic medical conditions. Future health intervention and promotion strategies should include social participation as a health-promoting behaviour.

The cross-sectional study presented in **Chapter Four** investigated associations of social cohesion and socio-economic status with multiple health behaviours among a sample of 13,367

older adults in China. Participants who reported a higher level of social cohesion were found to be more likely to be socially active, more likely to have adequate VF consumption, and less likely to be a daily smoker, but social cohesion was not significantly associated with being physically active. People with higher (estimated household) incomes were found to be less likely to be daily smokers, more likely to have adequate VF, and more likely to be socially active, but less likely to be sufficiently physically active. Lower educational levels were related to reduced likelihood of having adequate VF and being socially active, but greater likelihood of being a daily smoker. This study provides important information toward developing a fuller understanding of the role of social cohesion in benefiting older adults' health behaviours. Associations of social cohesion and SES with health behaviours (smoking, physical activity, and vegetable and fruit consumption) differed between men and women in China. In the development of health promotion programs for seniors, health professionals and policymakers should include elements that are designed to enhance social cohesion. Meanwhile, our findings underscored the importance of considering gender differences when designing health promotion programmes aiming to promote Chinese older adults' health behaviours.

In the longitudinal study presented in **Chapter Five**, we firstly investigated how household income relates to social participation over time among older adults in China and secondly examined the relationship between crucial background characteristics and social participation. In total, 3,863 participants were included in this study, which included three phases: baseline/wave 1 (from June 2011 to March 2012); wave 2 (the year 2013); and wave 4 (the year 2015). Generalized estimating equations were used to investigate longitudinal associations between household income and social participation, with and without adjustment of crucial background characteristics. Over time, people in the highest income groups were found to be more likely to be socially active than those in the lowest income groups. Social participation was found to be less likely among older adults living in rural areas and among those living with a spouse and/or a child. Meanwhile, participants with a higher educational level were found to be more likely to be socially active than participants with less education. The findings of this study indicated that insufficient financial resources may limit social participation. Accordingly, income-related policies should examine augmentation of pensions for older Chinese citizens, especially for those in more vulnerable groups, such as people with low levels of education and those living in rural areas.

The longitudinal study reported in **Chapter Six** investigated distinct longitudinal patterns of multiple health behaviours and whether particular patterns were associated with distinct trajectories of depressive symptoms among elderly Chinese people. Harmonized CHARLS data (wave 1, 2, and 4) representing a sample of 8,439 participants were analysed. Latent class analysis was used to identify longitudinal patterns of multiple health behaviours; latent transition analysis was used to estimate probabilities of transition from one class to another across waves. Random effects models were used to examine associations between behavioural patterns and trajectories of depressive symptoms. Our data analysis revealed five distinct longitudinal patterns of health behaviours among older adults in China, all of which were quite stable over time and encompassed

combinations of risky (e.g. smoking) and health-promoting (e.g. physically active) behaviours. Furthermore, particular health behaviour patterns were found to be associated with distinct trajectories of depressive symptoms over time. Overall, health behaviour patterns involving low probabilities of social participation were associated with more depressive symptoms over time. Furthermore, the stability of these behaviour patterns across waves suggests that earlier life interventions may be needed. These findings should be considered in future health promotion strategies aimed at reducing depressive symptoms among elderly Chinese people.

Chapter Seven provides a general discussion of the main findings, methodological considerations, a theoretical reflection, and recommendations for health professionals and policy makers. Relationships of health behaviours, social cohesion, and socioeconomic status with QoL and health outcomes, including depressive symptoms, cognitive functioning, and physical functioning in older adults in China are discussed. The findings presented in this thesis contribute to a fuller understanding of the crucial roles that health behaviours, social cohesion, and socioeconomic status can have in successful ageing. This chapter includes theoretical reflection on social cohesion's conceptualization and the model of successful ageing used in this thesis, as well as discussion of measurement limitations, including self-reporting bias. Finally, it includes our suggestions for future research investigating potential intervention strategies aimed at enhancing successful ageing by improving health behaviours and social cohesion, as well as research into the longitudinal relationships of multiple health behaviour patterns with other essential elements of successful ageing, such as QoL, cognitive function, and physical function.

