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Preplanned Studies

Population Attributable Fractions for Modifiable Factors of Longevity and Healthy Longevity Among the Late-Elderly Aged 75 Years or Older — China, 1998–2018

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Summary

What is already known about this topic?

Limited evidence on healthy longevity was provided in the world, and no studies investigated the fractions of healthy longevity attributed to modifiable factors.

What is added by this report?

Incidences of longevity and healthy longevity in China are provided. It reveals that the total weighted population attributable fractions for lifestyles and all modifiable factors were 32.8% and 83.7% for longevity, respectively, and 30.4% and 73.4% for healthy longevity, respectively.

What are the implications for public health practice?

China has a high potential for longevity and healthy longevity. Strategies may be targeted at education and residence in early life as well as healthy lifestyles, disease prevention, and functional optimization in late life.

Globally, the population of the late-elderly (aged ≥ 75 years) was expected to rise from 275 million in 2020 to 768 million by 2050 (*1*), which might result in large disease burdens accompanied by increased life years of ill-health (*2*–*3*). However, the lack of data on multiple health measurements of older adults in large long-term cohorts increases the difficulty in studying healthy longevity. To fill the gap, analyses were conducted using data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) from 1998 to 2018. Separate logistic regression models were performed to identify factors associated with longevity and healthy longevity among 11,005 late-elderly participants, who were more likely to survive to 90 years old than younger adults. The corresponding population attributable fractions (PAFs) were also calculated. The incidence densities were 17.0/1,000 person-years for healthy longevity and 63.0/1,000 person-years for usual longevity. Considering early life factors, lifestyles, functional health, and diseases, the total weighted PAFs were 83.7% for longevity and 73.4% for healthy longevity, suggesting great potential for longevity and healthy longevity in China. Effective strategies may include targeting people through education and residence in early life, healthy lifestyles, disease prevention, and functional optimization in late life.

Study participants were recruited from the CLHLS study, which is the first study to investigate factors of healthy longevity in China covering 23 provincial-level administrative divisions (PLADs) (*3*). The study included 11,005 late-elderly participants who had the potential to survive to age 90 years by 2018, with complete measurement of outcomes and candidate factors for analysis (Supplementary Figure S1, available in http://weekly.chinacdc.cn). Healthy longevity was defined with reference to the WHO definition of healthy ageing and participants were classified into three categories (*2*): 1) healthy longevity: age at death ≥90 years, with good physical performance, cognitive function, mental health, visual function, and hearing function; 2) usual longevity: age at death ≥90 years, with at least one kind of functional impairment or disability mentioned above; 3) non-survival: age at death <90 years, irrespective of functional status (Supplementary Methods, available in http://weekly.chinacdc.cn). Candidate influencing factors, including demographic characteristics, lifestyles, functional status, self-rated health, and diseases, were collected through face-to-face interviews with all participants (Supplementary Methods).

Factors of longevity and healthy longevity were identified with separate logistic regression models via a bidirectional stepwise procedure and inclusion of candidate factors with $P<0.1$ in the raw estimates only

adjusted for age: 1) non-longevity versus longevity; 2) usual longevity versus healthy longevity. As participants with different baseline ages will have different periods to age 90, age was included as a confounder as opposed to a risk factor in the analyses. The PAFs of modifiable factors were calculated by transforming them into binary or multifactorial variables according to previous studies and were adjusted for communality, which explains the overlap between factors (*4*–*5*). We performed a principal component analysis to calculate the communality for each factor and took into account how much each unobserved component explained each measured factor (*5*). Both age and sex were considered fixed variables. In this study, the PAF is interpreted as the probability gains of longevity or healthy longevity if all participants kept to healthy lifestyles or were in the absence of adverse health status factors (*4*). All analyses were finished with R 4.1.3 for Windows (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at two-tailed with a *P*-value <0.05.

Overall, 3,454 (31.4%) participants survived to age 90, of which 735 (6.7%) were classified as having healthy longevity and 2,719 (24.7%) were classified as having usual longevity. The corresponding incidence densities were 17.0/1,000 and 63.0/1,000 person-years, respectively. Rural residents and women were more likely to be classified as having longevity, but most of them were classified as having usual longevity, indicative of a lower likelihood of being classified as having healthy longevity. The incidences of longevity, healthy longevity, and usual longevity were higher in older adults with advanced ages (Table 1).

Odds ratios [95% confidence intervals (*CIs*)] for factors retained in the final logistic regression models are presented in Table 2. The PAFs for modifiable factors associated with longevity and healthy longevity are displayed in Table 3. Of all modifiable lifestyles, performing housework, watching TV or listening to the radio, and never smoking are the top three factors contributing to longevity (weighted PAFs were 6.7%, 4.9%, and 3.3%, respectively); never smoking or having quit, normal weight or overweight, and tea-drinking are the top three factors contributing to healthy longevity (weighted PAFs were 8.8%, 6.0%, and 4.9%, respectively). All modifiable lifestyles combined may explain 32.8% probability gains of longevity and 30.4% probability gains of healthy longevity. The probability gains reached 83.7% and 73.4% when all potentially modifiable factors, excluding age and sex, were considered. Among factors other than lifestyles, interventions at early ages also contribute to considerable probability gains of longevity and healthy longevity (weighted PAF of residence areas was 2.7% for longevity, weighted PAF of education years was 2.3% for healthy longevity); early prevention and usage of supporting tools or equipment to optimize functional abilities are also important in promoting longevity [weighted PAFs of chewing ability, activities of daily living (ADL) limitations, and cognitive impairment were 2.2%, 13.1%, and 9.3%, respectively] and healthy longevity (weighted PAFs of chewing ability, ADL limitations, and hearing function were 4.4%, 15.4%, and 20.5%, respectively).

TABLE 1. Person-years of follow-up, number of outcome events, and incidence per 1,000 person years of observation by residence, sex, and age groups among Chinese late-elderly, 1998–2018.

Groups	All participants		Longevity		Healthy longevity		Usual longevity	
	No. of participants	Person-years	No. of events	Incidence	No. of events	Incidence	No. of events	Incidence
Total	11,005	43,154	3,454	80.0	735	17.0	2,719	63.0
Residence								
Urban	4,683	17,980	1,371	76.3	311	17.3	1,060	59.0
Rural	6,322	25,174	2,083	82.7	424	16.8	1,659	65.9
Sex								
Men	5,595	21,103	1,572	74.5	417	19.8	1,155	54.7
Women	5,410	22,051	1,882	85.3	318	14.4	1,564	70.9
Age group (years)								
75–79	1,516	9,339	179	19.2	40	4.3	139	14.9
80–84	4,791	20,952	938	44.8	185	8.8	753	36.0
85–89	4,698	12,862	2,337	181.7	510	39.7	1,827	142.0

TABLE 2. Odds ratios (95% *CI*s) for factors associated with longevity and healthy longevity among Chinese late-elderly, 1998–2018.

Characteristics	Longevity		Healthy longevity	
	***OR* (95% *CI*)**	***P*-value**	***OR* (95% *CI*)**	***P*-value**
Women	1.45 (1.30–1.61)	<0.001	0.71 (0.58–0.87)	0.001
Rural	1.16 (1.05–1.28)	0.003	Not included	
Education years (per 1 year)	Not included	–	1.05 (1.03–1.08)	<0.001
Smoking				
Never smokers	1 (ref)	–	1 (ref)	–
Current smokers	0.86 (0.76–0.97)	0.016	0.79 (0.62–0.99)	0.044
Former smokers	0.83 (0.72–0.95)	0.007	1.14 (0.89–1.46)	0.310
Performing housework			Not included	
Rarely or not	1 (ref)	–	–	–
Occasionally	1.25 (1.09–1.44)	0.002	–	–
Often	1.42 (1.29–1.57)	<0.001	–	–
Raising domestic animals				
Rarely or not	1 (ref)	–	1 (ref)	–
Occasionally	1.04 (0.88–1.22)	0.670	1.51 (1.13–2.01)	0.006
Often	1.23 (1.09–1.38)	0.001	1.35 (1.09–1.65)	0.005
Reading newspapers or book			Not included	
Rarely or not	1 (ref)	–	–	–
Occasionally	0.94 (0.78–1.13)	0.490	–	–
Often	1.19 (1.03–1.38)	0.019	–	–
Watching TV or listening to the radio			Not included	
Rarely or not	1 (ref)	–	–	–
Occasionally	1.11 (0.98–1.27)	0.110	–	–
Often	1.27 (1.14–1.43)	<0.001	–	–
Garlic consumption			Not included	
Rarely or not	1 (ref)	–	–	–
Occasionally	1.14 (1.04–1.26)	0.008	–	–
Often	1.05 (0.92–1.19)	0.510	–	–
Tea drinking	Not included			
Rarely or not	–	–	1 (ref)	–
Occasionally	–	–	1.37 (1.10–1.71)	0.005
Often	–	–	1.21 (0.99–1.47)	0.062
Good chewing ability	1.14 (1.03–1.25)	0.008	1.25 (1.05–1.48)	0.014
ADL score (per 1 point)	0.84 (0.80–0.88)	<0.001	0.85 (0.75–0.97)	0.018
MMSE score (per 1 point)	1.02 (1.01–1.03)	<0.001		
Psychological resources (per 1 point)	1.02 (1.01–1.03)	0.005	1.05 (1.03–1.08)	<0.001
Hearing loss	Not included		0.49 (0.33–0.74)	0.001
Heart disease	0.73 (0.61–0.87)	0.001		
Cerebrovascular disease	0.77 (0.60–0.98)	0.036	Not included	–
Respiratory disease	0.79 (0.69–0.91)	0.001	Not included	–
BMI	Not included			
Underweight	–	–	0.82 (0.68–0.98)	0.032
Normal	–	–	1 (ref)	–
Overweight	–	–	1.08 (0.81–1.43)	0.620
Obese	–	–	0.45 (0.22–0.89)	0.022
Self-rated health status			Not included	
Good	1.07 (0.97–1.19)	0.19	–	–
So so	1 (ref)	–	–	–
Bad	0.76 (0.65–0.89)	0.001	–	–

Note: Data are adjusted *OR* (95% *CI*). A value higher than 1 indicates participants are more likely to be longevity or healthy longevity. Not included means factors were not selected or non-significant (*P*>0.05) in the stepwise logistic models and not retained in the final models.
Abbreviation: *CI*=confidence interval; *OR*=odds ratio; ADL=activities of daily living; MMSE=mini-mental state examination; BMI=body mass index.

TABLE 3. Population attributable fractions for modifiable factors of longevity and healthy longevity among the late-elderly in China, 1998–2018.

