Clinical Research Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2019, Vol. 47(12) 6061–6081

DOI: 10.1177/0300060519882590
journals.sagepub.com/home/imr
SAGE

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 ($\beta = 0.099$) and better cognitive function ($\beta = 0.023$). Physical activity was significantly associated with fewer depressive symptoms ($\beta = -0.020$), higher QoL ($\beta = 0.086$), better cognitive function ($\beta = 0.072$), and better physical function ($\beta = -0.155$ [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.

Keywords

Health behaviour, health outcome, older adult, China

Date received: 14 March 2019; accepted: 24 September 2019

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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 aged ≥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 worldwide, 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 $\geq$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 depression[46] 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 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 subgrouped 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 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 sociodemographic characteristics (age, sex, marital status, employment, income, educational

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).

Characteristic	Total sample *n* (%)	Missing data *n* (%)	Mean ± SD
Socio-demographic			
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)		
Health behaviours			
Smoking		443 (3.3)	–
No	9440 (73.0)		
Yes	3484 (27.0)		
Pack-years[T]	1802 (13.5)	6.53 ± 14.76	

(continued)

Table 1. Continued

Characteristic	Total sample *n* (%)	Missing data *n* (%)	Mean ± SD
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

NCD, non-communicable disease; QoL, quality of life. [T]Continuous variable.

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).

Socio-demographic characteristic	Smoking (pack-years) Mean ± SD	Diet *n* (%)		Physical activity *n* (%)	
		Not Healthy	Healthy	Inactive	Active
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)
Sex					
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; 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).

	Health Behaviours					Health Outcomes			
	Smoking (pack-years)	Diet, *n* (%)		Physical activity, *n* (%)		Depressive symptoms[T]	QoL[a]	Cognitive function[a]	Physical function[T]
Province	Mean ± SD	Not healthy	Healthy	Inactive	Active	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Shandong (ref)									
Urban (0)	1.78 ± 8.06	123 (13.2)	810 (86.8)	481 (50.6)	470 (49.4)	0.04 ± 0.29	3.87 ± 0.43	43.81 ± 10.40	0.41 ± 1.64
Rural (1)	9.40 ± 18.07	308 (32.2)	650 (67.8)	251 (26.0)	715 (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	133 (17.6)	622 (82.4)	151 (19.4)	627 (80.6)	0.22 ± 0.66	3.67 ± 0.47	41.00 ± 9.39	0.34 ± 1.26
Rural (1)	10.59 ± 17.79	470 (73.7)	168 (26.3)	89 (11.9)	657 (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	233 (35.6)	422 (64.4)	167 (25.0)	500 (75.0)	0.31 ± 0.79	3.54 ± 0.54	44.76 ± 8.97	0.41 ± 1.34
Rural (1)	7.08 ± 15.00	566 (76.1)	178 (23.9)	160 (20.7)	612 (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	199 (24.4)	617 (75.6)	252 (30.7)	569 (69.3)	0.37 ± 0.76	3.77 ± 0.51	41.14 ± 8.45	0.47 ± 1.51
Rural (1)	6.93 ± 15.21	199 (32.0)	422 (68.0)	368 (44.8)	454 (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	308 (35.7)	555 (64.3)	212 (24.5)	654 (75.5)	0.43 ± 0.93	3.30 ± 0.57	36.06 ± 8.57	0.66 ± 2.07
Rural (1)	10.59 ± 16.92	370 (45.1)	451 (54.9)	150 (18.2)	673 (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	181 (24.1)	571 (75.9)	295 (36.9)	504 (63.1)	0.03 ± 0.25	3.73 ± 0.46	47.38 ± 9.94	0.26 ± 1.61
Rural (1)	1.11 ± 6.40	319 (42.9)	425 (57.1)	854 (88.6)	110 (11.4)	0.06 ± 0.33	3.84 ± 0.62	38.67 ± 8.08	0.42 ± 1.44
Yunnan									
Urban (0)	2.67 ± 10.15	191 (28.5)	479 (71.5)	263 (38.5)	420 (61.5)	0.17 ± 0.64	3.64 ± 0.57	43.21 ± 9.81	0.93 ± 2.72
Rural (1)	5.35 ± 13.99	231 (31.6)	501 (68.4)	193 (23.4)	633 (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	102 (13.1)	679 (86.9)	166 (21.1)	619 (78.9)	0.09 ± 0.46	3.68 ± 0.58	39.22 ± 9.06	0.76 ± 2.22
Rural (1)	11.51 ± 18.06	303 (47.6)	334 (52.4)	192 (28.4)	484 (71.6)	0.33 ± 0.67	3.58 ± 0.49	40.02 ± 9.31	0.27 ± 1.10

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

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 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