SAMENVATTING

In China vindt de vergrijzing plaats in een verbazingwekkend tempo, sneller dan in enig ander land in de geschiedenis. De vergrijzing van de bevolking brengt uitdagingen met zich mee om succesvol ouder te worden gedurende een langere levensduur. Tot nu toe is er in China weinig onderzoek gedaan naar de relatie tussen verschillende gezondheidsgedragingen en cruciale elementen van succesvol ouder worden, waaronder het behoud van cognitieve en fysieke functies, het verminderen van depressieve symptomen, en het optimaliseren van de kwaliteit van leven. Dit proefschrift heeft als doel het onderzoeken van longitudinale relaties tussen sociaal-economische omstandigheden, sociale cohesie, gezondheidsgedragingen en kwaliteit van leven en gezondheidsuitkomsten bij ouderen in China door middel van analyses van nationaal representatieve datasets.

In dit proefschrift worden twee datasets gebruikt: de SAGE (*Study on global AGEing and adult health*) dataset en de CHARLS (*China Health and Retirement Longitudinal Study*) dataset. Voor de cross-sectionele studies beschreven in **Hoofdstuk Twee, Hoofdstuk Drie en Hoofdstuk Vier** zijn de *wave 1* data gebruikt van de SAGE dataset van de Wereldgezondheidsorganisatie (WHO), die de meest recente beschikbare gegevens uit China vertegenwoordigt. Voor de longitudinale studies in Hoofdstuk Vijf en Hoofdstuk Zes is gebruik gemaakt van geharmoniseerde gegevens (*wave 1, 2 en 4*) van CHARLS, een nationaal representatieve steekproef van niet-geïnstitutionaliseerde Chinezen van 45 jaar en ouder.

De cross-sectionele studie in **Hoofdstuk Twee** betrof onderzoek naar associaties van gezondheidsgedragingen met kwaliteit van leven en gezondheidsuitkomsten. In totaal zijn gegevens van 13.367 deelnemers meegenomen in onze analyse. Wij vonden dat lichamelijke activiteit positief geassocieerd was met alle onderzochte gezondheidsuitkomsten en met een betere kwaliteit van leven. Ook bleek een adequate groente- en fruitconsumptie geassocieerd te zijn met een betere kwaliteit van leven en een betere cognitieve functie onder oudere volwassenen in China. Er bleken regionale verschillen te bestaan wat betreft trends in gezondheidsgedrag, alsmede in kwaliteit van leven en gezondheidsuitkomsten. Roken was niet significant gerelateerd aan kwaliteit van leven of aan een van de onderzochte gezondheidsuitkomsten. Al met al onderstrepen de bevindingen van deze studie dat het belangrijk is dat ouderen aan lichaamsbeweging doen en een dieet volgen met voldoende groenten en fruit.

Hoofdstuk Drie presenteert een cross-sectionele studie – die kan worden gezien als een verlengstuk van het onderzoek dat in **Hoofdstuk Twee** is beschreven, maar met een specifieke focus op chronisch zieke oudere volwassenen. In dit hoofdstuk is sociale participatie opgenomen als extra gezondheidsgedrag. In totaal zijn 6.629 deelnemers met ten minste één chronische ziekte geïncludeerd. Sociale participatie bleek geassocieerd te zijn met een betere kwaliteit van leven, fysiek functioneren en cognitief functioneren onder chronisch zieke oudere volwassenen in China. In dit meer specifieke cohort bleek lichaamsbeweging geassocieerd te zijn met een beter lichamelijk functioneren en een betere kwaliteit van leven, maar niet met beter cognitief functioneren, terwijl een gezond dieet niet geassocieerd was met een betere kwaliteit van leven. Deze

bevindingen suggereren dat sociale participatie essentieel gezondheidsgedrag kan zijn, vooral bij oudere volwassenen met chronische medische aandoeningen. Bij toekomstige strategieën voor gezondheidsinterventie en -bevordering zou sociale participatie – als gezondheidsbevorderend gedrag – een element moeten zijn.