Factors	PAFs for longevity (%)		PAFs for healthy longevity (%)	
	Raw	Weighted†	Raw	Weighted†
Lifestyle factors				
Smoking*	9.8	3.3	21.4	8.8
Tea drinking (often or occasionally)	Not included	Not included	12.0	4.9
Garlic consumption (often or occasionally)	7.5	2.5	Not included	Not included
Performing housework (often or occasionally)	19.9	6.7	Not included	Not included
Reading newspapers or books (often)	3.4	1.1	Not included	Not included
Raising domestic animals (often or occasionally)	4.8	1.6	9.8	4.0
Watching TV or listening to the radio (often or occasionally)	14.5	4.9	Not included	Not included
BMI (normal weight or overweight; 18.5–27.9 kg/m^2)	Not included	Not included	14.7	6.0
Other potentially modifiable factors				
Residence (rural)	7.9	2.7	Not included	Not included
Education years (≥6)	Not included	Not included	5.5	2.3
Chewing ability (good)	6.4	2.2	10.7	4.4
ADL limitations (no)	38.8	13.1	37.5	15.4
Cognitive impairment (no)	27.6	9.3	Not included	Not included
Mental health (good)	9.7	3.3	17.3	7.1
Hearing function (good)	Not included	Not included	49.8	20.5
Heart disease (no)	24.8	8.4	Not included	Not included
Cerebrovascular disease (no)	27.1	9.1	Not included	Not included
Respiratory disease (no)	19.0	6.4	Not included	Not included
Self-rated health status (good or so so)	26.7	9.0	Not included	Not included
Combined factors				
All modifiable lifestyle factors	47.5	32.8	46.8	30.4
All potentially modifiable factors	94.1	83.7	88.3	73.4

Note: All models were adjusted for age, sex, and all other potentially modifiable factors. Not included means factors were not selected or non-significant (P>0.05) in the stepwise logistic models and not retained in the final models.
Abbreviation: *CI*=confidence interval; PAF=population attributable fraction; BMI=body mass index; ADL=activities of daily living.
* Based on the results of separate logistic models, never smoking was considered in the calculation of PAFs for longevity, and never or quit smoking was considered in the calculation of PAFs for healthy longevity.
† Weighted PAFs were the relative contributions of each factor to the overall PAF of all potentially modifiable factors when adjusted for communality.

DISCUSSIONS

In this large cohort study of 11,005 late-elderly participants, incidences of longevity and healthy longevity in China were provided and 19 modifiable factors for longevity and healthy longevity were identified. The weighted PAFs of longevity and healthy longevity are 32.8% and 30.4%, respectively, for all modifiable lifestyle factors and would increase to 83.7% for longevity and 73.4% for healthy longevity when all potentially modifiable factors were considered. Longevity and healthy longevity should be considered from a life course perspective, in which education and residence in early life and lifestyles in late life would continuously influence both the health status (including functional status and diseases) of a person and the probability of longevity and healthy longevity. Although functional status and diseases are probably irreversible in late life, the benefits are still substantial if supporting environments are strengthened to optimize the intrinsic capacity and functional abilities of late-elderly populations.

In this study, the probability of healthy longevity in China was suggested to be similar of that in younger Americans (*6*–*7*). Sex and 19 modifiable factors associated with longevity and healthy longevity in China were identified. These results are consistent with previous findings. The PAF for modifiable lifestyles of healthy longevity is comparable to a previous study that investigated successful aging in the United Kingdom when not adjusted for communality (*4*). Sociodemographically, women, rural residents, and participants with higher education levels were more likely to be classified as having longevity and/or healthy longevity (*6*). Regarding lifestyles, never smoking and engaging in leisure activities were beneficial to longevity and/or healthy longevity in late-elderly participants, which may be explained by their effects on reducing the risk of cognitive impairment, ADL disability, and mortality (*4*,*6*,*8*); garlic consumption and tea drinking may protect the late-elderly participants by the antidotal effect, inhibiting the growth of cancer cells, and reducing inflammatory levels (*9*); late-elderly participants who were underweight or obese may suffer from higher risk of chronic diseases and disabilities, reducing the likelihood of healthy longevity (*10*). Regarding other health measurements, late-elderly participants with good chewing ability, ADL independence, cognitive function, mental health, and hearing function were more likely to reach longevity and/or healthy longevity. These late-elderly participants may suffer from slower functional declines, and good chewing ability also enabled the adequate intake of essential nutrients. Conversely, late-elderly participants with heart disease, cerebrovascular disease, respiratory disease, and bad self-rated health status were more likely to suffer from functional declines and less likely to reach longevity (*11*).

Several limitations need to be considered when interpreting these findings. First, this study did not include data on genetic information and biomarkers, which need to be further investigated in future studies. Second, the inclusion of Chinese late-elderly participants might limit the generalizability of these findings to other racial groups.

In summary, incidences of longevity and healthy longevity in China in a large cohort of late-elderly participants were provided and revealed that education and residence in early life, healthy lifestyles, disease prevention, and functional optimization in late life together contribute to longevity and healthy longevity. The findings of this study reinforced the importance of a life course perspective in health management and may be applied to develop intervention strategies against the burdens attributed to the ageing population in China.

Conflicts of interest: No conflicts of interest.

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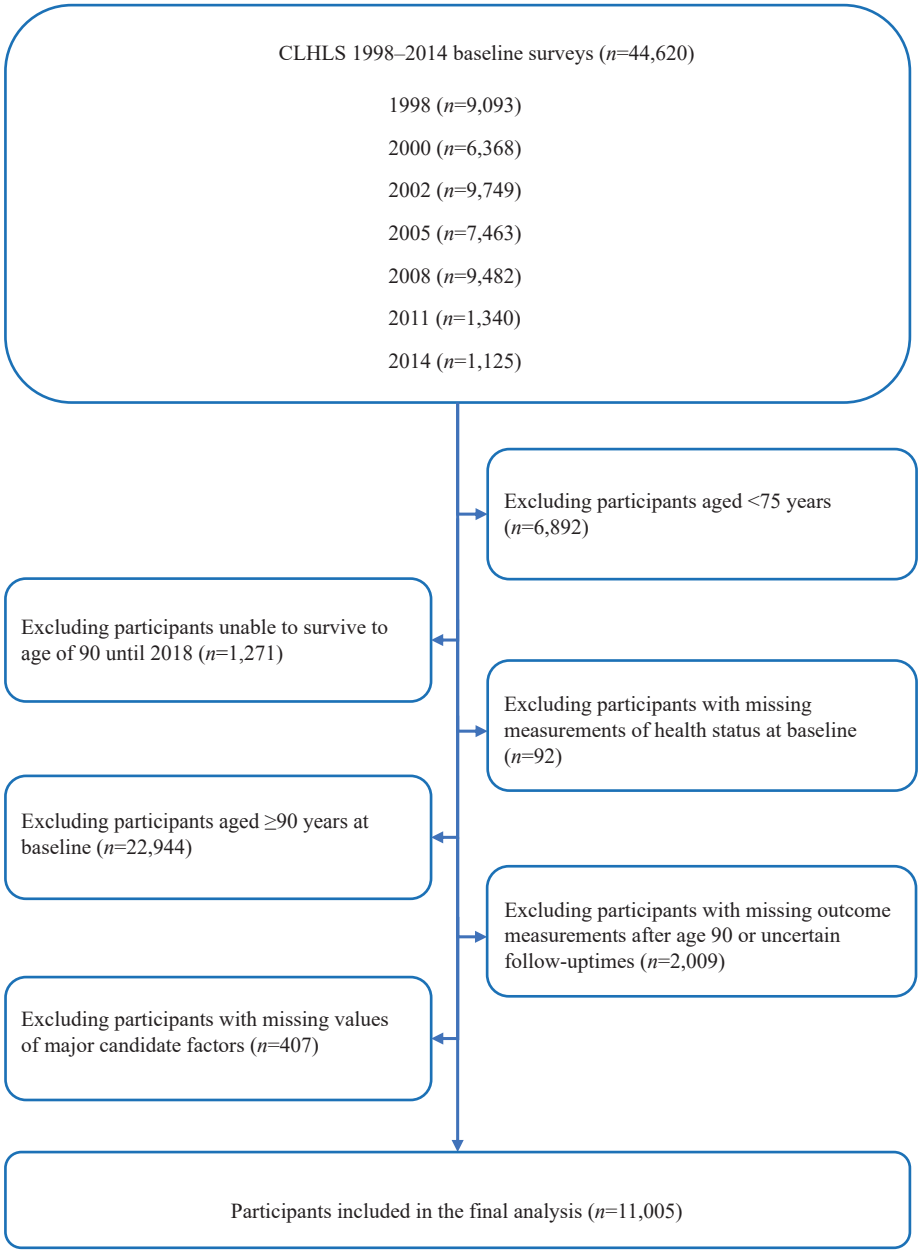
Supplementary Methods

Participants recruited at different baseline waves may have different periods to age 90, leading to a smaller number of participants included in the later cohorts for analyses (Supplementary Figure S1). To address the potential bias, baseline age as a confounder was included in the analyses (*1*).

Healthy longevity is a combination of healthy aging and longer lifespan. Nevertheless, there is still no consensus on the definition of healthy longevity around the world. Previous studies defined healthy longevity as healthy survival to a specific age (e.g., 70, 85, 90), without major diseases, and/or functional decline (physical performance, and/or cognitive impairment) (*1*–*5*). These studies paid more attention to diseases rather than functional status, which may not be consistent with the WHO's definition of healthy ageing as "the process of developing and maintaining the functional ability that enables wellbeing in older age;" presence of diseases is a factor rather than an



SUPPLEMENTARY FIGURE S1. Selection criteria for study participants, CLHLS 1998–2018.
Abbreviation: CLHLS=Chinese Longitudinal Healthy Longevity Survey.

exclusion criteria of healthy ageing (*6*).

In this study, a cut-off of 90 was used to define longevity, and healthy longevity was defined in combination with longevity and WHO's definition of healthy ageing, which focuses more on functional ability that reflects the intrinsic capacity of the individual (i.e., mental and physical capacities including abilities to walk, think, see, hear, and remember) and considers diseases as factors that influence intrinsic capacity and healthy ageing (*6*). This is similar to the definition proposed by U.S. National Academy of Medicine which links healthy longevity to maintaining physical, mental, and social health and well-being as humans live longer, rather than simply treating ailments (*7*–*8*).

According to the healthy ageing concept of WHO, healthy longevity was defined in combination of age at death, physical performance, cognitive function, mental health, visual function, and hearing function. Participants were classified into healthy longevity, usual longevity, and non-survival (Please find the details in the second paragraph of the main text).

