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Mediating effect of health consciousness in the relationship of lifestyle and sub-health status: A Chinese national cross-sectional study

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Strengths and limitations of this study

Sub health status (SHS) is common in Chinese urban residents, according to this large cross-sectional study of a nationally representative study.

Lifestyle can directly associate with physical SHS, but not with mental SHS and faintly with social SHS, which is firstly be investigated.

Health consciousness shows stronger direct association with physical, mental and social SHS than lifestyle, and takes mediating effect on the relationship of lifestyle with physical, mental and social SHS.

Abstract

Objective: Sub-health status (SHS), a third state between good health and disease, can easily develop into chronic diseases, and can be influenced by lifestyle and health consciousness. No studies have surveyed the intermediation of health consciousness on the relationship of lifestyle with SHS. This study aimed to analyze the association of lifestyle and SHS, and intermediation of health consciousness.

Design: A cross-sectional face-to-face survey using a four-stage stratified sampling method.

Participants: 3535 Chinese urban residents were investigated. SHS was measured using Sub-Health Measurement Scale V1·0. A structural equation model (SEM) was adopted to analyze relationships among lifestyle, health consciousness, and SHS. We applied a bootstrapping method to estimate the mediation effect of health consciousness.

Results: Lifestyle had a strong direct association with physical sub-health (β=-0·207), faint direct association with social health (β=-0·075), and no significant direct association with mental sub-health (β=-0·050). Health consciousness had a strong direct association with physical sub-health (β=0·480), mental sub-health (β=0·601), and social sub-health (β=0·559).

Conclusions: Health consciousness was much more important in preventing of physical, mental and social SHS than lifestyle itself, and might be a useful way to change unhealthy lifestyle and reducing the influence of poor lifestyle on physical, mental and social SHS.

Keywords: Sub-health status, Lifestyle, Health consciousness, Urban residents, China

Introduction

In 1946, the World Health Organization (WHO) [1] defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." It is reported that NCDs account for an estimated 80% of total deaths and 70% of the total number of disability-adjusted life-years (DALYs) in early twentieth century[2], and increase steadily with the urbanization and aging [3], with more than 88% of total deaths due to NCDs in 2019 in China[4]. A study pointed that NCDs accounted for 18 of the leading 20 causes of age-standardized years lived with disability on a global scale[5]. Preclinical status of CNDs and its early detection have become major issues in the promotion of the basic health service in the reform of health care[6].

Sub-health status (SHS), an intermediate status between chronic disease and health, is believed to be a subclinical, reversible stage of chronic disease[7]. People in SHS, although without a diagnosable condition, is characterized by a decline in vitality and physiological function, ambiguous health complaints, general weakness, and lack of vitality, and it has become a new public health challenge in China[8,9].

SHS has a prevalence of higher than 65% in China[10-13]. and become an increasingly concerned problem in many other countries[14,15]. Moreover, the prevalence may be severely underestimated since many individuals may not know that they suffer from SHS. For instance, in an investigation of 6,000 Chinese self-reported "healthy people", 72.8% were in "suboptimal health status" [16]. Identifying the influencing factors of SHS is important for preventing SHS, and would provide important information for first-level prevention of CND. In accordance with health definition released by WHO, SHS also contains of three dimensions: physical, mental and social adaption[17].

Lifestyle is an important factor associated with SHS, including smoking, alcohol use, skipping breakfast, poor nutrition, lack of exercise, and sleep problems[18,19]. In SHS, one can prevent a chronic disease by modifying his or her poor lifestyle. China's Blue Book on Self-Care[20] also proved this. Although, we ought to change bad lifestyle when we aware of those bad effects for health, actually this is difficult to achieve in practice[21,22]. Studies revealed that better knowledge and strong belief improves adherence to lifestyle changes[23,24], and preventing and controlling of chronic diseases[25,26]. Better knowledge and strong belief are important expression of health consciousness. Health consciousness is related with anxiety, stress, depression, and non-treated diseases[27]. However, to our knowledge, we haven't found studies about the association of health consciousness and SHS. What's more, a person may present different sub-health states in physical, mental and social adaptation, it is necessary to analyze SHS separately. We may want to know, whether improved health consciousness is associated with better lifestyle and less physical, mental and social SHS? Is there a mediating effect of health consciousness on the association of lifestyle with physical, mental and social SHS? This study used structural equation models to clarify these questions on a basis of a national representative sample of Chinese urban residents.

Methods

Study design and population

A cross-sectional survey using a four-stage stratified sampling method was conducted from March to September of 2018. 3969 residents age 14 and older who lived in the urban area more than six months in Guangdong, Heilongjiang and Sichuan provinces participated in this research. Of these, 389 participants were excluded for confirmed diseases in the last two months, 43 were excluded for missing values of lifestyle,

health consciousness, and SHS items. Finally, 3535 urban residents were analyzed, and the valid response rate was 89·1%. Every participant was volunteered, provided verbal consent prior to data collection, and could refuse to participate anytime. They were also invited to give advices of the questionnaire. This study was approved by Medical Ethics committee of Nanfang Hospital of Southern medical university (No. NFEC-2019-196). All data were kept strictly confidential.

Patient and Public Involvement

We established a participant Involvement mechanism. Each meeting and discussion we actively invited some of the participants in the research to discuss items of the questionnaire. Also, we asked investigators to record all questions that participants asked and questioned in the investigation. Although we couldn't feedback the SHS to every respondent for anonymous of this study, the participants and each urban resident will know their SHS as we established the norm of SHS for urban residents[28] and methods to prevent SHS by means of findings in this study.

Sample size

According to the detecting rate of SHS in Guangdong province[29] (65.5%), we estimated the sample size of each site of investigation by the sample size formula[30]:

$$n = \frac{\mu_\alpha^2 \rho(1-\rho)}{\delta^2} \quad (1)$$

with type I error α of 0.05, maximum permissible error of 0.03. The sample size of each site was no less than 965.

Survey instrument

A self-designed questionnaire was used for investigation, which was comprised of four parts: general demographic characteristics, consisting of age, gender, marital status, highest education level, per capita monthly household income, and insurance;

lifestyle(LS), including smoking, bad diet habit, alcohol intake, breakfast consumption, physical exercise, early to bed (before 11 pm), and sleep time; health consciousness, (HC) containing health knowledge, care for health, and effect of leisure promoting health; and sub-health measurement scale (SHMS) V1·0. The questionnaire was completed by each volunteer within 30 min. Verbal consents were deemed to be sufficient because the participants had volunteered for the study and could refuse to take part if they wished. The objective of the survey was to study the health status rather than to intervene. All data were kept strictly confidential. The ethics committee also approved the consent procedure.

SHS assessment

Sub-health status assessment was performed by SHMS V1·0 which was developed by our research group. It comprise of 39 items[17], and proved to be high reliability and validity in a Chinese population [31]. SHMS V1.0 consists of three subscales, physical sub-health status (PS), mental sub-health status (MS) and social sub-health status (SS). PS comprises of four factors: physical condition, organ function, body movement function and vigor out of 14 items. MS comprises of three factors: positive emotion, psychological symptoms and cognitive function out of 12 items. SS comprises of three factors: social adjustment, social resources and social support out of 9 items. For each item, there are five response categories (defined as ‘none’, ‘occasionally’, ‘sometimes’, ‘constantly’ and ‘always’) corresponding, respectively, to the frequency of occurrence of each symptom. In the data analysis, ‘none’ was assigned a score of 1, ‘occasionally’ 2, ‘sometimes’ 3, ‘constantly’ 4 and ‘always’ 5. Participants were asked about uncomfortable symptoms that they had experienced during the previous month. The total scores were then calculated. A low total score represents a low estimate of SHS (ie, poor health).

Lifestyle evaluation

Smoking was comprised of never smoke, quit, smoking with less 20 cigarettes a day, smoking with 20 cigarettes and more a day. Bad diet habit was divided into yes (if any one of the following seven situations exist: irregular eating time, dieting, overeating, dietary bias or pickiness, salty tasty, spicy tasty, and using snacks instead of meals), and no (without any situations exist). Alcohol intake was divided into never, occasionally, little alcohol every day, some alcohol every day, and much alcohol every day. Breakfast consumption, physical exercise and early to bed were all comprised of never, occasionally (one or two days a week), sometimes (three or four days a week), frequently (five or six days a week) and everyday. Sleep time were divided into five groups, <3hours/day, <5hours/day, <7hours/day, <9hours/day, and ⩾9hours/day.

Health consciousness evaluation

Health knowledge and attention to health consisted of very few/low, few/low, general, much/high and very much/high. Effect of leisure on health consisted of no effect, some effect and very effective.

Quality control and Data management

Investigators of each site were unified trained through face-to-face, video conferencing and telephone. Before the investigation, making sure that purpose and importance of the investigation and verbal informed consent were all detailed informed to the participants. Questionnaires were answered independently by respondents according to their own understanding, and re-answered for those missing data after checking by investigators. Before data coding and data entry, suspicious duplicate questionnaires with a repetition rate higher than 80% and completion rate lower than 80% were excluded. All questionnaire data were double-entered via

Epidata 3.1 software. The two data sets were cross compared for validity and errors.

Statistical analysis

Description was using means (standard deviations) and proportions. A one-way ANOVA with LSD multiple comparisons was used for comparisons. Structural equation modeling (SEM) was used to analyze the complexity of associations between lifestyle, health consciousness, and SHS. The relative χ^2 (CMIN/DF), the root mean-square error of approximation (RMSEA), the comparative fit index (CFI), the goodness-of-fit index (GFI), and the adjusted goodness-of-fit index (AGFI) were used to assessing model fit. The bootstrapping method of repeat sampling by 2000 times was applied to verify statistical significance and calculate the confidence intervals for the direct, indirect, and total effects. Participants with missing data were deleted from analysis. All *P*-values were two sided, with values <0.05 considered statistically significant. IBM SPSS Statistics 20·0 was used for the descriptive analysis. The SEM analysis was conducted with AMOS (SPSS Statistics version 20·0, SPSS Inc., Chicago, IL).

Results

Participants' demographic characteristics

Baseline characteristics of all study participants are presented in Table 1. Of the 3535 participants ,1746 (49.4%) were men and 1789 (50.6%) were women. The mean age was 38·91±14·23 years. Most of the participants (64·30%) were married. Participants with per capita monthly household income (RMB) less than 5000 RMB were 1939(54·85%). Participants with compulsory school (through grade 9), high school graduation, junior college degree, or university or college degree were 847 (23·96%), 764 (21·61%), 803 (22·72%) and 1117 (31·60%), respectively.

Association of lifestyle, health consciousness, and SHS

The mean (SD) of the overall SHS, PS, MS and SS transformed scores were 66.50 (11·99), 70.45 (12·80), 66.62 (14·28), and 60.21 (15·56), respectively. The ANOVA results showed that various groups of lifestyle and health consciousness differed on physical SHS, mental SHS, and social SHS, (Table 2). People who never smoked had the highest physical and social SHS scores; however, participants who quit smoking had lower physical, mental, and social SHS scores than participants who were still smoking. People who had bad diet habits and consumed the most alcohol had the lowest physical, mental, and social SHS scores. Physical, mental, and social SHS scores were higher for participants who regularly consumed breakfast, engaged in regular physical exercise, had early bedtimes (i.e., before 11 P.M.), and longer sleep duration.