De cross-sectionele studie die in Hoofdstuk Vier is beschreven, betreft onderzoek naar de associaties tussen sociale cohesie en sociaaleconomische status met meerdere gezondheidsgedragingen bij 13.367 oudere volwassenen in China. De deelnemers die een hoger niveau van sociale cohesie rapporteerden, bleken vaker sociaal actief te zijn, vaker voldoende groenten en fruit te eten en minder vaak dagelijks te roken, maar sociale cohesie was niet significant geassocieerd met lichamelijk actief zijn. Mensen met een hoger (geschat) huishoudinkomen bleken minder vaak een dagelijkse roker te zijn, meer geneigd te zijn voldoende groenten en fruit te eten en sociaal actief te zijn, maar minder geneigd om voldoende lichaamsbeweging te hebben. Een lager opleidingsniveau was gerelateerd aan een minder grote waarschijnlijkheid om voldoende groenten en fruit te eten en sociaal actief zijn, maar een grotere waarschijnlijkheid om dagelijks te roken. Deze studie verschaft belangrijke informatie voor het ontwikkelen van een beter begrip van de rol van sociale cohesie in het bevorderen van het gezondheidsgedrag van oudere volwassenen. De associaties van sociale cohesie en SES met gezondheidsgedrag (roken, fysieke activiteit, en groente- en fruitconsumptie) verschilden tussen mannen en vrouwen in China. Bij de ontwikkeling van gezondheidsbevorderende programma's voor ouderen zouden gezondheidswerkers en beleidsmakers elementen moeten opnemen die de sociale cohesie bevorderen. Tegelijkertijd maakten onze bevindingen het duidelijk dat het belangrijk is rekening te houden met genderverschillen bij het ontwikkelen van programma's die gericht zijn op het bevorderen van het gezondheidsgedrag van Chinese oudere volwassenen.

In de longitudinale studie die in **Hoofdstuk Vijf** is beschreven, hebben we ten eerste onderzocht hoe het huishoudinkomen zich in de loop der tijd verhoudt tot sociale participatie onder oudere volwassenen in China; en ten tweede hebben we de relatie tussen cruciale achtergrondkenmerken en sociale participatie onderzocht. In totaal zijn 3.863 deelnemers geïncludeerd in deze studie, die drie fasen omvatte: *baseline*/*wave 1* (van juni 2011 tot maart 2012); *wave* 2 (het jaar 2013); en *wave* 4 (het jaar 2015). Met behulp van gegeneraliseerde schattingsvergelijkingen zijn longitudinale verbanden tussen huishoudinkomen en sociale participatie onderzocht, met en zonder correctie voor cruciale achtergrondkenmerken. Door de tijd heen bleken mensen in de hoogste inkomensgroepen vaker sociaal actief te zijn dan mensen in de laagste inkomensgroepen. Sociale participatie bleek minder waarschijnlijk onder oudere volwassenen die in plattelandsgebieden woonden en onder degenen die samenwoonden met een echtgeno(o)t(e) en/of een kind. Hoger opgeleide deelnemers bleken vaker sociaal actief te zijn dan lager opgeleide deelnemers. De bevindingen van deze studie wijzen erop dat sociale participatie beperkt kan zijn vanwege onvoldoende financiële middelen. Derhalve zou in het kader van inkomensgerelateerd beleid aandacht moeten worden besteed aan verhoging van het pensioen voor oudere Chinezen, met name

mensen uit meer kwetsbare groepen, zoals mensen met een laag opleidingsniveau en mensen die in plattelandsgebieden wonen.