The functional performance was measured by qualified doctors at baseline and each follow-up survey until the end of study, death, or lost-to-follow-up. First, physical performance was measured by physical activities in three tests (stand up from a chair, pick up a book from floor, and turn around 360°) (*9*), and ADL (evaluated by Katz scale, including bathing, dressing, eating, transferring, toileting, and continence; participants who need any assistance with the activity were regarded as having an ADL disability; ADL score, ranges 6–18 points, was also calculated for participants, lower scores represent lower limitations in ADL) (*10*). Participants without limitations in ADL and physical activities were regarded as having good physical performance. Second, cognitive function was assessed by the mini-mental state examination (MMSE) with a total of 30 points for 24 questions, and the higher the score, the better the cognitive function. Education-adjusted cut-offs were applied to define cognitive impairment (*11*). Third, mental health was assessed by seven items (5-point response scale, 0–4 points were assigned to each item). The total score ranges 0–28 points, and the higher the score, the better the mental health. Late-elderly participants with scores ≥18 points (the median value) were classified as having good mental health (*12*). Fourth, visual function was examined by a vision test, defined as poor if the participant cannot see the circle on the cardboard sheet under a flashlight or if the participant is blind (*13*). Fifth, hearing function was examined during the interview, defined as hearing loss if the participant can only hear a part of what interviewer said with or without a hearing aid, or cannot hear anything (*14*).

A face-to-face interview was conducted using a validated questionnaire to collect the demographic characteristics (i.e., age, gender, place of residence, education years, marital status, etc.), lifestyles (i.e., smoking, drinking, exercising, performing housework, gardening, reading, raising domestic animals, watching TV or listening to radio, playing cards or mahjong, dietary intake, etc.), functional status (i.e., ADL, cognitive function, mental health measured by psychological resources, etc.), self-rated health and prevalence of chronic diseases (i.e., heart disease, cerebrovascular disease, diabetes, respiratory diseases, digestive disease, cancer, etc.) and other information. Meanwhile, height, weight, blood pressure, visual function, hearing function, and chewing ability were measured by qualified doctors for each participant during the interview (*10*), and the BMI was calculated and classified into underweight, normal weight, overweight, and obese according to cut-offs for the Chinese adults (*15*).

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Preplanned Studies

The Status of Blood Lipids Among Children and Adolescents — China, 2016–2017

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Summary

What is already known about this topic?

Dyslipidemia is attributed to cardiovascular disease (CVD). A recent report suggests dyslipidemia prevalence has increased among children and adolescents.

What is added by this report?

Dyslipidemia prevalence was 19.43% among Chinese children and adolescents aged 6–17 years in 2016–2017. The abnormal blood lipid prevalence and the average blood lipid levels showed a diversified distribution across demographics.

What are the implications for public health practice?

Continued monitoring of abnormal blood lipids among Chinese children and adolescents, especially triglyceride (TG) and high-density lipoprotein cholesterol (HDL-C), may inform public health interventions to promote long-term cardiovascular health and prevent CVD in adulthood.

Cardiovascular disease (CVD) is a leading cause of death globally (*1*). As one of the leading risk factors for CVD, dyslipidemia refers to a group of lipoprotein metabolism disorders caused by genetic variation and (or) environmental factors. A previous study reported dyslipidemia in childhood as a trajectory phenomenon (*2*). The early lesions among dyslipidemia children are vascular endothelial injury and arterial fatty streaks, and further develop into fibrous plates, which may increase the risk of dyslipidemia and CVD among adults. Therefore, screening youth for dyslipidemia may have the potential to identify early affected individuals, reduce long-term cholesterol burden through intervention, and prevent or delay cardiovascular events in adulthood (*3*). This study used cross-sectional data from China Nutrition and Health Surveillance of Children and Lactating Mothers (CNHSCLM) from 2016–2017. The study aims to report the status of blood lipids among Chinese children and adolescents aged 6–17 years at a national level.

In 2016–2017, the CNHSCLM used 275 disease surveillance points across 31 provincial-level administrative divisions (PLADs) and a multistage stratified cluster randomized sampling method to select a representative sample of children and adolescents aged 6–17 years. Similar recruitment methods to those used in the CNHSCLM have been reported elsewhere (*4*). Trained local personnel conducted the face-to-face questionnaire, physical measurements, and blood draw. Venous blood was collected from each subject to test four blood lipids, including total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C). After excluding incomplete data, 68,081 subjects who had been measured TC, TG, LDL-C, and HDL-C were included. The Ethics Committee for Research on Human Subjects of China CDC approved the study protocol (No. 201614). Interviewers obtain written informed consent before the start of the study.

High TC was defined as TC ≥5.18 mmol/L, high TG as TG ≥1.70 mmol/L, high LDL-C as LDL-C ≥ 3.37 mmol/L, low HDL-C as HDL-C <1.04 mmol/L, high non-HDL-C (non-HDL-C = TC – HDL-C) as non-HDL-C ≥3.75 mmol/L, and dyslipidemia was defined as any abnormality of the above indicators (*5–6*). A log transformation was applied to fit the normal distribution since some of the variables (TC, TG, and non-HDL-C) were non-normally distributed among participants. The post-stratification adjustment used China's Sixth National Census in 2010 (*7*). Prevalence and means were weighted to represent the national levels. Differences between groups were tested using Rao-Scott Chi-square test and ANOVA test. Linear regression was used to test age trends in abnormal blood lipid prevalence and blood lipid levels. $P<0.05$ was deemed significant. All statistical analyses were conducted using SAS software (version 9.4; SAS Institute, Inc., Cary, NC, USA).

The study included 68,081 children and adolescents aged 6–17 years; 34,017 males and 34,064 females; and 32,371 in urban areas and 35,710 in rural areas (Table 1). In 2016–2017, the overall dyslipidemia prevalence among Chinese children and adolescents was 19.43% [95% confidence interval (*CI*): 18.09%–19.96%], with 19.82% (95% *CI*: 19.07%–20.57%) in males and 18.89% (95% *CI*: 18.23%–19.73%) in females. There was an increasing age trend in dyslipidemia prevalence, from 15.83% for children aged 6–8 to 21.79% for adolescents aged 15–17 (P_{trend}<0.0001). The urban group had a higher dyslipidemia prevalence than the rural group (20.60% *vs.* 18.39%, *P*<0.0001) (Table 1). Table 1 also shows that the prevalence of low HDL-C was the highest, and that high TG was the second highest.

Overall, 11.63% of all children and adolescents had low HDL-C (Table 1). There was an increasing age trend in the prevalence of low HDL-C from 8.31% for children aged 6–8 to 15.49% for adolescents aged 15–17 (P_{trend}<0.0001). Males had a higher prevalence of low HDL-C than females (12.63% *vs.* 10.49%, *P*<0.0001). The prevalence of low HDL-C was greater in rural than urban areas (12.06% *vs.* 11.14%, *P*=0.0283).

Overall, 4.74% of all children and adolescents had high TG (Table 1). There was an increasing age trend in the prevalence of high TG from 2.54% for children aged 6–8 to 4.62% for adolescents aged 15–17 (P_{trend}<0.0001). No differences were seen between gender groups (4.54% *vs.* 4.97%, *P*=0.1323), and no differences were seen between urban and rural areas (4.92% *vs.* 4.58%, *P*=0.2331).

Similarly, with the prevalence of high TG, 4.69% of all children and adolescents had high TC (Table 1). There was a decreasing age trend in the prevalence of high TC from 5.21% for children aged 6–8 to 3.83% for adolescents aged 15–17 (P_{trend}<0.0001). The females had a higher prevalence of high TC than males (5.23% *vs.* 4.21%, *P*=0.0015). The prevalence of high TC was greater in urban than rural areas (6.25% *vs.* 3.31%, *P*<0.0001).

From 2016–2017, the average LDL-C and HDL-C levels were 2.09 mmol/L and 1.42 mmol/L,

TABLE 1. The prevalence of abnormal blood lipids among Chinese children and adolescents aged 6–17 years in 2016–2017. [% (95% *CI*)]

Characteristics	*N**	High TC	High TG	High LDL-C	Low HDL-C	High non-HDL-C	Dyslipidemia
Total	68,081	4.69 (4.37, 5.00)	4.74 (4.45, 5.03)	2.70 (2.47, 2.93)	11.63 (11.22, 12.04)	3.83 (3.54, 4.12)	19.43 (18.09, 19.96)
Gender							
Male	34,017	4.21 (3.80, 4.62)	4.54 (4.13, 4.94)	2.71 (2.37, 3.04)	12.63 (12.03, 13.23)	3.66 (3.27, 4.05)	19.82 (19.07, 20.57)
Female	34,064	5.23 (4.74, 5.72)	4.97 (4.57, 5.38)	2.69 (2.37, 3.01)	10.49 (9.94, 11.03)	4.02 (3.60, 4.45)	18.98 (18.23, 19.73)
χ^2	–	10.0324	2.2649	0.0054	26.9366	1.5140	2.4219
P	–	0.0015	0.1323	0.9413	<0.0001	0.2185	0.1196
Age (years)							
6–8	17,333	5.21 (4.63, 5.80)	2.54 (2.15, 2.92)	3.27 (2.79, 3.74)	8.31 (7.56, 9.05)	3.55 (3.07, 4.04)	15.83 (14.85, 16.81)
9–11	20,485	5.61 (4.89, 6.33)	5.49 (4.84, 6.14)	3.11 (2.56, 3.65)	8.63 (7.97, 9.30)	4.24 (3.60, 4.89)	18.33 (17.26, 19.40)
12–14	16,783	4.27 (3.60, 4.94)	6.38 (5.71, 7.06)	2.39 (1.87, 2.91)	13.12 (12.22, 14.02)	3.92 (3.27, 4.57)	21.11 (19.96, 22.25)
15–17	13,480	3.83 (3.29, 4.36)	4.62 (4.10, 5.13)	2.16 (1.82, 2.50)	15.49 (14.61, 16.36)	3.63 (3.12, 4.13)	21.79 (20.77, 22.82)
t_{trend}	–	−4.45	5.45	−4.46	13.62	−0.02	8.59
P_{trend}	–	<0.0001	<0.0001	0.0011	<0.0001	0.8221	<0.0001
Area							
Urban	32,371	6.25 (5.72, 6.77)	4.92 (4.50, 5.34)	3.67 (3.29, 4.06)	11.14 (10.57, 11.72)	5.09 (4.61, 5.58)	20.60 (19.81, 21.39)
Rural	35,710	3.31 (2.94, 3.67)	4.58 (4.19, 4.97)	1.84 (1.57, 2.11)	12.06 (11.48, 12.64)	2.71 (2.39, 3.03)	18.39 (17.67, 19.11)
χ^2	–	83.5250	1.4218	58.3577	4.8080	67.7579	16.4322
P	–	<0.0001	0.2331	<0.0001	0.0283	<0.0001	<0.0001

Note: "–" indicates no χ^2 or *P* values.
Abbreviation: *CI*=confidence interval; TC=total cholesterol; TG=triglyceride; LDL-C=low-density lipoprotein cholesterol; HDL-C=high-density lipoprotein cholesterol.
* *N* stands for the number of participants.

respectively. The geometric average TC, TG and non-HDL-C levels were 1.57 mmol/L, 0.62 mmol/L and 1.22 mmol/L, respectively. There were differences in the average blood lipid levels between different groups. The females had higher average blood lipid levels than males (all $P<0.0001$); the average blood lipid levels in urban areas were higher than in rural areas (all $P<0.0001$) (Table 2). Table 2 also suggests an increasing age trend in average TG, while decreasing age trends in other average blood lipids (all $P_{trend}<0.0001$).