SEM analysis of lifestyle, health consciousness, and SHS

We analyzed the association of lifestyle, health consciousness, and SHS by using SEM models (Figure). Three models were fitted reasonably well to the data. As shown in the figures: (1) all indicator variables that we hypothesized as predictors were significantly related to their respective latent factors, P<0·001; (2) lifestyle had a direct negative association with PS (β: -0·21, P<0·001) and SS (β: -0·07, P: 0·019), but no direct association with MS (β: -0·05, P: 0·11); (3) health consciousness had direct positive association with PS (β: 0·48, P<0·001), MS (β: 0·60, P<0·001), and SS (β: 0·56, P<0·001) , and mediating effects on the association of lifestyle with PS, MS and SS.

The association paths of lifestyle and health consciousness on SHS are presented in Table 3. Although, lifestyle and health consciousness were both associated with SHS, health consciousness had larger associations with PS (β: 0·480), MS (β: 0·601), and SS (β: 0·559) than lifestyle (β: -0·441, -0·352, -0·356 respectively). Association of

lifestyle and PS could be direct (β: -0·207; 95%CI: -0·273 to -0·140)) and indirect (β: -0·233; 95%CI: -0·291 to -0·187), with larger indirect association than direct association. However, we only Lifestyle impacted MS only indirectly (β: -0·302; 95%CI: -0·369 to -0·254) though health consciousness. Although lifestyle impacted SS both directly (β: -0·075; 95%*CI*: -0·137 to -0·008) and indirectly (β: -0·281; 95%CI: -0·340 to -0·235), the direct impact was weak.

Discussion

In this large cross-sectional study of a nationally representative sample, we found that lifestyle health consciousness showed significantly mediating effects on the association of lifestyle with PS, MS and SS. The direct association of PS, MS and SS with health consciousness were all significantly higher than with lifestyle. However, lifestyle only associated with PS moderately and SS faintly. No significant association was found between lifestyle and MS.

SHS is a subjective feeling and lacks objective clinical diagnostics, and self-assessed by questionnaire as the most appropriate method. SHMS V1·0 is a multidimensional scale that includes physical, mental, and social dimensions that correspond to the WHO's more comprehensive definition of health [32], and is widely used in China for assessing of SHS in urban residents, workers and students[10,11,17,19]. We found that Chinese residents had low score in PS, MS and SS, which means high risk of SHS in physical, mental and social adaption.

To the best of our knowledge, this is the first national representative analyzation of the mediating effect of health consciousness on the association of lifestyle with physical, mental and social SHS. All variables included in lifestyle and health consciousness were significantly associated with lifestyle and health consciousness. Urban residents with unhealthy lifestyle, such as smoking, alcohol intake, bad diet

habits, irregular breakfast consumption, less physical exercises, less frequent early to bed, and short of sleep time were more likely to get into PS, MS and SS. A study [32]revealed that breakfast eating habits are significantly associated with lifestyle and appear to be a useful predictor of a healthy lifestyle. People who skip breakfast are prone to unhealthy behaviors, such as limited exercise [33]. Insufficient sleep is associated with several health-risk behaviors[34], such as not meeting physical activity recommendations[35], using cigarettes and alcohol, and feeling sad or hopeless[36]. A poor diet was the third greatest influencing factor for physical and social health in this study, which was in line with previous studies[37,38].

This study firstly investigated significant associations of health consciousness with PS, MS and SS, which were relatively larger than those of lifestyle. Health consciousness, in this study, included three factors of health knowledge, attention to health, and effect of leisure on health. As the internal power of healthy behavior, health consciousness is the most important and fundamental reason to promote health. One who had more health knowledge believed they had control over their health[39].

The most important finding was that health consciousness played mediating effect in the relationship of lifestyle with physical, mental and social SHS. Studies have shown health consciousness is correlated with health behavior, information seeking and health coping[40]. Modify attitudes are effective for promoting health behavior change[41]. Already-health conscious are attentive to health warnings about the risks of unhealthy lifestyle, such as alcohol consumption[42].

Conclusions

In this large representative cross-sectional study of Chinese urban residents, we found that associations of physical, mental and social SHS with health consciousness were all much stronger than those of lifestyle. Lifestyle showed no direct association

with mental SHS, and only faintly direct association with social SHS. What's more, health consciousness played mediating effect in the relationship of lifestyle with physical，mental and social SHS. Health consciousness was much more important in preventing of physical, mental and social SHS than lifestyle itself, and might be a useful way to change unhealthy lifestyle and reducing the influence of poor lifestyle on physical, mental and social SHS.

Limitations

There are still some limitations in this study. First, although this is a face-to-face interview, all data were collected from a respondent-completed questionnaire, responses may comprise a level of inherent inaccuracy or bias. Second, although this survey used a four-stage stratified sampling method to minimize sampling error, it is inevitable. Moreover, this study couldn't include all but only seven most common lifestyle factors.

Contributors XJ developed the questionnaire and study design, supervised the analysis and contributed to the final version of the manuscript. XYL did the analyses and wrote the first draft. LGH, FYF, XMY, LYQ and JLJ were in charge of the investigation. All authors contributed to and read the final draft of the manuscript.

Competing interests No declared

Patient consent for publication Not required

Ethics approval Ethics approval to collect the patients' data was obtained from the Ethics Committee of the NanFang Hospital of Southern Medical University (NFEC-2019-196).

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Table 1 Participant's demographic characteristics (n=3535)

Characteristic	*N*	%
Gender		
Man	1746	49·39
Woman	1789	50·61
Age		
14-24	637	18·02
25-34	791	22·38
35-44	915	25·88
45-54	720	20·37
≥55	460	13·01
Information missing	12	0·34
Married status		
Unmarried	1049	29·67
Married	2273	64·30
Divorced	108	3·06
Widowed	82	2·32
Information missing	23	0·65
Per capita monthly household income (RMB)		
<5000	1939	54·85
>=5000	1561	44·16
Information missing	35	0·99
Highest education level		
Compulsory school (through grade 9)	847	23·96
High school graduation	764	21·61
Junior college degree	803	22·72
University/college degree	1117	31·60
Information missing	4	0·11

Table 2 Group comparisons of lifestyle, health consciousness, and SHS

Variates	*N*	PS Mean(SE)	MS Mean(SE)	SS Mean(SE)
Smoking				
Never	2333	71·12(12·52) #	66·74(14·12) #	60·96(15·28) #
Quit	409	67·1(13·59) *^	64·46(14·84) *^	55·98(16·59) *^$
<20 cigarettes /day	700	70·29(12·89) #	67·37(14·41) #	60·17(15·33) #
⩾ 20 cigarettes /day	93	69·45(13·11)	67·36(14·15)	60·48(16·95) #
Bad diet habits				
No	1896	72·89(12·75) *	69·75(13·88) *	62·93(14·77) *
Yes	1639	67·62(12·27)	63(13·88)	57·06(15·86)
Alcohol intake				
Never	1116	71·31(13·46) ^$&	67·3(14·37) ^&	61·04(16·2) ^&
Occasionally	1988	70·65(12·05) ^&	66·69(13·92) ^&	60·18(14·85) &
Little everyday	297	67·53(14) *#	64·86(15·81) *#	58·69(16·74) *&
Some everyday	83	68·2(12·89) *	65·44(14·05)	59·27(14·39) &
Much everyday	51	63·97(14·59) *#	61·27(15·83) *#	53·54(20·67) *#^$
Breakfast consumption				
Never	103	67·23(15·7) $&	62·62(15·65) $&	53·34(18·32) $&
Occasionally	419	66·54(12·8) $&	62·43(13·83) $&	54·06(16·59) $&
Sometimes	601	67·57(12·19) $&	62·15(13·02) $&	55·8(15·29) $&
Frequently	865	70·66(11·65) *#^&	66·46(13·25) *#^&	60·61(14·21) *#^&
Everyday	1547	72·72(12·93) *#^$	69·85(14·51) *#^$	63·82(14·82) *#^$
Physical exercise				
Never	567	68·38(13·51) #^$&	64·6(14·37) ^$&	57·82(15·77) #^$&
Occasionally	1453	70·4(11·86) *&	65·81(13·81) $&	59·5(14·55) *$&
Sometimes	857	70·46(13·19) *&	66·8(14·12) *$&	59·89(16·68) *$&
Frequently	358	71·87(13·81) *	69·19(14·99) *#^	63·97(15·18) *#^
Everyday	300	72·86(12·83) *#^	70·78(14·77) *#^	64·6(15·6) *#^
Early to bed				
Never	514	70·79(13·2)	65·95(14·73) &	59·05(15·95)

					$&
	Occasionally	1012	70·24(11·86) &	65·64(13·74) $&	59·41(15·66) $&
	Sometimes	853	69·8(12·76) &	65·23(14·36) $&	59·18(15·89) $&
	Frequently	587	70·17(12·91) &	67·47(13·66) #^&	61·16(14·09) *#^&
	Everyday	569	71·76(13·88) #^$	70·17(14·73) *#^$	63·24(15·6) *#^$
Sleep time					
	<3hours/day	22	56·33(11) ^$&	56·53(10·29) ^$&	46·09(14·79) ^$&
	<5hours/day	108	61·14(13·13) ^$&	56·21(14·34) ^$&	45·32(18·62) ^$&
	<7hours/day	811	66·83(12·35) *#$&	63·86(13·58) *#$&	57·68(15·63) *#$&
	<9hours/day	2278	72·16(12·24) *#^	67·95(14·12) *#^	61·77(14·64) *#^
	⩾9hours/day	316	71·56(14·01) *#^	68·35(14·71) *#^	61·52(16·76) *#^
Health knowledge					
	Very few	930	70·43(12·73) $	65·29(14·71) ^$&	57·47(15·3) #^$&
	Few	1138	69·83(12·69) $&	65·34(13·79) ^$&	58·99(15·26) *^$&
	General	1074	70·05(12·73) $	67·14(14·16) *#$&	61·15(15·46) *#$&
	Much	331	73·39(12·47) *#^	71·41(13·53) *#^&	67·25(14·03) *#^
	Very much	62	73·16(16·12) #	75·57(13·87) *#^$	69·94(18·31) *#^
Care for health					
	Very low	205	67·22(14·81) ^$&	60·62(16·92) ^$&	53·5(17·64) ^$&
	Low	551	67·33(13·52) ^$&	61·99(14·54) ^$&	54·67(16·65) ^$&
	General	1566	69·46(11·97) *#$&	65·44(13·34) *#$&	58·91(14·56) *#$&
	High	971	72·94(12·16) *#^&	70·05(13·18) *#^&	64·67(13·95) *#^&
	Very high	242	76·64(13·15) *#^$	76·15(13·55) *#^$	69·05(14·77) *#^$
Effect of leisure promoting health					
	No effect	437	63·89(12·89) #^	59·2(14·43) #^	50·59(16·77) #^
	Some effect	2463	70·17(12·18) *^	66·27(13·54) *^	60·09(14·44) *^
	Very effective	635	76·04(12·7) *#	73·1(14·18) *#	67·31(15·27) *#

Transformed scores were analyzed here· Statistical analysis included a one-way ANOVA followed by LSD multiple comparisons test· *=P<0·05 as compared to answer code 1; #=P<0·05 as compared to answer code 2; ^=P<0·05 as compared to

answer code 3; $=*P*<0·05 as compared to answer code 4, &=*P*< 0·05 as compared to answer code 5·