In de longitudinale studie die in **Hoofdstuk Zes** is beschreven zijn verschillende longitudinale patronen van meerdere gezondheidsgedragingen onderzocht. Tevens is nagegaan of bepaalde patronen waren geassocieerd met een kenmerkend verloop van depressieve symptomen onder Chinese ouderen. Geharmoniseerde *CHARLS data* (*wave* 1, 2, en 4) van 8.439 deelnemers zijn geanalyseerd. Een latente klassenanalyse diende om longitudinale patronen van meerdere gezondheidsgedragingen te identificeren; een latente transitieanalyse om de waarschijnlijkheid in te schatten van een overgang van de ene klasse naar de andere tussen de *waves*. Met behulp van *random effects* modellen zijn associaties onderzocht tussen gedragspatronen en het verloop van depressieve symptomen. Onze data-analyse bracht vijf verschillende longitudinale patronen van gezondheidsgedragingen bij oudere volwassenen in China aan het licht, die alle vrij stabiel waren door de tijd heen, met combinaties van risicovol (bv. roken) en gezondheidsbevorderend (bv. fysiek actief) gedrag. Bovendien bleken bepaalde patronen van gezondheidsgedrag geassocieerd te zijn met een kenmerkend verloop van depressieve symptomen door de tijd heen. Patronen van gezondheidsgedrag die gepaard gingen met een lage waarschijnlijkheid van sociale participatie waren geassocieerd met meer depressieve symptomen door de tijd heen. Verder geeft de stabiliteit van deze gedragspatronen bij alle *waves* aan dat leefstijlinterventies op jongere leeftijd nodig kunnen zijn. Deze bevindingen zouden in overweging moeten worden genomen bij toekomstige gezondheidsbevorderende strategieën gericht op het verminderen van depressieve symptomen onder Chinese ouderen.

Hoofdstuk Zeven biedt een algemene beschouwing over de belangrijkste bevindingen, methodologische overwegingen, een theoretische reflectie, en aanbevelingen voor gezondheidswerkers en beleidsmakers. De verbanden worden besproken tussen gezondheidsgedrag, sociale cohesie, en sociaal-economische status enerzijds, met kwaliteit van leven en gezondheidsuitkomsten – waaronder depressieve symptomen, cognitief functioneren, en lichamelijk functioneren – anderzijds bij oudere volwassenen in China. De bevindingen in dit proefschrift dragen bij aan een beter begrip van de cruciale rol die gezondheidsgedrag, sociale cohesie en sociaaleconomische status kunnen spelen bij gezond en gelukkig ouder worden. Dit hoofdstuk geeft ook een theoretische beschouwing over de conceptualisering van sociale cohesie en het model van gezond en gelukkig ouder worden dat in dit proefschrift is gebruikt, evenals een discussie over de beperkingen van de metingen, waaronder vertekening door zelfrapportage. Tenslotte bevat dit hoofdstuk onze suggesties voor toekomstig onderzoek naar mogelijke interventiestrategieën gericht op het bevorderen van gezond en gelukkig ouder worden door middel van het verbeteren van gezondheidsgedrag en sociale cohesie, evenals onderzoek naar de longitudinale relaties van meerdere gezondheidsgedragspatronen met andere essentiële elementen van gezond en gelukkig ouder worden, zoals kwaliteit van leven, cognitief functioneren, en lichamelijk functioneren.

WORDS OF GRATITUDE

"Life is like a box of chocolate. You never know what you're gonna get." This is very true as I never thought I would go back to school and be a PhD candidate after several years out of the *Ivory Tower*. Though, it probably is a perfect match with my research topic--successful ageing (活到老, 学到老). And, somehow, it also fulfills my childhood dream of becoming a writer.

At the age of ten, I published my very first essay in my life. I remember that the teacher always read out loud my writings in class, which made my childhood friends believe that I will become a writer when I grow up. Writing, indeed, brings me a lot of joy.

Nonetheless, pursuing a doctoral degree is not merely about writing papers; the journey can be hard at times. I could not make it without the support of many people in my life. Although it is unrealistic to mention everybody who has helped me with achieving this goal in one way or another, I do like to express my appreciation to a few of them who have played a particular role and significantly influenced me during this journey.

First of all, I would like to express my heartful appreciation to Anna. Thank you for your continuous encouragement and support during those years. Thank you for helping me to develop my research skills and become a better me. Thank you for being so responsible and caring whether I am doing okay. You are like the lighthouse in the darkness, guiding me to find the way ahead in tough times. I will forever treasure it. I remember that since my first year, you have already noticed that CSC-funded-fulltime-PhDs were not given the same access to certain services which are available to other EUR-paid PhDs. Knowing those obstacles, you actively conveyed this situation to the school and hoped the condition could be improved. To be honest, no matter what the result is, I am already very touched that someone cares about it and takes the initiative to help out. Taking you as a role model, I thought I should also do something for the PhD community. So I joined the board of Erasmus PhD Association in my second year, not for my benefit but for the whole PhD community, especially for those underrepresented. In one of my annual assessment reports, Anna and Jane, you wrote: "Zeyun has made an important contribution to the EUR PhD community. It's important to have PhD-students like Zeyun who invest time in the PhD community." Thank you for such a nice compliment and I am still working to contribute more to the community.