DISCUSSION

This is the latest study to present the status of current blood lipids on a national level in China containing three key findings. First, our study shows that in 2016–2017, dyslipidemia prevalence among Chinese children and adolescents aged 6–17 was 19.43%. Second, there were differences in the abnormal blood lipid prevalence and the average blood lipid levels between gender or area groups. Our study also demonstrated age trends in abnormal blood lipid prevalence and blood lipid levels.

Dyslipidemia prevalence in China in 2016–2017 (19.43%) was lower than a previous study reported (20.6%) (*8*). The inconsistency of current findings may be attributable to the heterogeneity of study population and study methodology. For example, the results were reported from subjects in Hainan Province (southern China) and Shaanxi Province (northwestern China), and the definition of high TG was based on age. Our findings are similar to the results of a study in western China which used same recruitment methods to select study population and the same criteria for the definition of abnormal blood lipids (*9*), the prevalence of high TC was greater in females, and the females had lower prevalence of low HDL-C. This may be attributed to differences in changes in hormone levels during puberty (*10*). Compared to rural people, urban people were consistently more likely to have high blood lipid levels. This may be explained by socioeconomic status (ie., food security), which may warrant further research. Our study shows increased age trends in the prevalence of low HDL-C and high TG, and decreased trends in the prevalence of high TC and high LDL-C, similar to a previous study (*11*). Of

TABLE 2. The average blood lipids among Chinese children and adolescents aged 6–17 years in 2016–2017. (mmol/L, mean±SD)

Characteristics	TC*	TG*	LDL-C	HDL-C	non-HDL-C*
Total	1.57±0.24	0.62±0.21	2.09±0.6	1.42±0.34	1.22±0.28
Gender					
Male	1.56±0.23	0.61±0.22	2.05±0.60	1.41±0.35	1.20±0.27
Female	1.59±0.25	0.64±0.21	2.13±0.59	1.43±0.33	1.23±0.29
F	220.09	521.60	248.36	54.86	214.44
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Age (years)					
6–8	1.59±0.19	0.58±0.18	2.16±0.62	1.49±0.35	1.22±0.23
9–11	1.59±0.22	0.63±0.21	2.13±0.59	1.47±0.35	1.23±0.27
12–14	1.56±0.28	0.65±0.22	2.03±0.59	1.39±0.34	1.21±0.32
15–17	1.55±0.26	0.63±0.22	2.04±0.58	1.35±0.31	1.21±0.30
t_{trend}	−11.42	14.59	−13.15	−26.72	−4.00
P_{trend}	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Area					
Urban	1.59±0.20	0.63±0.23	2.16±0.62	1.43±0.33	1.24±0.24
Rural	1.56±0.27	0.62±0.19	2.03±0.57	1.42±0.34	1.20±0.32
F	284.64	66.33	819.87	18.72	378.89
P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Abbreviation: SD=standard deviation; TC=total cholesterol; TG=triglyceride; LDL-C=low-density lipoprotein cholesterol; HDL-C=high-density lipoprotein cholesterol.
* Log-transformed value.

the five cholesterol measures examined in this report, the top two abnormalities in blood lipid prevalence were low HDL-C and high TG, closely associated with obesity. One possible pathway is that due to the increasing blood free fatty acids in obese people, TG accumulates in visceral fat, and the liver synthesizes extra TG and releases it into the circulation, causing high TG. In this case, HDL-C disintegrates easily after the action of cholesteryl ester transfer protein and hepatic lipase, causing the decreasing HDL-C Ultimately (*12*).

This study was subject to some limitations. The definition of dyslipidemia in this study referred to the expert consensus standard for the prevention and treatment of dyslipidemia in children and adolescents, which limited the direct comparison with other estimates reported using different criteria. However, it also provides a basis for formulating prevention and treatment strategies and measures for dyslipidemia in children and adolescents. Overall, given the diversified demographics of the current status of blood lipids, continued monitoring of abnormal blood lipid levels among Chinese children and adolescents, especially TG and HDL-C, may inform public health interventions to promote long-term cardiovascular health and prevent CVD in adulthood. Furthermore, attention must be paid to obesity among children and adolescents, due to the relationship between obesity and high TG and low HDL-C.

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Preplanned Studies

Prevalence and Patterns of Multimorbidity Among Adults Aged 18 Years and Older — China, 2018

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Summary

What is already known about this topic?

Multimorbidity is becoming more common and poses a major challenge to healthcare systems. However, the prevalence and patterns of multimorbidity among Chinese adults aged ≥18 years are largely unknown.

What is added by this report?

This study found that 46.5% of Chinese adults had multimorbidity in 2018. And the prevalence of multimorbidity prevalence is increased with age. Prevalence of multimorbidity was higher among men, Han Chinese, adults with lower educational level, and those with lower household income. The most common multimorbidity pattern is a combination of three chronic conditions, hypertension, dyslipidemia, and obesity.

What are the implications for public health practices?

As multimorbidity diversifies characteristics and patterns, guideline development, clinical management, and public intervention should consider the complexity of multimorbidity.

In 2008, the World Health Organization defined multimorbidity as the presence of two or more chronic conditions in an individual (*1*). Multimorbidity is associated with an increased risk of premature death, hospitalization, reduced function, depression, polypharmacy, worsened quality of life, and, thus, poses a substantial economic burden on health systems (*2*). However, few studies have shown the prevalence and patterns of multimorbidity among adults aged 18 years and older in China, most of which focused on middle-aged and older adults. This study used data from the 2018 China Chronic Disease and Risk Factor Surveillance (CCDRFS) to estimate the prevalence and patterns of multimorbidity among Chinese residents aged ≥18 years. For adults with two chronic conditions in China, hypertension and dyslipidemia were the most prevalent multimorbidity combination. For those with three, hypertension, dyslipidemia, and obesity were the most prevalent co-occurence of three chronic conditions. Effective prevention and control measures are essential to reduce the burden of multimorbidity in China.

The CCDRFS program was established in 2004 to provide periodic nationwide data on the prevalence of major chronic diseases and the associated behaviors and metabolic risk factors. Details of the design, objective, and survey methods of the CCDRFS have been described previously (*3*). In 2018, 194,811 individuals were invited and 184,876 participated yielding a 94.9% response rate. This study analyzed 163,972 participants aged ≥18 years in 2018. Those missing information on the included chronic diseases or conditions and sampling weights were excluded.

In this study, information on the following 12 chronic conditions with high prevalence in China that significantly affect health or decrease functional performance and quality of life was collected by the 2018 CCDRFS: cancer, hypertension, diabetes, dyslipidemia, heart disease, stroke, chronic kidney disease, chronic obstructive pulmonary disease (COPD), musculoskeletal disorders, cervical and lumbar diseases, digestive system disorders, and obesity. Additionally, the inclusion criteria also considered a core list of chronic conditions for any multimorbidity measurement as recommended by a systematic review (*4*). Although it is controversial whether obesity should be considered as a chronic condition or a risk factor in multimorbidity studies, the British Academy of Medical Sciences recommended that obesity should be reported in multimorbidity research wherever possible (*5*). In this study, multimorbidity was defined as the presence of two or more of the 12 chronic conditions coexisting in an individual.

To assess the 12 selected conditions, the CCDRFS used a combined method that included self-reports based on physician diagnosis, physical measurements, and/or laboratory tests. Participants were asked if they

had previously been diagnosed with either of the 12 selected chronic conditions by a doctor at a township health center, community health center, or higher-level health center. The definition and diagnostic criteria of the included chronic conditions and methods of data collection are shown in Supplementary Table S1 (available in http://weekly.chinacdc.cn/).

Estimates of prevalence rate and their 95% confidence intervals (*CI*s) for multimorbidity were generated using a range of characteristics, including age group, sex, ethnicity, household income, residency, educational level, and region. The top three most common multimorbidity combinations with two and three chronic conditions were described by sex and age group.

Descriptive analyses were performed using frequencies for categorical variables and means [standard deviation (SD)] for continuous variables. For all estimates, sampling weights were used (*3*). Rao Scott chi-squared tests were used to test global differences, and logistic regression models were used to test for trends in ordinal categorical variables. Contingency tables were used to generate the most prevalent multimorbidity combinations of two and three chronic conditions. All differences were found to be statistically significant using two-tailed significance tests ($P<0.05$). All statistical analyses were performed using the SAS software package (version 9.4, SAS Institute, Inc. Cary, NC, USA), and Microsoft Office Excel 2019MSO (version 2205, Microsoft Corporation, Santa Rosa, California, USA) was used to generate the figures.

In this study, a total of 163,972 Chinese residents aged ≥18 years were included, with 72,444 (44.2%) males and 91,528 (55.8%) females. In 2018, 46.5% (95% *CI*: 45.6%–47.3%) had multimorbidity (Table 1). Men aged 18–59 years old were more likely to have multimorbidity than women. However, the prevalence was higher among women aged ≥60 years. The prevalence of multimorbidity increased with age, decreased with household income in all age groups, and decreased with educational levels among adults aged 18–44 years. Among adults with three or more chronic conditions, multimorbidity prevalence was higher among people with lower household income and educational levels than in the other groups (Supplementary Table S2, available in http://weekly.chinacdc.cn/).

Most people with any of the 12 chronic conditions examined had two or more conditions rather than a single condition alone (Figure 1). People with stroke and heart disease were more likely to suffer from multimorbidity.

For adults with two chronic conditions in China, the most prevalent multimorbidity combination of two chronic conditions was hypertension and dyslipidemia (12.9%) (Table 2). Additionally, it was also the most prevalent among people aged ≥45 years. The second most common combination of two chronic condition was dyslipidemia and obesity (12.8%). Among Chinese adults with three chronic conditions, hypertension, dyslipidemia, and obesity was the most prevalent (12.4%) (Table 2).