Table 3 Influencing path of lifestyle and health consciousness on SHS

SHS	Path way	Mean standardized effects	95%CI		*P*-value
			lower bound	upper bound	
PS					
	LS—PS(total)	-0·441	-0·488	-0·395	<0·001
	LS—PS(direct)	-0·207	-0·273	-0·140	<0·001
	LS—HC—PH(indirect)	-0·233	-0·291	-0·187	<0·001
	HC—PS	0·480	0·402	0·561	<0·001
MS					
	LS—MS(total)	-0·352	-0·396	-0·307	<0·001
	LS—MS(direct)	-0·050	-0·113	0·021	0·158
	LS—HC—MS(indirect)	-0·302	-0·369	-0·254	<0·001
	HC—MS	0·601	0·527	0·679	<0·001
SS					
	LS—SS(total)	-0·356	-0·398	-0·312	<0·001
	LS—SS(direct)	-0·075	-0·137	-0·008	0·029
	LS—HC—SS(indirect)	-0·281	-0·340	-0·235	<0·001
	HC—SS	0·559	0·491	0·635	<0·001

LS=lifestyle behaviors, HC=health consciousness, PS=physical sub-health status, MS=mental sub-health status, SS=social sub-health status

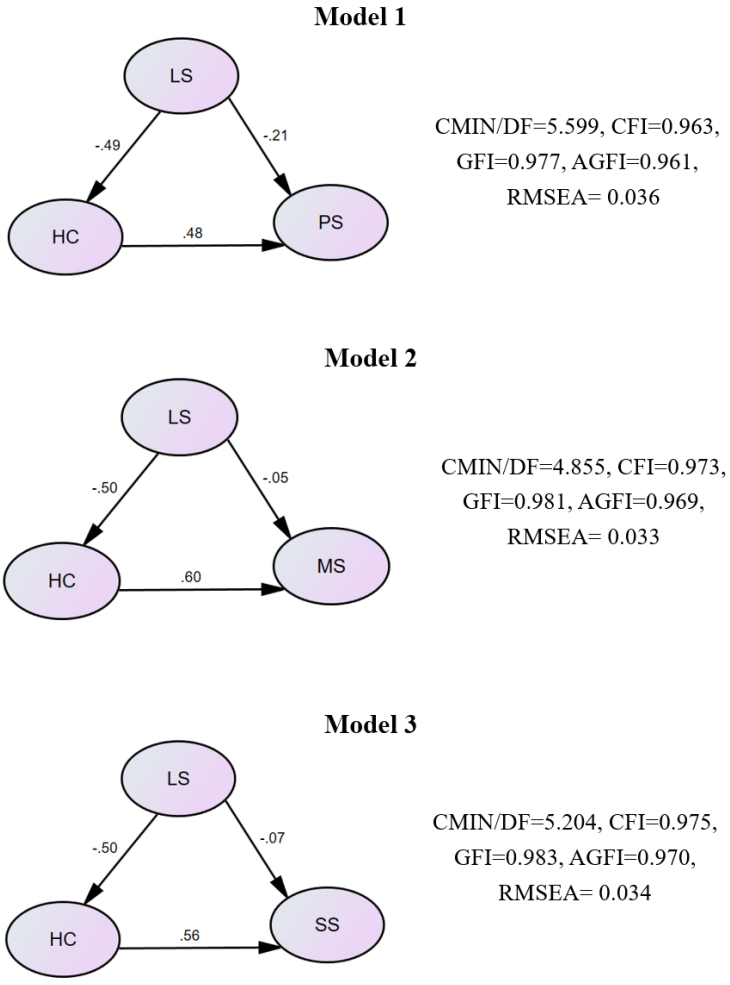

Figure. SEM model of lifestyle, health consciousness and PS (Model 1), MS (Model 2), or SS (Model 3). All the standardized regression coefficients are presented as single-headed arrows, and statistically significant at 0.05 significance level, except for path of LS to MS. Abbreviations: PS, physical sub-health status, MS, mental sub-health status, SS, social sub-health status.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	8
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9

		(b) Indicate number of participants with missing data for each variable of interest	18
Outcome data	15*	Report numbers of outcome events or summary measures	9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	19-20
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12-13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Mediating effect of health consciousness in the relationship of lifestyle and suboptimal health status: A cross-sectional study involving Chinese urban residents

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ABSTRACT

Objective: *Suboptimal health status* (SHS), a third state between good health and disease, can easily develop into chronic diseases, and can be influenced by lifestyle and health consciousness. No study has surveyed the intermediation of health consciousness on the relationship between lifestyle and SHS. This study aimed to analyze the association of lifestyle and SHS, and intermediation of health consciousness in Chinese urban residents.

Design: A cross-sectional face-to-face survey using a four-stage stratified sampling method.

Participants: We investigated 5,803 Chinese urban residents aged 18 years and over. We measured SHS using the Sub-Health Measurement Scale V1.0. We adopted a structural equation model (SEM) to analyze relationships among lifestyle, health consciousness, and SHS. We applied a bootstrapping method to estimate the mediation effect of health consciousness.

Results: Lifestyle had stronger indirect associations with physical (β -0.185, 95% CI -0.228 to -0.149), mental (β -0.224, 95% CI -0.265 to -0.186) and social SHS (β -0.216, 95% CI -0.257 to -0.179) via health consciousness than direct associations of physical (β -0.144, 95% CI -0.209 to -0.081), mental (β -0.146, 95% CI -0.201 to -0.094), and social SHS (β -0.130, 95% CI -0.181 to -0.077). Health consciousness has a strong direct association with physical (β 0.360, 95% CI 0.295 to 0.427), mental (β 0.452, 95% CI 0.392 to 0.510), and social suboptimal health (β 0.434, 95% CI 0.376 to 0.490). Ratio of mediating effect of health consciousness to direct effect of lifestyle with physical, mental, and social SHS was 1.28, 1.53, and 1.66, respectively.

Conclusions: Health consciousness was more important in preventing physical, mental, and social SHS than lifestyle. Therefore, it might be useful in changing

unhealthy lifestyle and reducing the influence of poor lifestyle on physical, mental and social SHS.

Strengths and limitations of this study

- The participants, who were recruited through a cross-sectional survey using a four-stage stratified sampling method, were representative of Chinese urban residents.
- To the best of our knowledge, this is the first national representative analysis of the mediating effect of health consciousness on the association of lifestyle with physical, mental, and social SHS.
- Although we used a four-stage stratified sampling method, sampling errors are still inevitable.
- This study only included the seven most common lifestyle factors.

Keywords: Suboptimal health status, Lifestyle, Health consciousness, Urban residents, China

INTRODUCTION

In 1946, the World Health Organization (WHO) [1] defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." It is reported that non-communicable diseases (NCDs) account for an estimated 80% of the total deaths and 70% of the total number of disability-adjusted life-years (DALYs) in the early twentieth century.[2] Moreover, NCD increase steadily with urbanization and aging, [3] being attributed with more than 88% of total deaths in China in 2019.[4] Furthermore, a study pointed out that NCDs accounted for 18 of the 20 leading causes of age-standardized years lived with disability on a global scale.[5] The preclinical status of NCDs and its early detection have become major issues in the promotion of basic health service in the reform of health care.[6]

Suboptimal health status (SHS), an intermediate status between chronic disease and health, is believed to be a subclinical and reversible stage of chronic disease.[7] People in SHS, although without a diagnosable condition, are characterized by a decline in vitality and physiological function, ambiguous health complaints, general weakness, and lack of vitality. In fact, it has become a new public health challenge in China.[8 9]

It is reported that SHS can be measured objectively using microbiome,[10] telomere length,[11] plasma stress hormones,[12] plasma metabolites,[13] and glycan.[14] However, these objective measures are not easily accessible, and sometimes may not be obvious, especially when people have uncomfortable feelings without abnormal symptoms. A self-rated method that uses a questionnaire is widely applicable in assessing SHS. In China, the sub-health measurement scale (SHMS V1.0), suboptimal health status questionnaire (SHSQ-25)[15] and Chinese sub-health scale (CSHES)[16] were widely used for assessing SHS. However, compared to the other questionnaires, SHMS V1.0

assesses of the physical, mental, and social aspects of SHS, which is in accordance with the health concept proposed by WHO in 1947. SHS has a prevalence of above 65% in China,[17-20] and has become an increasingly concerning problem in many countries.[21 22] Moreover, its prevalence may be severely underestimated since many individuals are not aware that they suffer from SHS. For instance, in an investigation involving 6,000 Chinese self-reported "healthy people," 72.8% were in "suboptimal health status."[23] Thus, identifying the influencing factors of SHS is important in preventing it, and would provide important information for first-level prevention of NCD. In accordance with the definition released by the WHO, SHS has three dimensions: physical, mental and social adaption.[24]

Lifestyle is an important factor associated with SHS. This includes smoking, alcohol use, skipping breakfast, poor nutrition, lack of exercise, and sleep problems.[25 26] In SHS, individuals can prevent a chronic disease by modifying their poor lifestyles, as supported by China's Blue Book on Self-Care.[27] Although, it is a given fact that individuals ought to change their bad lifestyles when experiencing adverse health issures, this is difficult to achieve in practice.[28 29] Studies revealed that better knowledge and strong beliefs improve the adherence to lifestyle changes[30 31] and prevent and control chronic diseases;[32 33] better knowledge and strong beliefs are important expressions of health consciousness.

Health consciousness is a psychological construct that corresponds to the awareness about one's health, and the willingness to change one's behaviors in order to improve it.[34 35] Moreover, it is related to anxiety, stress, depression, and non-treatable diseases.[36] However, to our knowledge, there are on studies anent the association of health consciousness to SHS. People may present different suboptimal health states in their physical, mental, and social adaptation; thus, it is necessary to

analyze SHS separately. We aimed to investigated whether improved health consciousness is associated with better lifestyle and less physical, mental and social SHS. Moreover, we aimed to discover the possible mediating effect of health consciousness on the association of lifestyle with physical, mental, and social SHS. Thus, we used structural equation models to clarify these questions, on the basis of a national representative sample of Chinese urban residents.

METHODS

Study design and population

We conducted a cross-sectional survey using a four-stage stratified sampling method from December 2017 to October 2018. In the first stage, we chose one province each from five administrative divisions in China; we selected Guangdong province, Heilongjiang province, Sichuan province, Gansu province, and Tianjin city. Second, we chose three to four cities from each province by considering their level of economic development and regional distribution. Subsequently, we randomly selected two to four streets in the selected urban areas. Lastly, we investigated the urban residents who conveniently qualified from each street.

This study included individuals aged 18 years and older, who lived in an urban area for more than six months, and volunteered in our investigation. We excluded individuals who had a confirmed disease in the last two months, were unable to complete the questionnaire due to visual or hearing impairment, and with missing values in lifestyle, health consciousness, and SHS items. We investigated a total of 6,578 individuals and excluded 775. Thus, we analyzed a total of 5,803 urban residents. Among them, 1,704, 1,328, 954, 925, and 892 participants were from Guangdong, Heilongjiang, Sichuan, Gansu, and Tianjin provinces, respectively. All participants that volunteered provided their verbal consent prior to data collection, and

were given the option to cease from participating anytime. They were also invited to give advices regarding the questionnaire. This study was approved by Medical Ethics committee of Nanfang Hospital of Southern Medical University (No. NFEC-2019-196). All data were kept strictly confidential.

Patient and Public Involvement

The participants were not involved in the development of the research question or design of this study. However, we disseminated the results of this analysis through public conferences, including summarized statements and open access to the published reports.