And thank you, Jane. Thank you for your feedback and comments on my research. Thank you for introducing the concept of SPSS syntax to me while working on my first paper. Interestingly, I've been using the SPSS graphical user interface since my bachelor's thesis but never heard of the word "syntax," which is actually a very good way of archiving statistical steps. I keep using syntax as a habit since then. Although you mainly work from home before the pandemic and now everybody works from home for more than one year already. I remember one of our conversations during

our Socio-Medical Sciences (SMS) team lunch was about the different working cultures between EMC and ESHPM. I mentioned that one of the differences was that researchers in the EMC celebrate each of their publications with cakes, and colleagues from the whole faculty would come to congratulate the authors. I did eat cakes there many times and had nice conversations with those authors. I think colleagues should celebrate each other's achievements because it is also an excellent way to exchange research ideas.

And without a doubt, I cannot finish my papers without my co-authors. Thank you, Prof.dr. Jos Twisk, Thijs, Dr. Oliver Perra, Dr. Jin, and (of course), Anna and Jane. I remember that Prof.dr Jos Twisk kindly answered my questions about general equation estimation. Dr. Jin provides insightful advice for the rationale of the paper. Thijs introduced the concept of latent classes to me and helped me to get familiar with the terminologies and methodology of latent class analysis, which build the foundation of the last paper. Dr. Oliver Perra patiently taught me latent transitions analysis, latent class growth analysis and guided me to build the models piece by piece. As the last paper involved more sophisticated statistical analysis, which means I would need to keep learning. Meanwhile, I need to covert a Stata dataset to an Mplus data file. Though, this is not the end of the difficulty, as the Mplus plot function is not available for the Mac system. I would need to use R to view the plots produced by Mplus, which is not super tricky once one learns to do so. But it indeed took me a while to figure it out. The moment that I finally can view my Mplus plot in R made me happy as if I won a one-million lottery. These experiences "forced" me to use various software that I was unfamiliar with before, but I believe the time spent on it was definitely worth it. That's really the pure joy of doing science.

And thank you members of my inner committee, Prof. dr. Joris van de Klundert, Prof.dr. Hein Raat, and Prof.dr. Lilian Lechner. Thank you for taking the time to assess my dissertation. I also would like to thank Prof.dr. Kees Ahaus, Prof. Shanlian Hu, Dr. Igna Bonfrer and Dr. Jeroen van Wijngaarden for being on the plenary committee of my defense. Dr. Igna Bonfrer, we have worked together for a while, although unfortunately, that paper was not included in this thesis; I believe these experiences definitely enriched my knowledge of data analyzing. Prof.dr. Kees Ahaus, I remember you said that you enjoyed the dish of Peking duck when you visit China. It's great to have you assess my dissertation regarding successful ageing in China. And, Dr. Jeroen van Wijngaarden, thank you for sharing the chocolate box with us in my office; that's a friendly working culture of sharing tasty food. Prof.dr. Lilian Lechner, although I haven't met you yet, I very much appreciate your evaluation of my thesis. Prof. Joris van de Klundert, I remember you would always enthusiastically greeting us when you visit our office. And I always say to your students that you are very famous. In my first year in ESHPM, I attended the World of Health Care Congress in Den Haag, and the organizer, Susan, asked me whether I know you. Also, in my second year of my PhD, I accidentally found your profile in a booklet for a healthcare-related conference organized by the Consulate General of the Netherlands in Shanghai many years ago. What a small world. Prof. Shanlian Hu and Prof.dr. Hein Raat, I will have separate paragraphs to thank you. I am looking forward to seeing you all in my defence.