DISCUSSION

In 2018, the prevalence of multimorbidity among Chinese adults aged ≥18 years was 46.5%. Previous systematic reviews have reported that the pooled prevalence of multimorbidity was 42.4% (*6*). Estimates of multimorbidity prevalence vary widely across studies due to the lack of consensus on the definition and the number of chronic conditions included. Multimorbidity is common in all age groups in this study, especially among the elderly. This implies that research and prevention strategies for multimorbidity should not only focus on the elderly but should also recognize its impact among young and middle-aged adults. Men aged 18–59 years and women aged ≥60 years had a higher prevalence of multimorbidity. Menopausal and postmenopausal women experience hormonal changes accompanied by an increased risk of several chronic diseases, which may lead to higher multimorbidity prevalence among women aged ≥60 years (*7*). The prevalence of multimorbidity increased with age, consistent with previous studies (*8*). Many studies worldwide have confirmed that increasing age has a large impact on multimorbidity prevalence. The goal for older people with multimorbidity is to improve functional limitations and reduce adverse effects stimulated by chronic illness, and current best practices for the young population should focus on the prevention of common risk factors. Furthermore, the prevalence of multimorbidity decreased with household income in all age groups, and it decreased with educational levels among adults aged 18–44 years. According to a previous study, a low education level was significantly associated with the likelihood of multimorbidity (*9*). Health awareness was higher among those with higher education levels than among those with lower education levels. Additionally, multimorbidity is strongly associated with socioeconomic deprivation (*8*). This suggests that

TABLE 1. Prevalence of multimorbidity* among adults aged 18 years and older — China, 2018†.

Characteristics	*N*	≥2 Chronic conditions, % (95% *CI*§)			
		18–44 years	45–59 years	≥60 years	Total
Total	163,972	32.1 (31.0−33.2)	59.8 (58.9−60.6)	74.6 (73.8−75.5)	46.5 (45.6−47.3)
Gender					
Male	72,444	39.5 (38.0–41.0)	60.9 (59.7−62.1)	70.5 (69.5−71.6)	50.1 (49.0−51.2)
Female	91,528	24.5 (23.2–25.8)	58.6 (57.7−59.5)	78.5 (77.6−79.4)	42.8 (41.7−43.9)
P value for difference		<0.0001	0.0005	<0.0001	<0.0001
Ethnicity					
Han	144,178	32.0 (30.9–33.2)	59.8 (58.9–60.7)	74.9 (74.1–75.8)	46.6 (45.7–47.6)
Minorities	19,794	32.7 (30.6–34.8)	59.2 (57.6–60.8)	70.7 (68.6–72.8)	44.7 (43.0–46.3)
P value for difference		0.6113	0.5313	<0.0001	0.0475
Residency					
Urban	67,262	32.8 (31.4–34.3)	59.2 (57.8–60.5)	77.2 (75.8–78.5)	45.6 (44.3–47.0)
Rural	96,710	31.2 (29.8–32.6)	60.3 (59.3–61.4)	72.6 (71.7–73.5)	47.3 (46.2–48.4)
P value for difference		0.109	0.1767	<0.0001	0.0521
Household income (CNY)					
<15,000	27,034	34.3 (31.5–37.0)	62.1 (60.5–63.7)	73.1 (72.0–74.3)	53.3 (51.6–55.0)
15,000–	33,681	32.9 (30.5–35.3)	60.5 (59.1–62.0)	73.1 (71.7–74.5)	48.1 (46.6–49.5)
30,000–	35,819	33.8 (31.9–35.8)	59.2 (57.8–60.6)	76.5 (75.1–77.8)	46.7 (45.2–48.2)
>60,000	29,759	30.8 (29.0–32.7)	57.8 (56.3–59.3)	77.1 (75.4–78.7)	42.1 (40.4–43.7)
Unwilling to disclosure	37,679	30.4 (28.5–32.4)	60.1 (58.5–61.7)	73.9 (72.7–75.0)	45.8 (44.3–47.4)
P value for trend¶		0.0385	0.0001	<0.0001	<0.0001
Education					
Illiterate	25,900	39.3 (34.4–44.2)	62.6 (61.0–64.2)	76.1 (74.8–77.3)	67.4 (66.0–68.8)
Primary	55,295	39.9 (37.6–42.1)	59.5 (58.4–60.7)	73.7 (72.7–74.7)	56.5 (55.2–57.8)
Secondary	71,397	32.5 (31.1–33.8)	60.3 (59.2–61.4)	74.4 (72.7–76.0)	44.1 (42.9–45.3)
Tertiary or higher	11,380	26.6 (24.9–28.4)	52.5 (49.9–55.2)	75.6 (72.7–78.4)	30.1 (28.4–31.8)
P value for trend		<0.0001	0.1070	0.9703	<0.0001
Region					
East	61,661	32.0 (30.3–33.7)	59.4 (58.0–60.7)	75.7 (74.4–77.0)	46.4 (44.9–47.8)
Center	46,605	33.3 (31.6–35.1)	60.7 (59.0–62.4)	75.6 (74.1–77.0)	47.8 (46.1–49.4)
West	55,706	30.9 (28.8–33.0)	59.3 (57.7–60.8)	71.8 (70.3–73.3)	45.0 (43.5–46.6)
P value for difference		0.2645	0.3941	0.0003	0.0947

Abbreviation: *CI*=confidence interval; CNY=Chinese Yuan.

* Adults considered with multimorbidity are persons who had been diagnosed by a healthcare professional that they had two or more of the following 12 conditions: cancer, hypertension, diabetes, dyslipidemia, heart disease, stroke, chronic kidney disease, chronic obstructive pulmonary disease (COPD), musculoskeletal disorders, cervical and lumbar diseases, digestive system disorders, and obesity.

† Table presented weighted prevalence, which represents the overall national population. The standard population estimation for 2010 were obtained from the National Bureau of Statistics of China.

§ Considered complex survey design.

¶ Category "unwilling to disclosure" was excluded in the trend test.

future strategies designed to reduce multimorbidity should consider the importance of socioeconomic status factors. Most individuals with selected chronic conditions have at least two or more diseases. Participants with stroke and heart disease had the highest multimorbidity prevalence, which was similar to the findings of previous studies (*8*).

Hypertension and dyslipidemia were the most prevalent co-occurence of two chronic conditions among Chinese adults, and dyslipidemia, hypertension,

TABLE 2. Top 3 prevalent multimorbidity* combination of two and three chronic conditions among adults — China, 2018†.

Characteristics		With two chronic conditions	Prevalence % (95% CI§)	With three chronic conditions	Prevalence % (95% CI§)
Total	1	Hypertension + Dyslipidemia	12.9 (12.1–13.8)	Hypertension + Dyslipidemia + Obesity	12.4 (11.3–13.6)
	2	Dyslipidemia + Obesity	12.8 (11.6–14.1)	Hypertension + Diabetes + Dyslipidemia	6.1 (5.5–6.7)
	3	Dyslipidemia + Cervical and lumbar diseases	9.7 (9.0–10.3)	Hypertension + Dyslipidemia + Cervical and lumbar diseases	5.4 (4.9–5.9)
Gender					
Male	1	Dyslipidemia + Obesity	16.1 (14.3–18.0)	Hypertension + Dyslipidemia + Obesity	16.0 (14.3–17.6)
	2	Hypertension + Dyslipidemia	15.2 (14.0–16.3)	Hypertension + Diabetes + Dyslipidemia	6.7 (5.8–7.6)
	3	Dyslipidemia + Cervical and lumbar diseases	9.3 (8.4–10.2)	Hypertension + Dyslipidemia + Cervical and lumbar diseases	5.5 (4.7–6.2)
Female	1	Cervical and lumbar diseases + Digestive system disorders	11.8 (10.6–12.9)	Hypertension + Dyslipidemia + Obesity	8.2 (6.9–9.4)
	2	Dyslipidemia + Cervical and lumbar diseases	10.2 (9.0–11.5)	Musculoskeletal diseases + Cervical and lumbar diseases + Digestive system disorders	6.6 (5.9–7.3)
	3	Hypertension + Dyslipidemia	10.2 (9.4–10.9)	Hypertension + Diabetes + Dyslipidemia	5.4 (4.8–6.0)
Age groups (years)					
18–44	1	Dyslipidemia + Obesity	21.4 (19.4–23.5)	Hypertension + Dyslipidemia + Obesity	21.0 (18.6–23.4)
	2	Dyslipidemia + Cervical and lumbar diseases	11.8 (10.5–13.0)	Dyslipidemia + Cervical and lumbar diseases + Digestive system disorders	6.6 (5.2–8.0)
	3	Hypertension + Dyslipidemia	9.4 (8.0–10.9)	Dyslipidemia + Obesity + Cervical and lumbar diseases	5.7 (4.6–6.6)
45–59	1	Hypertension + Dyslipidemia	15.5 (14.5–16.6)	Hypertension + Dyslipidemia + Obesity	9.7 (8.9–10.6)
	2	Dyslipidemia + Cervical and lumbar diseases	9.4 (8.8–10.0)	Hypertension + Dyslipidemia + Cervical and lumbar diseases	7.0 (6.3–7.8)
	3	Cervical and lumbar diseases + Digestive system disorders	7.7 (7.1–8.2)	Hypertension +Diabetes + Dyslipidemia	7.0 (6.2–7.8)
≥60	1	Hypertension + Dyslipidemia	16.2 (15.3–17.1)	Hypertension + Diabetes + Dyslipidemia	8.0 (7.3–8.8)
	2	Hypertension + Chronic kidney diseases	7.7 (7.0–8.5)	Hypertension + Musculoskeletal diseases + Cervical and lumbar diseases	5.6 (5.0–6.3)
	3	Hypertension + Diabetes	7.6 (6.9–8.3)	Hypertension + Dyslipidemia + Chronic kidney diseases	5.2 (4.5–5.9)

* Adults considered with multimorbidity are persons who had been diagnosed by a healthcare professional that they had two or more of the following 12 conditions: cancer, hypertension, diabetes, dyslipidemia, heart disease, stroke, chronic kidney disease, chronic obstructive pulmonary disease (COPD), musculoskeletal disorders, cervical and lumbar diseases, digestive system disorders, and obesity.
† Table presented weighted prevalence, which represents the overall national population. Standard population estimation for the year 2010 were obtained from the National Bureau of Statistics of China.
§ *CI*=confidence interval, considered complex survey design.

and obesity were the most prevalent co-occurence of three chronic conditions. According to a systemic review in Asia, cardiovascular and metabolic diseases were the most prevalent multimorbidity pattern, and the most common diseases identified in this pattern included hypertension, diabetes, dyslipidemia, coronary heart disease, kidney disease, stroke, and obesity (*10*). The combination of hypertension and dyslipidemia may be linked to increasing obesity in the Chinese people. Moreover, obesity is also associated with multimorbidity. Notably, some chronic conditions are considered to be risk factors for other more serious diseases, for example, hypertension can often lead to cardiovascular disease and stroke. The identification of these multimorbidity patterns could potentially recognize more serious diseases. Understanding the reasons for disease clusters may help to identify the possible etiology of clusters and prevent their development in the first place. On the other hand, from a clinical perspective, the identification of multimorbidity patterns contributes to developing more targeted treatments and care plans for patients with multimorbidity.