Survey instrument

We used a self-designed questionnaire for investigation, which is comprised of four parts: general demographic characteristics, which included age, gender, marital status, highest education level, per capita monthly household income, and insurance; lifestyle, which included smoking, bad diet habit, alcohol intake, breakfast consumption, physical exercise, early to bed (before 11 pm), and sleep time; health consciousness, which included health knowledge, care for health, and effect of leisure promoting health; and sub-health measurement scale (SHMS) V1.0. Each volunteer completed the questionnaire within 30 minutes. Verbal consents were deemed to be sufficient because the participants had volunteered for the study and could refuse to take part if they wished. The objective of the survey was to study the health status of the participants rather than intervene. All data were kept strictly confidential. The ethics committee approved the consent procedure.

SHS assessment

We performed suboptimal health status assessment using SHMS V1.0, which was developed by our research group. It comprised of 39 items[24] that were proven to have

high reliability and validity in a Chinese population.[37] SHMS V1.0 consists of three subscales: physical suboptimal health status (PS), mental suboptimal health status (MS), and social suboptimal health status (SS). PS consists of 14 items that comprises four factors: physical condition, organ function, body movement function, and vigor. MS consists of 12 items that comprises three factors: positive emotion, psychological symptoms, and cognitive function. SS consists of nine items that comprises three factors: social adjustment, social resources, and social support. For each item, there are five response categories (1=*none*, 2=occasionally, 3=sometimes, 4=constantly, and 5=always) that correspond to the frequency of occurrence of each symptom. We asked the participants regarding the uncomfortable symptoms that they had during the previous month. We then calculated the total scores. A low total score represents a low estimate of SHS (i.e., poor health). The cut-off value for suboptimal health diagnosis referred to norms of SHMS V1.0 for Chinese urban residents were established by our research group. [38]

Lifestyle evaluation

Smoking was comprised of none smokers, past smokers, and current smokers. Bad diet habit was divided into "yes" (if any one of the following seven situations exist: irregular eating time, dieting, overeating, dietary bias or pickiness, salty tasty, spicy tasty, and using snacks instead of meals), and "no". Alcohol intake was divided into "never," "occasionally," "little everyday," and "much everyday." Breakfast consumption was comprised of "never," "occasionally" (i.e., one or two days a week), "sometimes" (i.e., three or four days a week), "frequently" (i.e., five or six days a week), and "everyday." Physical exercise was divided into "everyday," "frequently" (i.e., five or six days a week), "sometimes" (i.e., three or four days a week), and "occasionally" (i.e., one or two days a week, and no physical exercise). Sleep time

were divided into three groups, "<7hours/day," "7-9hours/day," and "≥9hours/day. "

Health consciousness evaluation

Health knowledge and attention to health consisted of "very few/low," "few/low," "general," "much/high," and "very much/high." Effect of leisure on health consisted of "no effect," "some effect," and "very effective."

Quality control and Data management

The investigators for each site were trained through face-to-face, video conferencing, and telephone. Before the conduct of the investigation, we made sure that its purpose and importance were explained to the participants in detail, and obtained their verbal informed consent. The respondents answered the questionnaires independently and according to their own understanding, while missing data were re-answered after checking by the investigators. Before data coding and entry, suspicious duplicate questionnaires, which are those with a repetition rate higher than 80% and completion rate lower than 80% were excluded. All questionnaire data were double-entered using Epidata 3.1 software. The two data sets were cross compared for validity and errors.

Statistical analysis

Description was using means (standard deviations) and proportions. We used a one-way ANOVA with LSD-test for multiple comparisons. Cluster effect nested within sampling regions was examined by using interclass correlation coefficient (ICC) calculated in a two-level linear multilevel model. We used structural equation modeling (SEM) to analyze the complexity of associations between lifestyle, health consciousness, and SHS (Model 1: SEM model of lifestyle, health consciousness, and PS; Model 2: SEM model of lifestyle, health consciousness, and MS; Model 3: SEM model of lifestyle, health consciousness, and SS). Mediating effect of health consciousness was the same with indirect association of lifestyle and SHS via health

consciousness. Ratio of mediating effect of health consciousness to direct effect of lifestyle (indirect effect divided by direct effect) and proportion of mediating effect of health consciousness to total effect (indirect effect divided by total effect multiply by a hundred) of lifestyle with physical, mental, and social SHS were also calculated. We used the relative χ^2 (CMIN/DF), root mean-square error of approximation (RMSEA), comparative fit index (CFI), goodness-of-fit index (GFI), and adjusted goodness-of-fit index (AGFI) to assess the model fit. We applied the bootstrapping method of repeat sampling by 2,000 times to verify statistical significance and calculate the confidence intervals for the direct, indirect, and total effects. Participants with missing data were deleted from analysis. All *P*-values were two sided, with values < 0.05 considered as statistically significant. We used IBM SPSS Statistics 20.0 for descriptive analysis. Lastly, we conducted SEM analysis with AMOS (SPSS Statistics version 20·0, SPSS Inc., Chicago, IL).

RESULTS

Participants' demographic characteristics

Baseline characteristics of all study participants are presented in Table 1. Of the 5,803 participants,2,772 (47.77%) were men and 3,031 (52.23%) were women. The mean age was 40.90±15.46 years. Most of the participants (65.98%) were married. Moreover, 1,939 (57.21%) of the participants have a per capita monthly household income (RMB) of less than 5,000 RMB. Participants with compulsory school (up to grade 9), high school, junior college, and university degree and above were 1,341 (23.1%), 1,298 (22.4%), 1,374 (23.7%) and 1,786 (30.8%), respectively.

Association of lifestyle, health consciousness, and SHS

The mean (*SD*) of the overall SHS, PS, MS and SS transformed scores were 67.15 (11.99), 70.92 (12.67), 67.01 (14.55), and 61.46 (15.56), respectively. The ANOVA

results showed that various groups of lifestyle and health consciousness differed on physical SHS, mental SHS, and social SHS (Table 2). People who never smoked had the highest physical and social SHS scores; however, participants who quit smoking had lower physical, mental, and social SHS scores than participants who were still smoking. People who had bad diet habits and consumed the most alcohol had the lowest physical, mental, and social SHS scores. Physical, mental, and social SHS scores were higher for participants who regularly consumed breakfast, engaged in regular physical exercise, had early bedtimes (i.e., before 11 P.M.), and longer sleep duration.

SEM analysis of lifestyle, health consciousness, and SHS

Because we used the multi-stage sampling method in this study, there might be a cluster effect nested within sampling regions. We examined ICC and its significance using a two-level linear multilevel model. For physical, mental, and social SHS, there was no cluster effect in the regions, while the ICC was 0.028, 0.01, and 0.035, with P values of 0.085, 0.103, and 0.084, respectively. Thus, traditional SEM models could be used in the analysis of the association of lifestyle, health consciousness, and SHS (Figure 1). Three models fit reasonably well to the data. As shown in the models: (1) all indicator variables that we hypothesized as predictors were significantly related to their respective latent factors, $P < 0.001$; (2) lifestyle had a direct negative association with PS (β -0.14, $P<0.001$), MS (β -0.15, $P < 0.001$) and SS (β -0.13, P 0.001); (3) health consciousness had direct positive association with PS (β 0.36, $P < 0.001$), MS (β 0.452, $P < 0.001$), and SS (β 0.434, $P < 0.001$), and mediating effects on the association of lifestyle with PS, MS and SS.

The association paths of lifestyle and health consciousness on SHS are presented in Table 3. Although lifestyle and health consciousness were both associated with SHS,

health consciousness had larger associations with PS (β 0.360), MS (β 0.452), and SS (β 0.434) than lifestyle (β -0.329, -0.370, and -0.345 respectively). Association of lifestyle and PS could be direct (β -0.144, 95% CI -0.209 to -0.081)) and indirect (β -0.185, 95% CI -0.228 to -0.149), with faintly larger indirect association than direct association. However, the indirect association (β -0.224, 95% CI -0.265 to -0.186) of lifestyle and MS was obviously higher than direct association (β -0.146, 95% CI -0.201 to -0.094). The same higher indirect association (β -0.216, 95% CI -0.257 to -0.179) was found in the association of lifestyle and SS than direct association (β -0.130, 95% CI -0.181 to -0.077). Ratio of mediating effect of health consciousness to direct effect of lifestyle with physical, mental, and social SHS was 1.28, 1.53, and 1.66, respectively. Proportion of mediating effect of health consciousness to total effect of lifestyle with physical, mental, and social SHS was 56.23%, 60.54%, and 62.61%, respectively.

DISCUSSION

In this large cross-sectional study involving a nationally representative sample, we found that lifestyle health consciousness showed significantly mediating effects on the association of lifestyle with PS, MS and SS. The direct associations of PS, MS, and SS with health consciousness were all significantly higher than lifestyle. However, the indirect associations of lifestyle with PS, MS and SS were higher than indirect associations via health consciousness.

SHS is a subjective feeling that lacks objective clinical diagnostics; thus, a self-assessed questionnaire is the most appropriate method of determining it. SHMS V1.0 is a multidimensional scale that includes physical, mental, and social dimensions that correspond to the WHO's more comprehensive definition of health.[39] Moreover, it is widely used in China for assessing SHS in urban residents, workers and

students.[17 18 24 26] We found that Chinese urban residents had low scores in PS, MS and SS, which means that they are at high risk to SHS in physical, mental, and social adaption. This result is in accordance with other studies involving young and middle-aged intellectuals in Guangzhou,[40] Chinese migrant workers,[41] and those that use other SHS evaluation questionnaires in China, such as the SHSQ-25.[6 9] Similarly, African[14] and Caucasian[42] studies showed the same SHS rate.

To the best of our knowledge, this is the first national representative analysis of the mediating effect of health consciousness on the association of lifestyle with physical, mental and social SHS. All variables included in lifestyle and health consciousness were accordingly significantly associated. Urban residents who engage in unhealthy lifestyle practices, such as smoking, alcohol intake, bad diet habits, irregular breakfast consumption, less physical exercises, less frequent early to bed, and short sleep time were more likely to get into PS, MS and SS. A study[39] revealed that breakfast eating habits are significantly associated with lifestyle, and appear to be a useful predictor of a healthy lifestyle; people who skip breakfast are prone to unhealthy behaviors, such as limited exercise.[43] Moreover, insufficient sleep is associated with several health-risk behaviors,[44] such as not meeting physical activity recommendations,[45] using cigarettes and alcohol, and feeling sad or hopeless.[46] Furthermore, poor diet was the third greatest influencing factor for physical and social health, which was in line with previous studies.[47 48]

This study investigated the significant associations of health consciousness with PS, MS, and SS, which were relatively more significant than those of lifestyle. Moreover, in this study, health consciousness, included health knowledge, attention to health, and effect of leisure on health. As the internal power of healthy behavior, health consciousness is the most important and fundamental factor in promoting health. In

fact, individuals who had more health knowledge believed that they had control over their health.[49]

The most important finding was that health consciousness played a mediating effect in the relationship of lifestyle with physical, mental and social SHS, which was higher than direct effect of lifestyle. Studies have shown that health consciousness is correlated with health behavior, information seeking and health coping.[50] Modifying the attitudes is effective in promoting changes in health behavior,[51] since health-conscious people are attentive to health warnings regarding the risks of having an unhealthy lifestyle.[52]

Limitations

This study has some limitations. First, although we used face-to-face interviews, all data were collected from a respondent-completed questionnaire; thus, responses may have a level of inherent inaccuracy or bias. Second, although we used a four-stage stratified sampling method, sampling errors are still inevitable. Lastly, this study only included the seven most common lifestyle factors.

CONCLUSION

In this large representative cross-sectional study of Chinese urban residents, we found that direct association of lifestyle with physical, mental, and social SHS were smaller than direct association and mediating effect of health consciousness. Moreover, health consciousness was more important in preventing physical, mental, and social SHS than lifestyle, and might be useful in changing unhealthy lifestyle and reducing the influence of poor lifestyle on physical, mental, and social SHS.