Thank you Director Jin (Chunlin) and Professor Hu (Shanlian). Your support and encouragements have helped me reach many milestones. Thank you for selecting me as a visiting scholar to conduct the 6-months research in Rotterdam, the sister city of Shanghai. Director Jin, thank you for giving me so many opportunities of conducting meaningful research under your guidance. Those experience have greatly help me with my PhD research. SHDRC has been growing prosperous during your leadership, I am lucky enough to be part of it. I've already remember the words you said to us when we first started working at SHDRC; you said that you hope someday our Shanghai research center can be proud of us. I hope I didn't let you down. Professor Hu, as the founder and leader of the development of health economics in China, you are so down-to-earth and never make people feel a distance from you. Although I was not directly under your research lead, you are so kind to me and taught me important life philosophies. I have integrated those valuable advices throughout my research during those years, and I will continue following the guidance you gave me. It is my great honor to have you on the committee and witness another milestone in my career. My PhD is truly an extension of the cooperation that you once established between Shanghai and Rotterdam.

Thank you Professor Hein (Raat). Thank you for being such a nice host when I visited the EMC. I still remember the first meeting in your office that you introduced all those interesting Rotterdam stores to Xinye and me. Of course, I also remember the late meetings with you to discuss my questions. Sometimes I was afraid that I might ask too many questions, but you were never tired of my questions. I also remember the delicious diner your family prepared for us (especially the tuna steak prepared by your daughter). And, Thank you, Marjolein. I can still remember that you are always so excited with every achievement that I made with my research, which has greatly encouraged me with my research. I remember that we struggled with categorizing a factor for the systematic review, and you even asked your father for help. And I remember that I was so amazed by knowing that your father was a biologist (what a good resource!). And I was so grateful that you use all types of sources to help me to conduct good research. Now, I am about to graduate; thank you for honoring me by being my paranymph on this special occasion!

Thank you, Professor Chen (Jie). Working under your leadership has been an honor for me. I remember the very first project that I conducted under your guidance is to evaluate the outputs and effectiveness of a United Nations-China Joint Programme entitled "Improving Nutrition, Food Safety and Food Security for China's most vulnerable women and children." These experiences are precious for developing my research ability and built the foundation for achieving my doctoral degree. I also remember that you took Haiyin and me to the International Health Technology Assessment Conference in Seoul (Korea), which was my first international conference abroad. I have learned so many etiquettes of attending an international conference from you. You told us so many interesting stories while you worked in the headquarter of the WHO in Geneva, which significantly broadened my view of the world.

Thank you, my colleagues, in the SMS group. Sanne, the first colleague I met on my first working day, voluntarily taught me Dutch grammar and "rescued" me in our team outing while the wind was too strong. And Lotte, you sent me many valuable materials regarding the integrated healthcare system of the Netherlands, which greatly help my Shanghai colleagues' research on integrated care. Also, Renee, thank you for organizing the team lunch together with Anna. And the Journal Club you organized is also very helpful, which I learned a lot from there. And thank you, Liza, for preparing all the required documents before I arrive in the Netherlands; and for sending me birthday cards during those years. And, thank you, my PhD peer, Stefan Lipman (from Buddy system of EUR), who greatly helped me find my way (PhD courses, gym, bank ...) at the beginning of my PhD. Also, thank you, Thomas, for taking care of my plants when I was out of the office. I am glad they are still alive today.

I also would like to say "thank you" to the board of EPAR, Young@EUR, my Chinese friends and colleagues in EUR.

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Special thanks to my parents, family members, and friends who gave me strength and support during those years. Mother and father, your wishes to me are to be happy and healthy, apply what I have learned to real life, and become a valuable person to our society. I will remember these. Lastly, like John Roberts once address at his son's middle school graduation, I would wish the same for myself:

"From time to time in the years to come, I hope you will be treated unfairly, so that you will come to know the value of justice. I hope you will suffer betrayal, because that will teach you the importance of loyalty. Sorry to say, but I hope you will be lonely from time to time, so that you don't take friends for granted. I wish you bad luck again, from time to time, so that you will be conscious of the role of chance in your life, and understand that your success is not completely deserved, and the failure of others is not completely deserved, either. And when you lose, as you will from time to time, I hope every now and then your opponent will gloat over your failure. It is a way for you to understand the importance of sportsmanship. I hope you will be ignored, so you will learn the importance of listening to others. And I hope you will have just enough pain to learn compassion."