This study has some limitations. First, no mental health conditions were included in the study. Thus, the prevalence of multimorbidity might have been underestimated. Second, some chronic diseases were self-reported, leading to an underestimation owing to

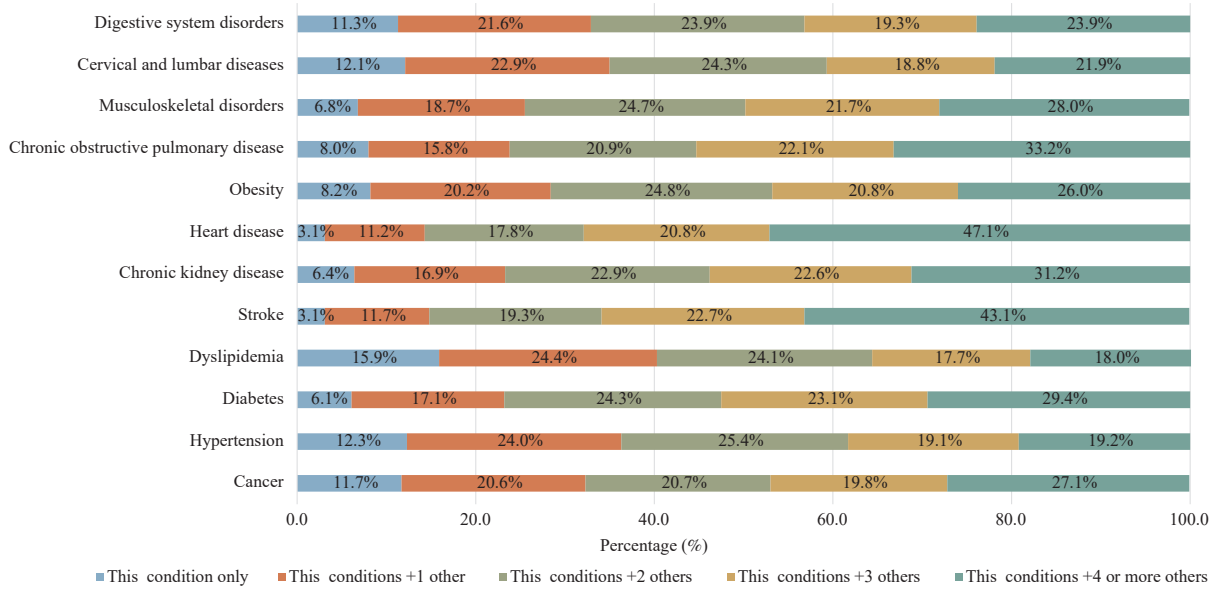

FIGURE 1. Distribution of multimorbidity of each chronic disease among adults — China, 2018.
Abbreviation: COPD=chronic obstructive pulmonary disease.

information bias. Third, some missing data on chronic conditions were excluded, resulting in significant differences in age, income, and ethnicity between the included participants and the excluded participants with missing values. This suggests that population representation was relatively limited. Therefore, the generalizability of the findings to other populations should be interpreted with caution.

In conclusion, this study used a nationally representative sample of Chinese adults to assess the prevalence and common patterns of multimorbidity. It is important to shift from single disease-oriented clinical guidelines to multimorbidity frameworks in Chinese populations, particularly among the elderly, people with low income, and those with low educational levels.

Conflicts of interest: No conflicts of interest.

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SUPPLEMENTARY TABLE S1. Definition/diagnostic criteria and prevalence of each chronic disease/condition included.

Chronic conditions	*N*	Prevalence (%)	Data collection	Definition/diagnostic criteria
Dyslipidemia	67,354	38.2	Laboratory test and/or self-report	Total cholesterol (TC) ≥6.22 mmol/L (240 mg/dL); or high density lipoprotein cholesterol (HDL-C) <1.04 mmol/L (40 mg/dL); or low density lipoprotein cholesterol (LDL-C) ≥4.14 mmol/L (160 mg/dL); or triglyceride (TG) 2.26 mmol/L (200 mg/dL), and/or have been diagnosed with dyslipidemia by hospitals at the township (community) level or above
Hypertension	69,578	28.1	Physical measurement and/or self-report	Systolic blood pressure ≥140 mmHg (18.6 kPa) and/or diastolic blood pressure ≥90 mmHg (12 kPa) without the use of anti-hypertensive drugs; and/or have been diagnosed with hypertension by hospitals at the township (community) level or above and have been taking medication for the last 2 weeks.
Cervical and lumbar diseases	51,186	24.5	Self-report	Cervical spondylosis, lumbar muscles strain, disc herniation.etc.
Diabetes	28,104	11.9	Laboratory test and/or self-report	Fasting blood glucose ≥7.0 mmol/L and/or 2 hours after taking sugar (OGTT-2h) blood glucose ≥11.1 mmol/L, and/or have been diagnosed with diabetes by hospitals at the township (community) level or above.
Chronic kidney disease	20,334	8.5	Laboratory test	Estimated glomerular filtration rate (eGFR) <60 mL/(min·1.73 m^2) or urine protein/creatinine ratio >30 mg/g was defined as chronic kidney disease.
Obesity	26,700	16.5	Physical measurement	BMI ≥28 kg/m^2
Digestive system disorders	30,187	14.9	Self-report	Gastritis, gastric ulcer, cirrhosis of liver or other digestive disease,etc.
Musculoskeletal disorders	33,929	13.0	Self-report	Osteoarthritis, musculoskeletal impairment due to injury, etc.
COPD	9,861	3.7	Self-report	Chronic obstructive pulmonary disease
Stroke	8,708	2.9	Self-report	Ischemic stroke and hemorrhagic stroke
Heart disease	6,595	2.2	Self-report	Myocardial infarction, angina, atrial fibrillation, heart bypass surgery, heart stent surgery
Cancer	3,545	1.7	Self-report	Cancer or malignant tumor (including benign craniocerebral tumor)

Abbreviation: BMI=body mass index; COPD=chronic obstructive pulmonary disease.

SUPPLEMENTARY TABLE S2. Prevalence and numbers of adults aged 18 years and older with chronic conditions* — China, 2018†.

Characteristics	Number of chronic conditions, % (95% CI§)					Mean numbers of multimorbidity (SD)
	0	1	2	3	≥4	
Total	26.5 (25.7–27.4)	27.0 (26.4–27.6)	20.8 (20.3–21.3)	13.2 (12.8–13.6)	12.4 (11.9–12.9)	1.7±1.5
Gender						
Male	21.7 (20.8–22.6)	28.2 (27.4–29.0)	23.1 (22.2–23.9)	14.5 (13.9–15.0)	12.5 (11.9–13.1)	1.7±1.4
Female	31.4 (30.4–32.5)	25.8 (25.1–26.5)	18.5 (18.0–19.0)	12.0 (11.5–12.5)	12.3 (11.7–12.9)	1.6±1.6
Age groups (years)						
18–44	37.4 (36.2–38.6)	30.5 (29.5–31.4)	18.2 (17.4–19.1)	8.9 (8.4–9.4)	5.0 (4.6–5.4)	1.2±1.2
45–59	15.0 (14.5–15.6)	25.2 (24.6–25.8)	24.9 (24.3–25.4)	17.5 (17.1–18.0)	17.4 (16.7–18.1)	2.1±1.5
≥60	7.3 (6.9–7.7)	18.0 (17.4–18.6)	23.4 (22.9–23.9)	21.4 (20.9–21.8)	29.9 (28.9–30.9)	2.7±1.7
Ethnicity						
Han	26.4 (25.6–27.3)	26.9 (26.3–27.6)	20.8 (20.3–21.4)	13.2 (12.8–13.6)	12.6 (12.1–13.1)	1.7±1.5
Minorities	27.7 (25.1–30.2)	27.7 (26.2–29.1)	20.4 (19.4–21.4)	13.5 (12.9–14.1)	10.7 (9.7–11.7)	1.6±1.5
Residency						
Urban	27.9 (26.8–29.0)	26.4 (25.6–27.3)	20.7 (20.0–21.5)	12.7 (12.1–13.3)	12.2 (11.4–13.0)	1.6±1.5
Rural	25.0 (23.9–26.1)	27.6 (27.0–28.3)	20.9 (20.3–21.5)	13.8 (13.5–14.2)	12.6 (12.0–13.2)	1.7±1.5
Household income (CNY)						
<15,000	21.5 (20.0–23.0)	25.2 (23.7–26.8)	21.3 (20.2–22.4)	15.4 (14.4–16.4)	16.6 (15.4–17.7)	1.9±1.6
15,000–	24.0 (22.8–25.1)	27.9 (26.5–29.4)	21.0 (20.0–22.0)	14.1 (13.4–14.8)	13.0 (12.3–13.7)	1.7±1.5
30,000–	26.0 (24.7–27.3)	27.3 (26.2–28.5)	21.5 (20.5–22.4)	13.3 (12.6–14.1)	11.9 (11.2–12.6)	1.7±1.6
>60,000	30.7 (29.3–32.2)	27.2 (26.0–28.4)	20.2 (19.3–21.2)	11.5 (10.8–12.3)	10.3 (9.4–11.1)	1.5±1.5
Unwilling to disclosure	27.4 (26.0–29.0)	26.7 (25.5–28.0)	20.3 (19.2–21.4)	13.1 (12.3–13.9)	12.4 (11.7–13.2)	1.7±1.5
Education						
Illiterate	12.3 (11.4–13.2)	20.3 (19.4–21.1)	22.5 (21.6–23.4)	20.0 (19.2–20.8)	24.9 (23.6–26.2)	2.4±1.7
Primary	18.6 (17.7–19.6)	24.9 (24.0–25.7)	22.7 (22.0–23.4)	16.9 (16.0–17.7)	16.9 (16.0–17.7)	2.0±1.6
Secondary	27.2 (26.3–28.2)	28.6 (27.8–29.5)	21.0 (20.2–21.7)	12.2 (11.7–12.7)	10.9 (10.3–11.6)	1.6±1.5
Tertiary or higher	41.6 (39.7–43.5)	28.3 (26.9–29.7)	17.0 (15.7–18.3)	8.2 (7.4–9.0)	4.9 (4.3–5.6)	1.1±1.2
Region						
East	27.4 (26.3–28.5)	26.2 (25.3–27.1)	20.9 (20.0–21.8)	13.3 (12.6–13.9)	12.2 (11.4–12.9)	1.6±1.5
Center	24.8 (23.4–26.2)	27.4 (26.4–28.4)	20.9 (20.0–21.8)	13.4 (12.8–14.0)	13.4 (12.4–14.5)	1.7±1.6
West	27.2 (25.3–29.1)	27.8 (26.7–28.9)	20.5 (19.7–21.3)	12.9 (12.1–13.7)	11.6 (10.9–12.3)	1.6±1.5

Abbreviation: *CI*=confidence interval; SD=standard division; CNY=Chinese Yuan.