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Role of the funding source

The sponsors of the study had no role in the study design, data collection, data analysis, or data interpretation. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Competing Interests

No declared

Author Contributions

XJ developed the questionnaire and study design, supervised the analysis and contributed to the final version of the manuscript. XYL did the analyses and wrote the first draft. LGH, FYF, XMY, LYQ and JLJ were in charge of the investigation. All authors contributed to and read the final draft of the manuscript.

Patient consent for publication

Not required

Ethics approval

Ethics approval to collect the patients' data was obtained from the Ethics Committee of the NanFang Hospital of Southern Medical University (NFEC-2019-196).

Data availability statement

Data are available upon reasonable request. Data are available upon reasonable request. Readers can contact Xu Jun (drugstat@163.com) to submit raw data access requirements.

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Table 1 Participant's demographic characteristics (*n*=3535)

Characteristic	*N*	%
Gender		
Man	2772	47.77
Woman	3031	52.23
Married status		
Unmarried	1556	26.81
Married	3829	65.98
Divorced or widows	386	6.65
Information missing	32	0.55
Per capita monthly household income (RMB)		
<5000	3320	57.21
>=5000	2419	41.69
Information missing	64	1.10
Highest education level		
Compulsory school (through grade 9)	1343	23.14
High school graduation	1298	22.37
Junior college degree	1374	23.68
University degree and above	1786	30.78
Information missing	2	0.03

Table 2 Group comparisons of lifestyle, health consciousness, and SHS

Variates	*N*	PS Mean(SE)	MS Mean(SE)	SS Mean(SE)
Smoking				
Never	3987	71.56(12.48)$^{\#\wedge}$	67.13(14.46)$^{\#}$	62.15(15.16)$^{\#\wedge}$
Quit	614	68.32(13.49)$^{*\wedge\$}$	65.41(15.11)$^{*\wedge\$}$	58.38(17.2)$^{*\wedge}$
<20 cigarettes /day	1027	70.31(12.67)$^{*\#}$	67.4(14.44)$^{\#}$	60.93(15.53)$^{*\#}$
⩾ 20 cigarettes /day	164	70.85(12.90)$^{\#}$	68.26(15.44)$^{\#}$	61.02(17.86)
Bad diet habits				
No	3357	73.1(12.52)$^{\#}$	70.2(14.14)$^{\#}$	64.19(14.77)$^{\#}$
Yes	2446	67.92(12.25)*	62.64(13.97)*	57.71(15.84)*
Alcohol intake				
Never	2077	71.93(13.13)$^{\#\wedge\$\&}$	68.18(14.66)$^{\#\wedge\$\&}$	62.61(15.78)$^{\#\wedge\&}$
Occasionally	3099	70.86(12.06)$^{*\wedge\$\&}$	66.55(14.21)$^{*\&}$	61.15(15.11)$^{*\&}$
Little everyday	421	68.85(13.65)$^{*\#\&}$	66.29(15.75)$^{*\&}$	59.93(16.69)$^{*\&}$
Some everyday	106	68.35(12.88)$^{*\#\&}$	65.17(13.79)$^{*\&}$	60.27(14.29)$^{\&}$
Much everyday	72	63.47(14.37)$^{*\#\wedge\$}$	60.1(16.45)$^{*\#\wedge\$}$	53.97(20.69)$^{*\#\wedge\$}$
Breakfast consumption				
Never	139	67.93(15.07)$^{\$\&}$	62.4(17.25)$^{\$\&}$	53.46(19.83)$^{\wedge\$\&}$
Occasionally	600	66.88(12.63)$^{\$\&}$	62.69(14.12)$^{\$\&}$	55.79(16.70)$^{\$\&}$
Sometimes	830	68.03(11.99)$^{\$\&}$	61.81(13.07)$^{\$\&}$	56.37(15.38)$^{*\$\&}$
Frequently	1539	71.07(11.94)$^{*\#\wedge\&}$	66.48(14.01)$^{*\#\wedge\&}$	61.75(14.52)$^{*\#\wedge\&}$
Everyday	2671	72.91(12.73)$^{*\#\wedge\$}$	70.22(14.46)$^{*\#\wedge\$}$	64.69(14.75)$^{*\#\wedge\$}$
Physical exercise				
Never	848	68.55(13.27)$^{\#\wedge\$\&}$	64.24(14.4)$^{\#\wedge\$\&}$	58.21(15.68)$^{\#\wedge\$\&}$
Occasionally	2338	70.43(11.78)$^{*\$\&}$	65.54(13.92)$^{*\wedge\$\&}$	60.36(14.45)$^{*\wedge\$\&}$
Sometimes	1373	71.26(13.11)$^{*\&}$	67.54(14.53)$^{*\#\$}$	61.51(16.75)$^{*\#\$\&}$
Frequently	608	71.77(13.03)$^{*\#\&}$	68.72(14.85)$^{*\#\wedge}$	64.57(15.24)$^{*\#\wedge\&}$
Everyday	627	74.73(12.73)$^{*\#\wedge\$}$	73.53(14.82)$^{*\#\wedge\$}$	67.12(15.11)$^{*\#\wedge\$}$
Early to bed				
Never	947	70.29(12.36)$^{\$\&}$	64.8(14.74)$^{\$\&}$	59.72(15.61)$^{\$\&}$
Occasionally	1512	70.3(11.94)$^{\$\&}$	65.57(13.71)$^{\$\&}$	60.08(15.33)$^{\$\&}$
Sometimes	1224	70.01(12.84)$^{\$\&}$	65.84(14.46)$^{*\#\$\&}$	60.47(15.99)$^{\$\&}$
Frequently	997	71.49(12.76)$^{*\#\wedge\&}$	68.36(14.46)$^{*\#\wedge\&}$	63.07(14.79)$^{*\#\wedge\&}$
Everyday	1113	72.98(13.39)$^{*\#\wedge\$}$	70.99(14.84)$^{*\#\wedge\$}$	64.52(15.49)$^{*\#\wedge\$}$
Sleep time				
<3hours/day	35	62.96(12.11)$^{\wedge\$\&}$	58.87(13.81)$^{\wedge\$\&}$	49.68(20.42)$^{\wedge\$\&}$
<5hours/day	145	62.44(12.88)$^{\wedge\$\&}$	56.97(14.78)$^{\wedge\$\&}$	48.51(18.88)$^{\wedge\$\&}$
<7hours/day	1377	67.89(12.34)$^{*\#\$\&}$	64.88(14.09)$^{*\#\$\&}$	59.86(15.83)$^{*\#\$\&}$
<9hours/day	3748	72.47(12.29)$^{*\#\wedge\&}$	68.14(14.38)$^{*\#\wedge}$	62.65(14.82)$^{*\#\wedge}$
⩾9hours/day	492	71.09(13.67)$^{*\#\wedge\$}$	68.15(15.30)$^{*\#\wedge}$	61.95(16.59)$^{*\#\wedge}$
Health knowledge				
Very few	1332	70.27(12.55)$^{\$\&}$	65.17(14.79)$^{\wedge\$\&}$	58.31(15.43)$^{\#\wedge\$\&}$
Few	1794	70.38(12.51)$^{\$\&}$	65.77(14.27)$^{\wedge\$\&}$	60.13(15.41)$^{*\wedge\$\&}$
General	1913	70.71(12.52)$^{\$\&}$	67.54(14.37)$^{*\#\$\&}$	62.55(15.13)$^{*\#\$\&}$

Much	628	74.11(12.58)*#^	71.47(13.79)*#^&	67.2(14.62)*#^&
Very much	120	74.65(15.97)*#^	75.26(15.28)*#^$	70.61(18.46)*#^$
Care for health				
Very low	329	67.73(14.32)^$&	61.09(16.65)^$&	55.25(17.71)^$&
Low	789	67.61(13.11)^$&	62.33(14.42)^$&	56.1(16.47)^$&
General	2485	69.5(11.9)*#$&	65.37(13.69)*#$&	59.76(14.35)*#$&
High	1752	73.66(12)*#^&	70.3(13.74)*#^&	65.28(14.44)*#^&
Very high	437	76.86(13.36)*#^$	76.27(14.12)*#^$	70.57(15.73)*#^$
Effect of leisure promoting health				
No effect	733	65.7(12.87)#^	60.94(14.56)#^	54.24(17.22)#^
Some effect	3870	70.37(12.04)*^	66.1(13.76)*^	60.68(14.39)*^
Very effective	1163	76.39(12.75)*#	74.11(14.58)*#	69(15.28)*#

Transformed scores were analyzed here. Statistical analysis included a one-way ANOVA followed by LSD multiple comparisons test. *: $P < 0.05$ as compared to answer code 1; #: $P < 0.05$ as compared to answer code 2; ^: $P < 0.05$ as compared to answer code 3; $: $P < 0.05$ as compared to answer code 4, &: $P < 0.05$ as compared to answer code 5.

Table 3 Influencing path of lifestyle and health consciousness on SHS

SHS	Path way	Mean standardized effects	95%CI		*P*-value
			lower bound	upper bound	
PS					
	Lifestyle—PS(total)	-0.329	-0.385	-0.278	<0.001
	Lifestyle—PS(direct)	-0.144	-0.209	-0.081	<0.001
	Lifestyle—Health consciousness—PS(indirect)	-0.185	-0.228	-0.149	<0.001
	Health consciousness—PS	0.360	0.295	0.427	<0.001
MS					
	Lifestyle—MS(total)	-0.370	-0.408	-0.330	<0.001
	Lifestyle—MS(direct)	-0.146	-0.201	-0.094	0.001
	Lifestyle—Health consciousness—MS(indirect)	-0.224	-0.265	-0.186	<0.001
	Health consciousness—MS	0.452	0.392	0.510	<0.001
SS					
	Lifestyle—SS(total)	-0.345	-0.383	-0.308	<0.001
	Lifestyle—SS(direct)	-0.130	-0.181	-0.077	0.001
	Lifestyle—Health consciousness—SS(indirect)	-0.216	-0.257	-0.179	<0.001
	Health consciousness—SS	0.434	0.376	0.490	<0.001

PS = physical suboptimal health status, MS = mental suboptimal health status, SS = social suboptimal health status

Figure 1. SEM model of lifestyle, health consciousness and PS (Model 1), MS (Model 2), or SS (Model 3). All the standardized regression coefficients are presented as single-headed arrows, and statistically significant at 0.05 significance level. Abbreviations: PS= physical sub-health status, MS=mental sub-health status, SS=social sub-health status.