ABOUT THE AUTHOR

Zeyun Feng (born in December, 1986) holds a joint Nordic Master of Gerontology degree (University of Jyväskylä, Finland; Lund University, Sweden; and University of Iceland) and a Master of Health Sciences of Public Health and Gerontology (MSc) degree (2010-2012). Prior to completing her doctoral training in the Netherlands, Zeyun returned to China to work as a research fellow at Shanghai Health Development Research Center (SHDRC). In the Department of Shanghai Health Technology Assessment Center, Zeyun worked directly under the leadership of Prof. Jie Chen, a former Assistant Director-General of World Health Organization headquarters (the then first highest-ranking Chinese person in the WHO). Since 2012, Zeyun has been a researcher in more than 20 projects. In 2013, Zeyun won SHDRC's Scientific Research New Talent Award for outstanding work performance. Thereafter, the research team of Dr. Chunlin Jin, Dr. Hansheng Ding, and Zeyun was selected for several high-level research awards, including the Shanghai Science and Technology Information Achievement Award. In 2016, she was a visiting scholar at the Erasmus Medical Center for a period of six months (supported by a fellowship from the China Medical Board-Collaborating Program in Evidence-based Health Policy-making. PI: Prof. Shanlian Hu). In 2017, Zeyun started her PhD training at Erasmus University Rotterdam (in the Socio-Medical Sciences Department, led by prof.dr. Anna P. Nieboer), focusing her research on successful ageing. Among Zeyun's various research interests, her main interest has been to explore (social) factors that are associated with health-related behaviours and how different patterns of multiple health behaviours shape trajectories of depression (and other elements of successful ageing) in older adults. During her PhD training, Zeyun performed well in her coursework (e.g. obtaining an 8.8 score in an advanced statistical course) and received high evaluation scores from students that she supervised. While earning her PhD, Zeyun served as a board member at the Erasmus PhD Association Rotterdam (the central representative body) and Young@EUR.

PHD PORTFOLIO

PhD candidate	Zeyun Feng
Department	Socio-Medical Sciences, Erasmus School of Health Policy & Management, Erasmus University Rotterdam
PhD period	September 2017- September 2021
Promotors	Prof.dr. A.P. Nieboer
	Prof.dr. J.M. Cramm

Training and professional development

PhD courses/workshops	ECTS/h	Year
Brush up your SPSS skills	1.0 ECTS	2017
How to survival your PhD	2.5 ECTS	2017
Brush up your research design	2.5 ECTS	2017
English academic writing	2.5 ECTS	2018
Multilevel modeling 1	2.5 ECTS	2018
Multilevel modeling 2	2.5 ECTS	2018
English writing C1	25 h	2018
Risbo educational courses (basic didactics)	16 h	2018
Dutch A2.1 Pre-Intermediate, score: 6.7/10	39 h	2018
Introduction to data analysis (NIHES summer programme)	20 h	2019
Social epidemiology (NIHES summer programme)	15 h	2019
Searching, finding, and manageing your literature	1.0 ECTS	2019
Professionalism and integrity in research (professional skills course)	1.5 ECTS	2019
Analytic storytelling	2.5 ECTS	2019
How to finish your PhD in time	2.5 ECTS	2019
Self-presentation: focus, structure, interaction, and visualization	2.5 ECTS	2019
Data analysis with R	2.5 ECTS	2020
Repeated measurement (NIHES), score: 8.8/10	1.7 ECTS	2020
Teaching in English C1	25 h	2020
Latent class analysis & Latent transition analysis	11 h	2021
Conferences		**Year**
World of Health Care Congress-Improving healthcare globally, Den Haag, the Netherlands (invited speaker)		2017
The 11th European Public Health Conference, Ljubljana, Slovenia (oral presentation)		2018
PhD Platform ESHPM Academic Open day (oral presentation)		2018
MultiJuSe research conference at Erasmus School Health of Policy & Management (presentation)		2020
Gerontological Society of America Annual Scientific Meeting (Online)		2020
Peer-review		**Year**
Journal: PLOS One (1)		2020