* 12 chronic conditions measured were: cancer, hypertension, diabetes, dyslipidemia, heart disease, stroke, chronic kidney disease, chronic obstructive pulmonary disease (COPD), musculoskeletal disorders, cervical and lumbar diseases, digestive system disorders, and obesity.

† Table presented weighted prevalence, which represents the overall national population. Standard population estimation for the year 2010 was obtained from the National Bureau of Statistics of China.

§ Considered complex survey design.

Healthy China

A Projection of Life Expectancy Based on the Global Burden of Disease Study 2019 — China, 1990–2030

Jing Yang[1]; Ruhai Bai[2]; Lijun Wang[1]; Xiaoqi Feng[3]; Yunning Liu[1,#]; Maigeng Zhou[1]

Life expectancy (LE) is an important indicator for the overall health of a population, usually refers to the total number of years a group of people at birth can expect to live, given existing age-specific mortality rates (*1*). Healthy China 2030, the national strategic health plan released in 2016, set a goal that by 2030, the average LE of Chinese residents should reach 79 years. To examine the success of the plan at its midterm stage, it is necessary to evaluate its achievements so far, and assess if the goal can be realized by 2030 in each provincial-level administrative division (PLAD) separately. This study used the data of the Global Burden of Diseases Study (GBD) 2019 to describe the LE changes from 1990 to 2019 in the mainland of China with 31 PLADs, and applied an ensemble of models to project national and subnational attainment of the LE goal through 2030. Findings showed that LE in China increased from 68.0 years in 1990 to 77.6 years in 2019, with significant sex and regional disparities. China as a whole will achieve the LE goal of 79 by 2030, based on the trend from 1990–2019. About 45% of PLADs may not reach the goal, most of which are western PLADs with lower socioeconomic levels. Enhanced policies and actions should be adopted in PLADs that may not achieve the LE goal.

Data for LE at birth and age-sex-specific mortality of China, and its 31 PLAD units (Hong Kong Special Administrative Region, Macao Special Administrative Region, and Taiwan, China were not included in this study) from 1990 to 2019, were obtained from GBD 2019, which used standardized and comparable methods to estimate national and subnational disease burden from 1990 to 2019, making it possible to examine the long-term trend of LE in China and its PLADs. Primary data sources for China include surveillance data from the China Disease Surveillance Points system, censuses, the Maternal and Child Health Surveillance system and national surveys (*2*). For the calculation of LE, the estimation of the probability of death between birth and the age of 5 years, and between ages 15 and 60 years was produced and then input into the GBD model life table system, to generate a complete set of age-sex-specific mortality rates and then develop the complete life tables for all PLADs and years (*3*). Details of the method have been published elsewhere (*1*,*3*–*4*).

A probabilistic Bayesian model average (BMA) was used to combine 21 individual models to make LE projections. These models took into account the features of mortalities related to age, period, and cohort, as well as statistical features such as giving more weight to recent data points (*5*). This approach more completely captured the uncertainty about future trends in LE, and the projection error was smaller than a single model (*5*). Details of the method were referred to a previous study (*5*).

In this study, 31 PLADs were divided into four categories based on the achievement of LE goals for both sexes combined, and the LE gains since 2015, the baseline year for Healthy China 2030 goals. Substantial gains were defined as LE changes ≥3 years and moderate gains as LE changes <3 years. We also assessed the contributions of mortality decline in three age groups (0–29 years, 30–64 years, and 65 years and older) toward the projected increase in LE at birth, by calculating LE at birth, at 30 years, and at 65 years in 2015 and 2030 for each PLAD, and then estimating the changes in LE of each age group and calculating its proportion in the total gains in LE at birth. All the analyses were carried out in the software R (version 4.0.3, R Core Team, Vienna, Austria) using the package "maple" (*5*).

In the mainland of China, LE at birth was 77.6 years in 2019, which marked a 9.6 year-increase since 1990. Women's LE was higher than men's, with a gap of 4.1 years in 1990 and 6.0 years in 2019. Generally, LE in eastern PLADs was higher than in central and western PLADs. In 2019, seven eastern PLADs already reached 79 years of LE, including Beijing Municipality, Shanghai Municipality, Zhejiang Province, Guangdong Province, etc. The lowest LE was in western PLADs like Xizang (Tibet) Autonomous

Region (70.1 years), Xinjiang Uygur Autonomous Region (71.9 years), and Qinghai Province (72.1 years). LE has increased in all PLADs from 1990 to 2019. The three PLADs with the largest gains in LE were Xizang (Tibet) Autonomous Region (15.2 years), Jiangxi Province (14.2 years), and Guizhou Province (13.0 years), while the ones with the smallest gains were Hebei Province (5.7 years), Liaoning Province (6.2 years), and Tianjin Municipality (6.3 years) (Table 1).

Based on the trend from 1990 to 2019, LE in China will reach 80.2 years [95% credible interval (*CI*): 78.7, 82.4] by 2030 for both sexes combined, with an increase of 3.5 years (95% *CI*: 2.0, 5.7) compared to 2015. Women's LE will reach 83.8 years (95% *CI*: 81.6, 86.9) by 2030, while men's LE will be 77.1 years (95% *CI*: 75.7, 79.4) (Table 2).

It's estimated that 17 PLADs will achieve the LE goal by 2030, and 14 PLADs may not. We divided 31 PLADs into four categories. Group 1 includes 13 PLADs, which will achieve the goal and substantially increase LE by 2030. Seven are from the eastern area, with Beijing Municipality having the nationwide highest LE at 86.1 years (95% *CI*: 82.7, 88.8). Shaanxi Province and Chongqing Municipality are the only two western PLADs that will achieve the goal. Group 2 includes four PLADs, three from the eastern area and one from the central area, which will achieve the goal but with a moderate increase in LE (Table 2).

Group 3 includes 11 PLADs that may not achieve the goal but with a substantial increase in LE, nine from the western area and two from the central area. Tibet is projected to have the nationwide lowest LE at 73.5 years (95% *CI*: 70.4, 76.2) by 2030 but with the largest gain at 4.4 years (95% *CI*: 1.4, 7.2). Group 4 has three PLADs, which may not meet the goal and only have moderate increases in LE. Notably, Hebei Province is the only eastern PLAD that may not achieve the LE goal (Table 2).

In most PLADs, over half of the projected gains in LE among women from 2015–2030 will be due to mortality declines in the age group above 65 years. However, the contribution in the same age group will be much less among men. For most western PLADs, more than half of the gains in LE will be due to mortality declines in age groups below 65 years (Figure 1).

DISCUSSION

Consistent with other studies (*1*,*6*), this study found that LE at birth in the mainland of China increased remarkably from 1990 to 2019, but with significant sex and regional disparities. Generally, women and residents in eastern PLADs have higher LE than men and ones from central and western PLADs. LE in PLADs such as Beijing Municipality, Shanghai Municipality, and Zhejiang Province has reached the level of high-income countries (*1*). While western PLADs such as Xizang (Tibet) Autonomous Region and Xinjiang Uygur Autonomous Region, although with significant increases in LE, still have a huge gap with the PLADs having the highest LE. Differences in social determinants of health, like economic development, urbanization, education attainment, income equality, and healthcare provision, may explain the spatial variations in LE (*7*).

Overall, based on the trends from 1990 to 2019, China will be able to achieve the LE goal of 79 by 2030. However, about 45% of PLADs may not reach the goal, most of which are located in western PLADs with communities in lower socioeconomic strata. Previous study showed that since 1990, the main contributors to the increase of LE in China have shifted from children to older adults, and from infectious diseases and neonatal disorders to chronic diseases (*8*). While in most western PLADs, the transition seemed incomplete yet, where mortality declines among the elderly would contribute a relatively small part to the LE improvement. In addition, special attention should be given to those PLADs that may not meet the goal and have limited gains in LE, like Hebei Province, which had the lowest increase in LE from 1990 to 2019 and a high burden of cardiovascular diseases, including a high stroke burden not matched with its socio-demographic condition (*2*), indicating strengthened measures should be taken.

This study has at least two limitations. One is that the study was based on GBD data, and bias in the estimation of deaths in GBD would affect the final projection results. The other limitation is that the possible impact of COVID-19 was not ccounted in the projection. Evidence showed that the epidemic seemingly had no significant impact on LE from 2020–2021 in China (*9*) due to the strict dynamic zero-COVID policy for outbreak containment. However, with the relaxation of the policy since the end of 2022, the impact of COVID-19 needs further monitoring and evaluation.

While the country is making headway toward the LE

TABLE 1. Life expectancy at birth by sex in China, 1990 and 2019.