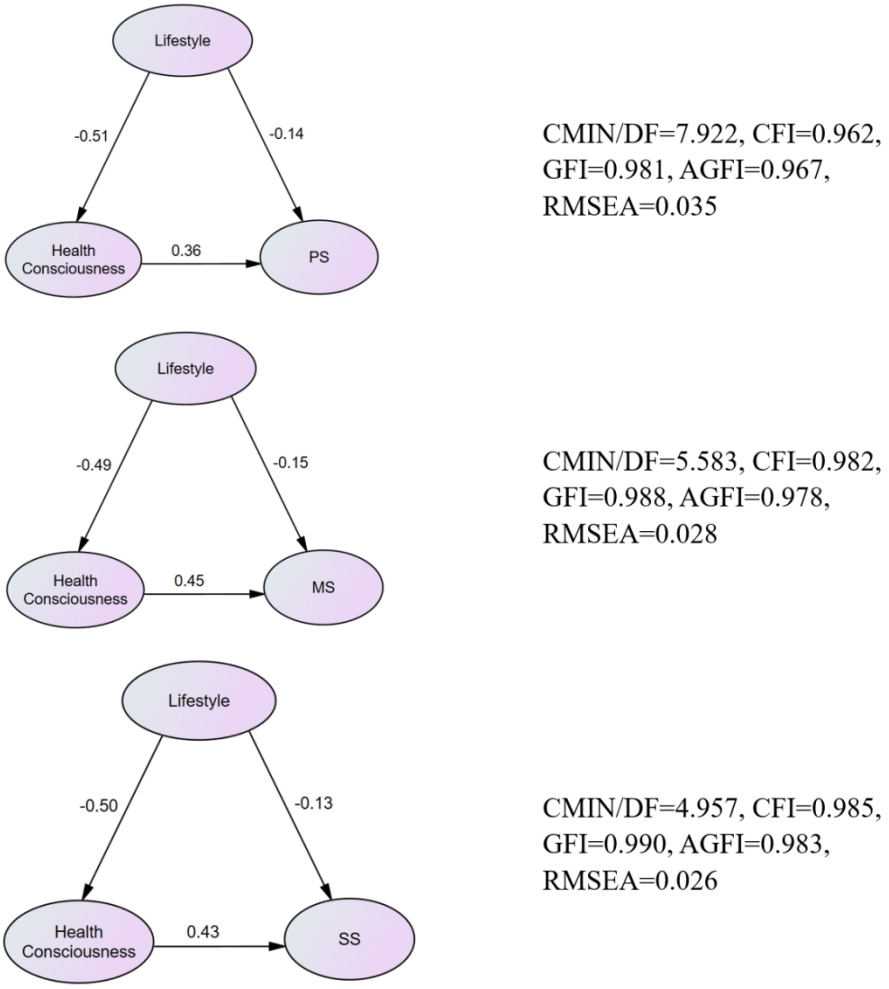

Figure 1. SEM model of lifestyle, health consciousness and PS (Model 1), MS (Model 2), or SS (Model 3). All the standardized regression coefficients are presented as single-headed arrows, and statistically significant at 0.05 significance level. Abbreviations: PS= physical sub-health status, MS=mental sub-health status, SS=social sub-health status.

SEM model of lifestyle, health consciousness and PS (Model 1), MS (Model 2), or SS (Model 3). All the standardized regression coefficients are presented as single-headed arrows, and statistically significant at 0.05 significance level. Abbreviations: PS= physical sub-health status, MS=mental sub-health status, SS=social sub-health status.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10

		(b) Indicate number of participants with missing data for each variable of interest	21
Outcome data	15*	Report numbers of outcome events or summary measures	10-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12, 22-24
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Mediating effect of health consciousness in the relationship of lifestyle and suboptimal health status: A cross-sectional study involving Chinese urban residents

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ABSTRACT

Objective: *Suboptimal health status* (SHS), a third state between good health and disease, can easily develop into chronic diseases, and can be influenced by lifestyle and health consciousness. No study has surveyed the intermediation of health consciousness on the relationship between lifestyle and SHS. This study aimed to analyze the association of lifestyle and SHS, and intermediation of health consciousness in Chinese urban residents.

Design: A cross-sectional face-to-face survey using a four-stage stratified sampling method.

Participants: We investigated 5,803 Chinese urban residents aged 18 years and over. We measured SHS using the Sub-Health Measurement Scale V1.0. We adopted a structural equation model (SEM) to analyze relationships among lifestyle, health consciousness, and SHS. We applied a bootstrapping method to estimate the mediation effect of health consciousness.

Results: Lifestyle had stronger indirect associations with physical (β -0.185, 95% CI -0.228 to -0.149), mental (β -0.224, 95% CI -0.265 to -0.186) and social SHS (β -0.216, 95% CI -0.257 to -0.179) via health consciousness than direct associations of physical (β -0.144, 95% CI -0.209 to -0.081), mental (β -0.146, 95% CI -0.201 to -0.094), and social SHS (β -0.130, 95% CI -0.181 to -0.077). Health consciousness has a strong direct association with physical (β 0.360, 95% CI 0.295 to 0.427), mental (β 0.452, 95% CI 0.392 to 0.510), and social suboptimal health (β 0.434, 95% CI 0.376 to 0.490). Ratio of mediating effect of health consciousness to direct effect of lifestyle with physical, mental, and social SHS was 1.28, 1.53, and 1.66, respectively.

Conclusions: Health consciousness was more important in preventing physical, mental, and social SHS than lifestyle. Therefore, it might be useful in changing

unhealthy lifestyle and reducing the influence of poor lifestyle on physical, mental and social SHS.

Strengths and limitations of this study

- The participants, who were recruited through a cross-sectional survey using a four-stage stratified sampling method, were representative of Chinese urban residents.
- To the best of our knowledge, this is the first representative analysis of the mediating effect of health consciousness on the association of lifestyle with physical, mental, and social SHS.
- Although we used a four-stage stratified sampling method, sampling errors are still inevitable.
- This study only included the seven most common lifestyle factors.

Keywords: Suboptimal health status, Lifestyle, Health consciousness, Urban residents, China

INTRODUCTION

In 1946, the World Health Organization (WHO) [1] defined health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." It is reported that non-communicable diseases (NCDs) account for an estimated 80% of the total deaths and 70% of the total number of disability-adjusted life-years (DALYs) in the early twentieth century.[2] Moreover, NCD increase steadily with urbanization and aging, [3] being attributed with more than 88% of total deaths in China in 2019.[4] Furthermore, a study pointed out that NCDs accounted for 18 of the 20 leading causes of age-standardized years lived with disability on a global scale.[5] The preclinical status of NCDs and its early detection have become major issues in the promotion of basic health service in the reform of health care.[6]

Suboptimal health status (SHS), an intermediate status between chronic disease and health, is believed to be a subclinical and reversible stage of chronic disease.[7] People in SHS, although without a diagnosable condition, are characterized by a decline in vitality and physiological function, ambiguous health complaints, general weakness, and lack of vitality. In fact, it has become a new public health challenge in China.[8 9]

It is reported that SHS can be measured objectively using microbiome,[10] telomere length,[11] plasma stress hormones,[12] plasma metabolites,[13] and glycan.[14] However, these objective measures are not easily accessible, and sometimes may not be obvious, especially when people have uncomfortable feelings without abnormal symptoms. A self-rated method that uses a questionnaire is widely applicable in assessing SHS. In China, the sub-health measurement scale (SHMS V1.0), suboptimal health status questionnaire (SHSQ-25)[15] and Chinese sub-health scale (CSHES)[16] were widely used for assessing SHS. However, compared to the other questionnaires, SHMS V1.0

assesses of the physical, mental, and social aspects of SHS, which is in accordance with the health concept proposed by WHO in 1947.

SHS has a prevalence of above 65% in China,[17-20] and has become an increasingly concerning problem in many countries.[21 22] Moreover, its prevalence may be severely underestimated since many individuals are not aware that they suffer from SHS. For instance, in an investigation involving 6,000 Chinese self-reported "healthy people," 72.8% were in "suboptimal health status."[23] Thus, identifying the influencing factors of SHS is important in preventing it, and would provide important information for first-level prevention of NCD[24]. In accordance with the definition released by the WHO, SHS has three dimensions: physical, mental and social adaption.[25] SHS concept is mainly based on Transitional Chinese Medicine (TCM) and prevention is important[26 27].

Lifestyle is an important factor associated with SHS. This includes smoking, alcohol use, skipping breakfast, poor nutrition, lack of exercise, and sleep problems.[28 29] The first SHS study on urban Chinese population[9] pointed that SHS was associated with risk factors of chronic diseases and contributed to the development of them. In SHS, individuals can prevent a chronic disease by modifying their poor lifestyles, as supported by China's Blue Book on Self-Care.[30] Although, it is a given fact that individuals ought to change their bad lifestyles when experiencing adverse health issues, this is difficult to achieve in practice.[31 32] Studies revealed that better knowledge and strong beliefs improve the adherence to lifestyle changes[33 34] and prevent and control chronic diseases;[35 36] better knowledge and strong beliefs are important expressions of health consciousness.

Health consciousness is a psychological construct that corresponds to the awareness about one's health, and the willingness to change one's behaviors in order

to improve it.[37] [38] Moreover, it is related to anxiety, stress, depression, and non-treatable diseases.[39] However, to our knowledge, there are on studies anent the association of health consciousness to SHS. People may present different suboptimal health states in their physical, mental, and social adaptation; thus, it is necessary to analyze SHS separately. We aimed to investigated whether improved health consciousness is associated with better lifestyle and less physical, mental and social SHS. Moreover, we aimed to discover the possible mediating effect of health consciousness on the association of lifestyle with physical, mental, and social SHS. Thus, we used structural equation models to clarify these questions, on the basis of a representative sample of Chinese urban residents.

METHODS

Study design and population

We conducted a cross-sectional survey using a four-stage stratified sampling method from December 2017 to October 2018. In the first stage, we chose one province each from five administrative divisions in China; we selected Guangdong province, Heilongjiang province, Sichuan province, Gansu province, and Tianjin city. Second, we chose three to four cities from each province by considering their level of economic development and regional distribution. Subsequently, we randomly selected two to four streets in the selected urban areas. Lastly, we investigated the urban residents who conveniently qualified from each street.

This study included individuals aged 18 years and older, who lived in an urban area for more than six months, and volunteered in our investigation. We excluded individuals who had a confirmed disease in the last two months, were unable to complete the questionnaire due to visual or hearing impairment, and with missing values in lifestyle, health consciousness, and SHS items. We investigated a total of

6,578 individuals and excluded 775. Thus, we analyzed a total of 5,803 urban residents. Among them, 1,704, 1,328, 954, 925, and 892 participants were from Guangdong, Heilongjiang, Sichuan, Gansu, and Tianjin provinces, respectively. All participants that volunteered provided their verbal consent prior to data collection, and were given the option to cease from participating anytime. They were also invited to give advices regarding the questionnaire. This study was approved by Medical Ethics committee of Nanfang Hospital of Southern Medical University (No. NFEC-2019-196). All data were kept strictly confidential.

Patient and Public Involvement

The participants were not involved in the development of the research question or design of this study. However, we disseminated the results of this analysis through public conferences, including summarized statements and open access to the published reports.

Survey instrument

We used a self-designed questionnaire for investigation, which is comprised of four parts: general demographic characteristics, which included age, gender, marital status, highest education level, per capita monthly household income, and insurance; lifestyle, which included smoking, bad diet habit, alcohol intake, breakfast consumption, physical exercise, early to bed (before 11 pm), and sleep time; health consciousness, which included health knowledge, care for health, and effect of leisure promoting health; and sub-health measurement scale (SHMS) V1.0. Each volunteer completed the questionnaire within 30 minutes. Verbal consents were deemed to be sufficient because the participants had volunteered for the study and could refuse to take part if they wished. The objective of the survey was to study the health status of the participants rather than intervene. All data were kept strictly confidential. The ethics

committee approved the consent procedure.