BMC Geriatrics (3)	2020
BMJ Open (1)	2021
SSM-Population Health (1)	2021
Clinical Interventions in Ageing (1)	2021
Abstracts: Gerontological Society of America (GSA) 2021 Annual Scientific Meeting	2021
Teaching and organizing activities	**Year**
Workshop instructor: Bachelor course Care for Later (International week workshop); Students' evaluation, 4.6/5	2019
Supervision master thesis: Urban-Rural differences in catastrophic health expenditures among empty nest and non-empty nest elderly in China (N. Miedema), thesis final score: 8/10	2019
Co-organizer of: How to deal with rejection (Publish or Perish!!?)	2020
Guest lecturer: Bachelor course Care for Later	2021

Awards

Award details	Year
Shanghai Decision Consulting Research Achievement Award for "Research on the Construction of a Unified Needs Assessment System for Elderly Care in Shanghai"	2015
Shanghai Municipality for the Decision-making Consultation Research Achievements Award for "Research on the construction of a medical science and technology innovation center with global influence and competitiveness in Shanghai"	2017
East China Science and Technology Information Achievement Award for "Theoretical design and empirical research on Shanghai public hospital compensation mechanism reform from 2015 to 2017: based on the price perspective"	2019
A GSA Behavioural and Social Sciences section Student Registration Award for the 2020 GSA Annual Scientific Meeting (registration fee covered)	2020
Shanghai Science and Technology Information Achievement Award for "Research on typical areas of integrated medical and health service system taking Shanghai as an example"	2020

PUBLICATIONS

Included in this dissertation (in English)

Feng, Z., Cramm, J.M., Nieboer, A.P. (2021). Associations of Social Cohesion and Socioeconomic Status with Health Behaviours among Middle-Aged and Older Chinese People. Int. J. Environ. Res. Public Health, 18, 4894.

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Not included in this dissertation (in English)

Yang, Z., **Feng, Z.,** Busschbach, J., Stolk, E., & Luo, N. (2019). How prevalent are implausible EQ-5D-5L health states and how do they affect valuation? A study combining quantitative and qualitative evidence. Value in Health, 22(7), 829-836.

Feng, Z., Lugtenberg, M., Franse, C., Fang, X., Hu, S., Jin, C., & Raat, H. (2017). Risk factors and protective factors associated with incident or increase of frailty among community-dwelling older adults: A systematic review of longitudinal studies. PloS one, 12(6), e0178383.

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Not included in this dissertation (in Chinese)

冯泽昀,王海银,陈多,杨燕,房良 & 金春林.(2018).日本医保支付政策及启示:以实验室项目为例. 中国卫生质量管理(01),104-106. doi:10.13912/j.cnki.chqm.2018.25.1.32.

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冯泽昀,陈洁,王海银,金春林 & 杨晓娟.(2015).澳大利亚技术评估对我国的启示. 硅谷(01),169-170.

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杨燕,王海银,冯泽昀,房良 & 金春林.(2018).台湾地区检验项目医保支付政策及启示. 中国卫生质量管理(02),101-104.

房良,王海银,杨燕,冯泽昀 & 金春林.(2018).美国检验项目医保支付政策研究及启示. 中国卫生质量管理(01),101-103.

谢春艳,陈多,杜丽侠,王常颖,信虹云,冯泽昀... & 丁汉升.(2016).英国牛津整合型老年人服务经验介绍. 中国卫生资源(02),158-162.

杜丽侠,杨逸彤,王常颖,陈多,谢春艳,冯泽昀... & 丁汉升.(2016).从日常生活活动能力视角看上海市老年照护需求. 中国卫生资源(01),61-64+69.

王海银,何达,王贤吉,冯泽昀,陈珉惺,杨晓娟 & 金春林.(2014).国内外卫生技术评估应用进展及建议. 中国卫生政策研究(08),19-23.

陈珉惺,张引,王海银,杨晓娟 & 冯泽昀.(2014).基于边界分析的民营医院发展问题的探析和启示. 中国医院管理(05),11-13.

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王海银,金春林,冯泽昀 & 陈珉惺.(2014).上海市医疗技术准入配置特征追踪研究. 中国卫生政策研究(01),55-58.

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