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[xxx]				QoL[a]				Cognitive function[a]				Physical function[xxx]			
Characteristic	β	SE	Statistical significance	Cohen's d	β	SE	Statistical significance	Cohen's d	β	SE	Statistical significance	Cohen's d	β	SE	Statistical significance	Cohen's d
Socio-demographic																
Age, years																
50-59 (0)																
60–69	–0.024	0.018	$P=0.032$	–0.013	0.043	0.013	$P<0.001$	0.021	–0.072	0.217	$P<0.001$	–0.017	0.011	0.048	NS	0.054
≥70	–0.050	0.021	$P<0.001$	0.026	0.052	0.015	$P<0.001$	0.213	–0.257	0.257	$P<0.001$	0.652	0.134	0.057	$P<0.001$	–0.489
Sex																
Male (0)																
Female (1)	0.056	0.017	$P<0.001$	–0.120	–0.018	0.012	NS	0.136	–0.067	0.209	$P<0.001$	0.202	–0.008	0.046	NS	–0.067
Marital status																
Single (0)																
Non-single (1)	–0.046	0.021	$P<0.001$	0.128	0.033	0.015	$P=0.001$	–0.342	0.045	0.251	$P<0.001$	–0.515	–0.004	0.056	NS	0.265
Educational level																
Low (0)																
Medium	0.003	0.018	NS	0.103	0.045	0.013	$P<0.001$	–0.276	0.196	0.220	$P<0.001$	–0.667	–0.009	0.049	NS	0.213
High	0.006	0.035	NS	0.204	0.052	0.025	$P<0.001$	–0.481	0.152	0.432	$P<0.001$	–0.822	–0.030	0.094	$P=0.005$	0.199
Permanent income (quintile)	–0.075	0.007	$P<0.001$	–	0.254	0.005	$P<0.001$	–	0.121	0.078	$P<0.001$	–	–0.091	0.017	$P<0.001$	–
Employment																
Non-working (0)																
Working (1)	–0.018	0.019	NS	–0.075	0.124	0.014	$P<0.001$	–0.130	0.027	0.232	$P=0.020$	0.009	–0.130	0.052	$P<0.001$	0.018
Residence																
Urban (0)																
Rural (1)	0.110	0.021	$P<0.001$	–0.113	–0.030	0.015	$P=0.024$	0.175	–0.143	0.249	$P<0.001$	0.480	0.138	0.055	$P<0.001$	–0.156
Province																
Shandong (0)				–				–								
Guangdong	0.107	0.028	$P<0.001$	–0.210	–0.030	0.020	$P=0.017$	–0.049	–0.026	0.337	$P=0.036$	–0.030	–0.038	0.074	$P=0.003$	0.083
Hubei	0.059	0.030	$P<0.001$	–0.137	–0.075	0.021	$P<0.001$	0.260	–0.006	0.365	NS	–0.040	–0.045	0.079	$P<0.001$	–0.002
Jilin	0.086	0.033	$P<0.001$	0.056	0.016	0.025	NS	0.308	–0.078	0.400	$P<0.001$	0.241	–0.037	0.088	$P=0.002$	0.028
Shaanxi	0.144	0.029	$P<0.001$	–0.389	–0.086	0.021	$P<0.001$	0.388	–0.140	0.348	$P<0.001$	0.474	–0.077	0.077	$P<0.001$	0.078
Shanghai	–0.057	0.028	$P<0.001$	0.351	0.034	0.020	$P=0.003$	–0.383	0.100	0.337	$P<0.001$	–0.375	–0.113	0.074	$P<0.001$	0.188

(continued)

Table 4. Continued

Characteristic	Depressive symptoms[xxx]				QoL[a]				Cognitive function[a]				Physical function[xxx]			
	β	SE	Statistical significance	Cohen's d	β	SE	Statistical significance	Cohen's d	β	SE	Statistical significance	Cohen's d	β	SE	Statistical significance	Cohen's d
Yunnan	0.001	0.029	NS	0.069	0.019	0.021	NS	–0.098	0.033	0.349	$P=0.004$	–0.094	0.033	0.077	$P=0.006$	–0.330
Zhejiang	–0.003	0.028	NS	0.095	0.003	0.020	NS	–0.067	–0.002	0.343	NS	–0.009	–0.070	0.074	$P<0.001$	0.028
NCDs																
No (0)																
Yes (1)	0.103	0.015	$P<0.001$	–0.108	–0.189	0.011	$P<0.001$	0.360	–0.049	0.182	$P<0.001$	0.136	0.080	0.040	$P<0.001$	–0.234
Health behaviours																
Smoking (pack-years)	0.010	0.001	NS	–	0.000	0.000	NS		–0.006	0.007	NS	–	–0.009	0.001	NS	–
Diet																
Not healthy (0)																
Healthy (1)	–0.020	0.017	NS	0.111	0.099	0.012	$P<0.001$	–0.363	0.023	0.198	$P=0.016$	–0.305	–0.017	0.044	NS	0.123
Physical activity																
Inactive (0)																
Active (1)	–0.020	0.017	$P=0.047$	–0.044	0.086	0.012	$P<0.001$	–0.159	0.072	0.202	$P<0.001$	–0.186	–0.155	0.044	$P<0.001$	0.382

QoL, quality of life; SE, standard error; NCD, non-communicable disease. [xxx]Higher scores represent more depressive symptoms or poorer physical function. [a]Higher 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.

NS, no statistically significant association ($P>0.05$).

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 $\geq$45 years were more active (80.8%) than urban residents (77.6%), but found that rural residents aged $\geq$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.

Acknowledgements

The authors would like to express their appreciation to all involved field workers as well as the respondents of WHO-SAGE WAVE 1 in China. We are also grateful to WHO for making the WHO-SAGE dataset publicly available, and to the China Scholarship Council for providing the PhD fellowship for ZF.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study used data from the WHO's Study on Global AGEing and Adult Health (SAGE). SAGE is supported by the US National Institute on Aging through Interagency Agreements (OGHA 04034785; YA1323-08-CN-0020; Y1-AG-1005-01) and through a research grant (R01-AG034479). ZF is supported by a China Scholarship Council (CSC) PhD Fellowship for her PhD study in Erasmus School of Health Policy & Management, Erasmus University Rotterdam, The Netherlands (scholarship No. 201708310108). The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. The views expressed in this paper are those of the authors, and do not necessarily represent the views or policies of the World Health Organization.

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