SHS assessment

We performed suboptimal health status assessment using SHMS V1.0, which was developed by our research group. It comprised of 39 items[25] that were proven to have high reliability and validity in a Chinese population.[40] SHMS V1.0 consists of three subscales: physical suboptimal health status (PS), mental suboptimal health status (MS), and social suboptimal health status (SS). PS consists of 14 items that comprises four factors: physical condition, organ function, body movement function, and vigor. MS consists of 12 items that comprises three factors: positive emotion, psychological symptoms, and cognitive function. SS consists of nine items that comprises three factors: social adjustment, social resources, and social support. For each item, there are five response categories (1=*none*, 2=occasionally, 3=sometimes, 4=constantly, and 5=always) that correspond to the frequency of occurrence of each symptom. We asked the participants regarding the uncomfortable symptoms that they had during the previous month. We then calculated the total scores. A low total score represents a low estimate of SHS (i.e., poor health). The cut-off value for suboptimal health assessment referred to norms of SHMS V1.0 for Chinese urban residents were established by our research group. [41]

Lifestyle evaluation

Smoking was comprised of none smokers, past smokers, and current smokers. Bad diet habit was divided into "yes" (if any one of the following seven situations exist: irregular eating time, dieting, overeating, dietary bias or pickiness, salty tasty, spicy tasty, and using snacks instead of meals), and "no". Alcohol intake was divided into "never," "occasionally," "little everyday," and "much everyday." Breakfast consumption was comprised of "never," "occasionally" (i.e., one or two days a week),

"sometimes" (i.e., three or four days a week), "frequently" (i.e., five or six days a week), and "everyday." Physical exercise was divided into "everyday," "frequently" (i.e., five or six days a week), "sometimes" (i.e., three or four days a week), and "occasionally" (i.e., one or two days a week, and no physical exercise). Sleep time were divided into three groups, "<7hours/day," "7-9hours/day," and "⩾9hours/day. "

Health consciousness evaluation

Health knowledge and attention to health consisted of "very few/low," "few/low," "general," "much/high," and "very much/high." Effect of leisure on health consisted of "no effect," "some effect," and "very effective."

Quality control and Data management

The investigators for each site were trained through face-to-face, video conferencing, and telephone. Before the conduct of the investigation, we made sure that its purpose and importance were explained to the participants in detail, and obtained their verbal informed consent. The respondents answered the questionnaires independently and according to their own understanding, while missing data were re-answered after checking by the investigators. Before data coding and entry, suspicious duplicate questionnaires, which are those with a repetition rate higher than 80% and completion rate lower than 80% were excluded. All questionnaire data were double-entered using Epidata 3.1 software. The two data sets were cross compared for validity and errors.

Statistical analysis

Description was using means (standard deviations) and proportions. We used a one-way ANOVA with LSD-test for multiple comparisons. Cluster effect nested within sampling regions was examined by using interclass correlation coefficient (ICC) calculated in a two-level linear multilevel model. We used structural equation modeling (SEM) to analyze the complexity of associations between lifestyle, health

consciousness, and SHS (Model 1: SEM model of lifestyle, health consciousness, and PS; Model 2: SEM model of lifestyle, health consciousness, and MS; Model 3: SEM model of lifestyle, health consciousness, and SS). Mediating effect of health consciousness was the same with indirect association of lifestyle and SHS via health consciousness. Ratio of mediating effect of health consciousness to direct effect of lifestyle (indirect effect divided by direct effect) and proportion of mediating effect of health consciousness to total effect (indirect effect divided by total effect multiply by a hundred) of lifestyle with physical, mental, and social SHS were also calculated. We used the relative χ^2 (CMIN/DF), root mean-square error of approximation (RMSEA), comparative fit index (CFI), goodness-of-fit index (GFI), and adjusted goodness-of-fit index (AGFI) to assess the model fit. We applied the bootstrapping method of repeat sampling by 2,000 times to verify statistical significance and calculate the confidence intervals for the direct, indirect, and total effects. Participants with missing data were deleted from analysis. All *P*-values were two sided, with values < 0.05 considered as statistically significant. We used IBM SPSS Statistics 20.0 for descriptive analysis. Lastly, we conducted SEM analysis with AMOS (SPSS Statistics version 20·0, SPSS Inc., Chicago, IL).

RESULTS

Participants' demographic characteristics

Baseline characteristics of all study participants are presented in Table 1. Of the 5,803 participants,2,772 (47.77%) were men and 3,031 (52.23%) were women. The mean age was 40.90±15.46 years. Most of the participants (65.98%) were married. Moreover, 1,939 (57.21%) of the participants have a per capita monthly household income (RMB) of less than 5,000 RMB. Participants with compulsory school (up to grade 9), high school, junior college, and university degree and above were 1,341

(23.1%), 1,298 (22.4%), 1,374 (23.7%) and 1,786 (30.8%), respectively.

Association of lifestyle, health consciousness, and SHS

The mean (*SD*) of the overall SHS, PS, MS and SS transformed scores were 67.15 (11.99), 70.92 (12.67), 67.01 (14.55), and 61.46 (15.56), respectively. The ANOVA results showed that various groups of lifestyle and health consciousness differed on physical SHS, mental SHS, and social SHS (Table 2). People who never smoked had the highest physical and social SHS scores; however, participants who quit smoking had lower physical, mental, and social SHS scores than participants who were still smoking. People who had bad diet habits and consumed the most alcohol had the lowest physical, mental, and social SHS scores. Physical, mental, and social SHS scores were higher for participants who regularly consumed breakfast, engaged in regular physical exercise, had early bedtimes (i.e., before 11 P.M.), and longer sleep duration.

SEM analysis of lifestyle, health consciousness, and SHS

Because we used the multi-stage sampling method in this study, there might be a cluster effect nested within sampling regions. We examined ICC and its significance using a two-level linear multilevel model. For physical, mental, and social SHS, there was no cluster effect in the regions, while the ICC was 0.028, 0.01, and 0.035, with P values of 0.085, 0.103, and 0.084, respectively. Thus, traditional SEM models could be used in the analysis of the association of lifestyle, health consciousness, and SHS (Figure 1). Three models fit reasonably well to the data. As shown in the models: (1) all indicator variables that we hypothesized as predictors were significantly related to their respective latent factors, $P < 0.001$; (2) lifestyle had a direct negative association with PS (β -0.14, $P<0.001$), MS (β -0.15, $P < 0.001$) and SS (β -0.13, P 0.001); (3) health consciousness had direct positive association with PS (β 0.36, $P < 0.001$), MS

(β 0.452, $P < 0.001$), and SS (β 0.434, $P < 0.001$), and mediating effects on the association of lifestyle with PS, MS and SS.

The association paths of lifestyle and health consciousness on SHS are presented in Table 3. Although lifestyle and health consciousness were both associated with SHS, health consciousness had larger associations with PS (β 0.360), MS (β 0.452), and SS (β 0.434) than lifestyle (β -0.329, -0.370, and -0.345 respectively). Association of lifestyle and PS could be direct (β -0.144, 95% CI -0.209 to -0.081)) and indirect (β -0.185, 95% CI -0.228 to -0.149), with faintly larger indirect association than direct association. However, the indirect association (β -0.224, 95% CI -0.265 to -0.186) of lifestyle and MS was obviously higher than direct association (β -0.146, 95% CI -0.201 to -0.094). The same higher indirect association (β -0.216, 95% CI -0.257 to -0.179) was found in the association of lifestyle and SS than direct association (β -0.130, 95% CI -0.181 to -0.077). Ratio of mediating effect of health consciousness to direct effect of lifestyle with physical, mental, and social SHS was 1.28, 1.53, and 1.66, respectively. Proportion of mediating effect of health consciousness to total effect of lifestyle with physical, mental, and social SHS was 56.23%, 60.54%, and 62.61%, respectively.

DISCUSSION

In this large cross-sectional study involving a representative sample, we found that lifestyle health consciousness showed significantly mediating effects on the association of lifestyle with PS, MS and SS. The direct associations of PS, MS, and SS with health consciousness were all significantly higher than lifestyle. However, the indirect associations of lifestyle with PS, MS and SS were higher than indirect associations via health consciousness.

SHS is a subjective feeling that lacks objective clinical diagnostics; thus, a

self-assessed questionnaire is the most appropriate method of determining it. SHMS V1.0 is a multidimensional scale that includes physical, mental, and social dimensions that correspond to the WHO's more comprehensive definition of health.[42] Moreover, it is widely used in China for assessing SHS in urban residents, workers and students.[17 18 25 29] We found that Chinese urban residents had low scores in PS, MS and SS, which means that they are at high risk to SHS in physical, mental, and social adaption. This result is in accordance with other studies involving young and middle-aged intellectuals in Guangzhou,[43] Chinese migrant workers,[44] and those that use other SHS evaluation questionnaires in China, such as the SHSQ-25.[6 9] Similarly, African[14] and Caucasian[45] studies showed the same SHS rate.

To the best of our knowledge, this is the first representative analysis of the mediating effect of health consciousness on the association of lifestyle with physical, mental and social SHS. All variables included in lifestyle and health consciousness were accordingly significantly associated. Urban residents who engage in unhealthy lifestyle practices, such as smoking, alcohol intake, bad diet habits, irregular breakfast consumption, less physical exercises, less frequent early to bed, and short sleep time were more likely to get into PS, MS and SS. A study[42] revealed that breakfast eating habits are significantly associated with lifestyle, and appear to be a useful predictor of a healthy lifestyle; people who skip breakfast are prone to unhealthy behaviors, such as limited exercise.[46] Moreover, insufficient sleep is associated with several health-risk behaviors,[47] such as not meeting physical activity recommendations,[48] using cigarettes and alcohol, and feeling sad or hopeless.[49] Furthermore, poor diet was the third greatest influencing factor for physical and social health, which was in line with previous studies.[50 51]

This study investigated the significant associations of health consciousness with PS,

MS, and SS, which were relatively more significant than those of lifestyle. Moreover, in this study, health consciousness, included health knowledge, attention to health, and effect of leisure on health. As the internal power of healthy behavior, health consciousness is the most important and fundamental factor in promoting health. In fact, individuals who had more health knowledge believed that they had control over their health.[52]

The most important finding was that health consciousness played a mediating effect in the relationship of lifestyle with physical, mental and social SHS, which was higher than direct effect of lifestyle. Studies have shown that health consciousness is correlated with health behavior, information seeking and health coping.[53] Modifying the attitudes is effective in promoting changes in health behavior,[54] since health-conscious people are attentive to health warnings regarding the risks of having an unhealthy lifestyle.[55]

Limitations

This study has some limitations. First, although we used face-to-face interviews, all data were collected from a respondent-completed questionnaire; thus, responses may have a level of inherent inaccuracy or bias. Second, although we used a four-stage stratified sampling method, sampling errors are still inevitable. Lastly, this study only included the seven most common lifestyle factors.

CONCLUSION

In this large representative cross-sectional study of Chinese urban residents, we found that direct association of lifestyle with physical, mental, and social SHS were smaller than direct association and mediating effect of health consciousness. Moreover, health consciousness was more important in preventing physical, mental, and social SHS than lifestyle, and might be useful in changing unhealthy lifestyle and reducing the

influence of poor lifestyle on physical, mental, and social SHS.

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Role of the funding source

The sponsors of the study had no role in the study design, data collection, data analysis, or data interpretation. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Competing Interests

No declared

Author Contributions

XJ developed the questionnaire and study design, supervised the analysis and contributed to the final version of the manuscript. XYL did the analyses and wrote the first draft. LGH, FYF, XMY, LYQ and JLJ were in charge of the investigation. All

authors contributed to and read the final draft of the manuscript.

Patient consent for publication

Not required

Ethics approval

Ethics approval to collect the patients' data was obtained from the Ethics Committee of the Nanfang Hospital of Southern Medical University (NFEC-2019-196).

Data availability statement

Data are available upon reasonable request. Data are available upon reasonable request. Readers can contact Xu Jun (drugstat@163.com) to submit raw data access requirements.

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Table 1 Participant's demographic characteristics (*n*=3535)

Characteristic	*N*	%
Gender		
Man	2772	47.77
Woman	3031	52.23
Married status		
Unmarried	1556	26.81
Married	3829	65.98
Divorced or widows	386	6.65
Information missing	32	0.55
Per capita monthly household income (RMB)		
<5000	3320	57.21
>=5000	2419	41.69
Information missing	64	1.10
Highest education level		
Compulsory school (through grade 9)	1343	23.14
High school graduation	1298	22.37
Junior college degree	1374	23.68
University degree and above	1786	30.78
Information missing	2	0.03

Table 2 Group comparisons of lifestyle, health consciousness, and SHS

Variates	*N*	PS Mean(SE)	MS Mean(SE)	SS Mean(SE)
Smoking				
Never	3987	71.56(12.48)#^	67.13(14.46)#	62.15(15.16)#^
Quit	614	68.32(13.49)*^$	65.41(15.11)*^$	58.38(17.2)*^
<20 cigarettes /day	1027	70.31(12.67)*#	67.4(14.44)#	60.93(15.53)*#
⩾ 20 cigarettes /day	164	70.85(12.90)#	68.26(15.44)#	61.02(17.86)
Bad diet habits				
No	3357	73.1(12.52)#	70.2(14.14)#	64.19(14.77)#
Yes	2446	67.92(12.25)*	62.64(13.97)*	57.71(15.84)*
Alcohol intake				
Never	2077	71.93(13.13)#^$&	68.18(14.66)#^$&	62.61(15.78)#^&
Occasionally	3099	70.86(12.06)*^$&	66.55(14.21)*&	61.15(15.11)*&
Little everyday	421	68.85(13.65)*#&	66.29(15.75)*&	59.93(16.69)*&
Some everyday	106	68.35(12.88)*#&	65.17(13.79)*&	60.27(14.29)&
Much everyday	72	63.47(14.37)*#^$	60.1(16.45)*#^$	53.97(20.69)*#^$
Breakfast consumption				
Never	139	67.93(15.07)$&	62.4(17.25)$&	53.46(19.83)^$&
Occasionally	600	66.88(12.63)$&	62.69(14.12)$&	55.79(16.70)$&
Sometimes	830	68.03(11.99)$&	61.81(13.07)$&	56.37(15.38)*$&
Frequently	1539	71.07(11.94)*#^&	66.48(14.01)*#^&	61.75(14.52)*#^&
Everyday	2671	72.91(12.73)*#^$	70.22(14.46)*#^$	64.69(14.75)*#^$
Physical exercise				
Never	848	68.55(13.27)#^$&	64.24(14.4)#^$&	58.21(15.68)#^$&
Occasionally	2338	70.43(11.78)*$&	65.54(13.92)*^$&	60.36(14.45)*^$&
Sometimes	1373	71.26(13.11)*&	67.54(14.53)*#$	61.51(16.75)*#$&
Frequently	608	71.77(13.03)*#&	68.72(14.85)*#^	64.57(15.24)*#^&
Everyday	627	74.73(12.73)*#^$	73.53(14.82)*#^$	67.12(15.11)*#^$
Early to bed				
Never	947	70.29(12.36)$&	64.8(14.74)$&	59.72(15.61)$&
Occasionally	1512	70.3(11.94)$&	65.57(13.71)$&	60.08(15.33)$&
Sometimes	1224	70.01(12.84)$&	65.84(14.46)*#$&	60.47(15.99)$&
Frequently	997	71.49(12.76)*#^&	68.36(14.46)*#^&	63.07(14.79)*#^&
Everyday	1113	72.98(13.39)*#^$	70.99(14.84)*#^$	64.52(15.49)*#^$
Sleep time				
<3hours/day	35	62.96(12.11)^$&	58.87(13.81)^$&	49.68(20.42)^$&
<5hours/day	145	62.44(12.88)^$&	56.97(14.78)^$&	48.51(18.88)^$&
<7hours/day	1377	67.89(12.34)*#$&	64.88(14.09)*#$&	59.86(15.83)*#$&
<9hours/day	3748	72.47(12.29)*#^&	68.14(14.38)*#^	62.65(14.82)*#^
⩾9hours/day	492	71.09(13.67)*#^$	68.15(15.30)*#^	61.95(16.59)*#^
Health knowledge				
Very few	1332	70.27(12.55)$&	65.17(14.79)^$&	58.31(15.43)#^$&

	Few	1794	70.38(12.51) $\$\&$	65.77(14.27) $\wedge\$\&$	60.13(15.41) $*\wedge\$\&$
	General	1913	70.71(12.52) $\$\&$	67.54(14.37) $*\#\$\&$	62.55(15.13) $*\#\$\&$
	Much	628	74.11(12.58) $*\#\wedge$	71.47(13.79) $*\#\wedge\&$	67.2(14.62) $*\#\wedge\&$
	Very much	120	74.65(15.97) $*\#\wedge$	75.26(15.28) $*\#\wedge\$$	70.61(18.46) $*\#\wedge\$$
Care for health					
	Very low	329	67.73(14.32) $\wedge\$\&$	61.09(16.65) $\wedge\$\&$	55.25(17.71) $\wedge\$\&$
	Low	789	67.61(13.11) $\wedge\$\&$	62.33(14.42) $\wedge\$\&$	56.1(16.47) $\wedge\$\&$
	General	2485	69.5(11.9) $*\#\$\&$	65.37(13.69) $*\#\$\&$	59.76(14.35) $*\#\$\&$
	High	1752	73.66(12) $*\#\wedge\&$	70.3(13.74) $*\#\wedge\&$	65.28(14.44) $*\#\wedge\&$
	Very high	437	76.86(13.36) $*\#\wedge\$$	76.27(14.12) $*\#\wedge\$$	70.57(15.73) $*\#\wedge\$$
Effect of leisure promoting health					
	No effect	733	65.7(12.87) $\#\wedge$	60.94(14.56) $\#\wedge$	54.24(17.22) $\#\wedge$
	Some effect	3870	70.37(12.04) $*\wedge$	66.1(13.76) $*\wedge$	60.68(14.39) $*\wedge$
	Very effective	1163	76.39(12.75) $*\#$	74.11(14.58) $*\#$	69(15.28) $*\#$

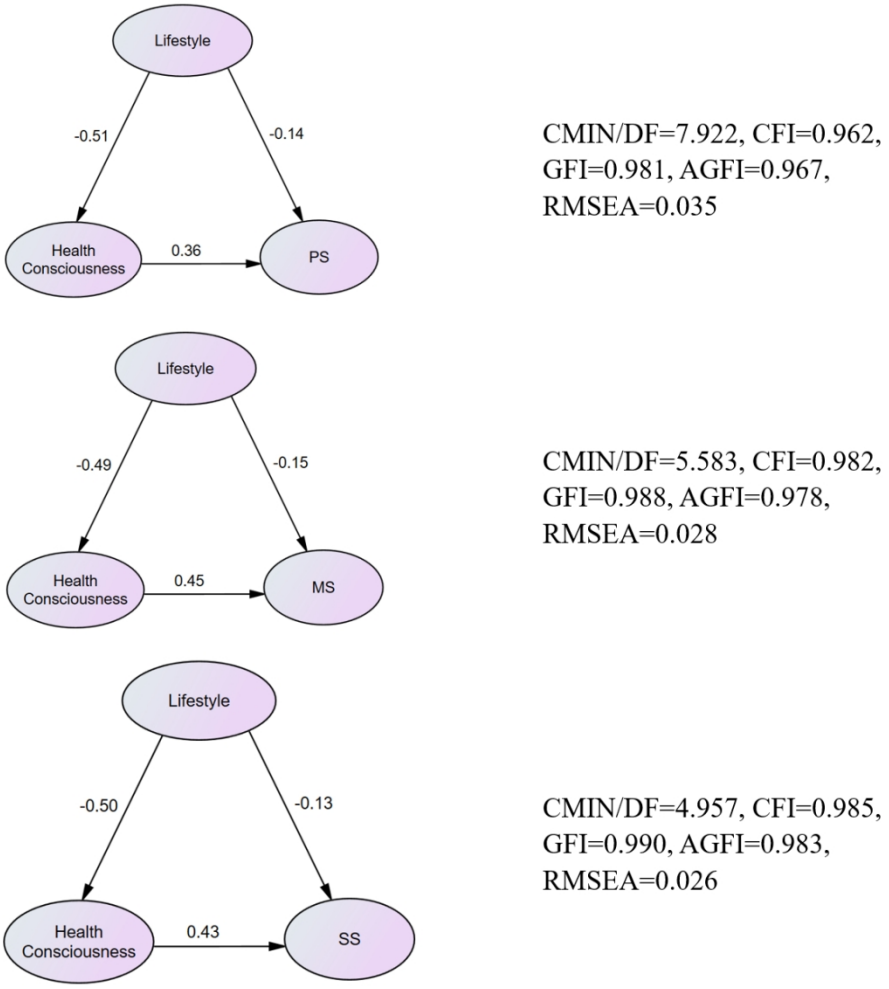
Transformed scores were analyzed here. Statistical analysis included a one-way ANOVA followed by LSD multiple comparisons test. *: $P < 0.05$ as compared to answer code 1; #: $P < 0.05$ as compared to answer code 2; ^: $P < 0.05$ as compared to answer code 3; $: $P < 0.05$ as compared to answer code 4, &: $P < 0.05$ as compared to answer code 5.

Table 3 Influencing path of lifestyle and health consciousness on SHS

SHS	Path way	Mean standardized effects	95%CI lower bound	95%CI upper bound	*P*-value
PS					
	Lifestyle—PS(total)	-0.329	-0.385	-0.278	<0.001
	Lifestyle—PS(direct)	-0.144	-0.209	-0.081	<0.001
	Lifestyle—Health consciousness—PS(indirect)	-0.185	-0.228	-0.149	<0.001
	Health consciousness—PS	0.360	0.295	0.427	<0.001
MS					
	Lifestyle—MS(total)	-0.370	-0.408	-0.330	<0.001
	Lifestyle—MS(direct)	-0.146	-0.201	-0.094	0.001
	Lifestyle—Health consciousness—MS(indirect)	-0.224	-0.265	-0.186	<0.001
	Health consciousness—MS	0.452	0.392	0.510	<0.001
SS					
	Lifestyle—SS(total)	-0.345	-0.383	-0.308	<0.001
	Lifestyle—SS(direct)	-0.130	-0.181	-0.077	0.001
	Lifestyle—Health consciousness—SS(indirect)	-0.216	-0.257	-0.179	<0.001
	Health consciousness—SS	0.434	0.376	0.490	<0.001

PS = physical suboptimal health status, MS = mental suboptimal health status, SS = social suboptimal health status

Figure 1. SEM model of lifestyle, health consciousness and PS (Model 1), MS (Model 2), or SS (Model 3). All the standardized regression coefficients are presented as single-headed arrows, and statistically significant at 0.05 significance level. Abbreviations: PS= physical sub-health status, MS=mental sub-health status, SS=social sub-health status.



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SEM model of lifestyle, health consciousness and PS (Model 1), MS (Model 2), or SS (Model 3). All the standardized regression coefficients are presented as single-headed arrows, and statistically significant at 0.05 significance level. Abbreviations: PS= physical sub-health status, MS=mental sub-health status, SS=social sub-health status.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10

		(b) Indicate number of participants with missing data for each variable of interest	21
Outcome data	15*	Report numbers of outcome events or summary measures	10-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-12, 22-24
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.