Regions	LE in 1990 (years)			LE in 2019 (years)			LE Change (years)		
	Both	Men	Women	Both	Men	Women	Both	Men	Women
The mainland of China	68.0	66.1	70.2	77.6	74.7	80.7	9.6	8.6	10.5
Eastern PLADs									
Beijing	73.6	71.4	76.2	82.7	79.6	85.9	9.1	8.2	9.7
Shanghai	74.5	72.4	76.6	82.7	80.3	85.0	8.2	7.9	8.4
Zhejiang	72.0	69.9	74.3	81.5	78.8	84.5	9.5	8.9	10.2
Guangdong	70.9	68.2	73.8	81.1	77.8	84.7	10.2	9.6	10.9
Jiangsu	71.9	69.5	74.4	80.8	77.9	83.8	8.9	8.4	9.4
Fujian	68.7	66.1	71.6	79.7	76.6	83.1	11.0	10.5	11.5
Tianjin	73.2	71.0	75.8	79.5	76.8	82.7	6.3	5.8	6.9
Shandong	70.5	68.3	72.8	78.7	75.7	81.9	8.2	7.4	9.1
Liaoning	71.0	68.6	73.8	77.2	73.8	81.0	6.2	5.2	7.2
Hainan	68.5	66.3	70.8	77.0	74.6	79.7	8.5	8.3	8.9
Hebei	70.0	68.0	72.3	75.7	72.6	79.1	5.7	4.6	6.8
Central PLADs									
Anhui	67.4	66.0	68.9	78.0	75.3	81.1	10.6	9.3	12.2
Jiangxi	63.4	61.4	65.5	77.6	74.8	80.6	14.2	13.4	15.1
Henan	69.0	66.7	71.3	77.5	74.4	80.7	8.5	7.7	9.4
Hubei	67.9	65.8	70.3	77.5	75.0	80.3	9.6	9.2	10.0
Jilin	67.0	64.3	70.4	77.1	75.8	78.4	10.1	11.5	8.0
Hunan	67.3	68.0	66.6	76.6	73.6	80.1	9.3	5.6	13.5
Shanxi	68.8	66.7	71.3	76.4	73.9	79.3	7.6	7.2	8.0
Heilongjiang	67.3	65.3	69.8	75.5	72.5	79.0	8.2	7.2	9.2
Western PLADs									
Shaanxi	65.0	63.3	67.1	76.7	74.4	79.4	11.7	11.1	12.3
Chongqing	65.8	63.4	68.8	76.5	73.8	79.5	10.7	10.4	10.7
Inner Mongolia	66.9	65.1	69.3	76.3	73.5	79.7	9.4	8.4	10.4
Gansu	66.0	63.7	68.6	76.1	73.6	78.9	10.1	9.9	10.3
Guangxi	68.3	66.0	70.9	76.1	72.6	80.2	7.8	6.6	9.3
Ningxia	65.2	63.3	67.5	75.9	73.4	78.6	10.7	10.1	11.1
Sichuan	66.1	64.3	68.1	75.5	72.5	79.0	9.4	8.2	10.9
Guizhou	61.8	60.0	63.9	74.8	72.1	77.8	13.0	12.1	13.9
Yunnan	62.6	60.3	65.2	74.2	71.1	77.9	11.6	10.8	12.7
Qinghai	62.5	60.6	64.7	72.1	70.1	74.4	9.6	9.5	9.7
Xinjiang	60.6	59.0	62.6	71.9	70.0	74.2	11.3	11.0	11.6
Tibet	54.9	52.2	57.8	70.1	67.6	72.9	15.2	15.4	15.1

Abbreviation: PLADs=provincial-level administrative divisions; LE=life expectancy.

goal, there is still uncertainty about the future. The findings of this study would support efforts for monitoring Healthy China 2030, and help to inform policies and decision-making at both national and subnational levels. Enhanced policies and actions should be adopted in PLADs that may not achieve the LE goal or make slow progress.

Conflicts of interest: No conflicts of interest.

TABLE 2. Forecasted life expectancy at birth by sex in China, 2030.

Regions	LE in 2030 years (95% *CI*)			Changes of LE from 2015 to 2030 years (95% *CI*)		
	Both	Men	Women	Both	Men	Women
The mainland of China	80.2 (78.7, 82.4)	77.1 (75.7, 79.4)	83.8 (81.6, 86.9)	3.5 (2.0, 5.7)	3.4 (2.0, 5.6)	3.6 (1.4, 6.7)
Group 1*						
Beijing	86.1 (82.7, 88.8)	82.4 (79.4, 84.8)	90.6 (85.8, 95.4)	3.4 (0.0, 6.2)	3.2 (0.3, 5.7)	4.0 (−0.9, 8.7)
Guangdong	84.8 (82.5, 87.6)	80.9 (790., 83.6)	89.5 (86.0, 94.0)	4.3 (2.0, 7.0)	4.0 (2.0, 6.6)	4.9 (1.4, 9.4)
Zhejiang	84.7 (82.6, 87.2)	81.4 (79.5, 83.6)	88.7 (85.9, 93.2)	3.8 (1.7, 6.4)	3.4 (1.5, 5.6)	4.6 (1.6, 8.9)
Jiangsu	83.9 (81.7, 86.5)	80.5 (78.9, 82.9)	87.5 (84.0, 91.5)	3.7 (1.5, 6.3)	3.4 (1.8, 5.8)	3.9 (0.3, 7.8)
Fujian	83.0 (81.1, 86.1)	79.7 (78.0, 82.4)	86.9 (84.4, 91.5)	4.2 (2.3, 7.2)	4.1 (2.4, 6.8)	4.3 (1.8, 8.9)
Tianjin	82.0 (80.1, 84.3)	78.9 (77.3, 81.4)	85.7 (83.5, 88.8)	3.1 (1.1, 5.3)	3.0 (1.3, 5.4)	3.1 (0.8, 6.1)
Shandong	81.2 (79.7, 82.9)	77.7 (76.5, 79.3)	85.1 (82.5, 88.2)	3.3 (1.6, 4.9)	2.9 (1.7, 4.4)	3.6 (1.0, 6.6)
Anhui	80.9 (79.6, 82.9)	77.7 (76.5, 79.9)	84.4 (82.6, 87.4)	3.9 (2.6, 5.9)	3.5 (2.3, 5.7)	4.3 (2.5, 7.2)
Jiangxi	80.7 (78.8, 83.4)	77.8 (75.8, 80.2)	83.8 (81.4, 87.0)	4.1 (2.2, 6.8)	4.1 (2.1, 6.5)	4.0 (1.5, 7.2)
Hubei	80.0 (78.8, 82.0)	77.2 (75.7, 79.1)	83.1 (81.1, 86.5)	3.6 (2.4, 5.6)	3.4 (1.9, 5.2)	3.7 (1.7, 7.1)
Jilin	79.8 (77.6, 81.7)	78.7 (75.9, 80.8)	80.9 (78.9, 82.9)	3.4 (1.2, 5.3)	3.7 (0.9, 5.8)	2.9 (0.9, 4.9)
Shaanxi	79.2 (77.9, 81.2)	76.8 (75.5, 79.0)	82.0 (80.2, 84.8)	3.5 (2.1, 5.5)	3.5 (2.2, 5.7)	3.5 (1.6, 6.2)
Chongqing	79.0 (78.1, 80.7)	76.2 (75.1, 78.1)	82.1 (80.6, 84.5)	3.7 (2.8, 5.5)	3.7 (2.6, 5.6)	3.6 (2.1, 6.0)
Group 2†						
Shanghai	85.5 (82.8, 87.4)	82.8 (80.7, 84.4)	88.7 (84.5, 92.3)	2.9 (0.2, 4.9)	2.9 (0.8, 4.5)	3.2 (−0.9, 6.9)
Henan	79.4 (78.1, 81.7)	76.2 (74.9, 78.2)	82.9 (80.9, 86.0)	2.8 (1.4, 5.0)	2.7 (1.5, 4.7)	2.9 (0.8, 5.9)
Liaoning	79.3 (78.0, 81.4)	75.4 (74.1, 77.9)	83.8 (81.8, 86.5)	2.8 (1.4, 4.9)	2.5 (1.1, 4.9)	3.1 (1.0, 5.7)
Hainan	79.0 (78.0, 80.5)	76.7 (75.7, 78.2)	81.9 (80.1, 84.0)	2.9 (2.0, 4.5)	3.0 (2.1, 4.6)	3.0 (1.3, 5.2)
Group 3§						
Inner Mongolia	78.9 (77.6, 81.2)	75.9 (74.5, 78.5)	82.5 (80.5, 85.7)	3.5 (2.2, 5.9)	3.5 (2.1, 6.1)	3.5 (1.5, 6.7)
Hunan	78.9 (77.6, 80.9)	75.4 (73.2, 77.7)	83.4 (80.4, 86.4)	3.3 (1.9, 5.2)	2.9 (0.9, 5.2)	4.0 (0.9, 6.9)
Gansu	78.3 (77.0, 80.6)	75.8 (74.4, 78.2)	81.3 (79.4, 84.2)	3.3 (2.1, 5.6)	3.4 (1.9, 5.8)	3.4 (1.5, 6.3)
Ningxia	78.1 (77.1, 79.7)	75.6 (74.6, 77.5)	81.0 (79.5, 83.1)	3.2 (2.3, 4.8)	3.2 (2.3, 5.2)	3.2 (1.6, 5.3)
Heilongjiang	77.9 (76.6, 79.1)	74.6 (73.3, 76.1)	81.7 (79.9, 83.6)	3.1 (1.8, 4.3)	2.9 (1.6, 4.4)	3.2 (1.3, 5.1)
Sichuan	77.7 (76.4, 80.1)	74.4 (73.3, 76.6)	81.5 (79.3, 84.8)	3.3 (2.0, 5.6)	3.0 (1.9, 5.3)	3.3 (1.1, 6.7)
Guizhou	77.4 (76.2, 79.3)	74.7 (73.5, 76.7)	80.3 (78.6, 82.7)	3.8 (2.6, 5.7)	3.7 (2.6, 5.8)	3.5 (1.9, 5.9)
Yunnan	76.5 (75.3, 78.1)	73.2 (72.0, 75.1)	80.2 (78.3, 82.3)	3.3 (2.1, 4.9)	3.2 (2.0, 5.2)	3.1 (1.1, 5.2)
Xinjiang	74.6 (73.1, 76.3)	72.5 (70.9, 74.6)	76.8 (75.0, 78.7)	3.8 (2.4, 5.6)	3.9 (2.3, 6.0)	3.5 (1.7, 5.4)
Qinghai	74.4 (73.2, 76.3)	72.3 (71.2, 74.4)	76.7 (74.9, 78.8)	3.4 (2.3, 5.4)	3.5 (2.4, 5.6)	3.3 (1.5, 5.4)
Tibet	73.5 (70.4, 76.2)	71.1 (68.0, 73.8)	76.1 (72.8, 78.8)	4.4 (1.4, 7.2)	4.9 (1.8, 7.6)	3.9 (0.7, 6.7)
Group 4¶						
Shanxi	78.5 (77.2, 79.7)	75.8 (74.7, 77.3)	81.6 (79.6, 83.6)	2.9 (1.6, 4.1)	2.8 (1.7, 4.3)	2.9 (0.9, 4.8)
Guangxi	77.9 (76.6, 79.9)	74.0 (72.7, 76.0)	82.5 (80.4, 85.1)	2.7 (1.4, 4.6)	2.4 (1.1, 4.4)	2.9 (0.7, 5.4)
Hebei	77.7 (75.9, 80.6)	74.5 (72.6, 77.1)	81.3 (79.0, 84.4)	2.9 (1.1, 5.8)	2.8 (1.0, 5.5)	2.8 (0.4, 5.8)

Abbreviation: *CI*=credible interval; LE=life expectancy.
* Group 1: LE ≥79 years by 2030, and changes ≥3 years (goal achieved, substantial gains).
† Group 2: LE ≥79 years by 2030, and changes <3 years (goal achieved, moderate gains).
§ Group 3: LE <79 years by 2030, and changes ≥3 years (goal not achieved, substantial gains).
¶ Group 4: LE <79 years by 2030, and changes <3 years (goal not achieved, moderate gains).

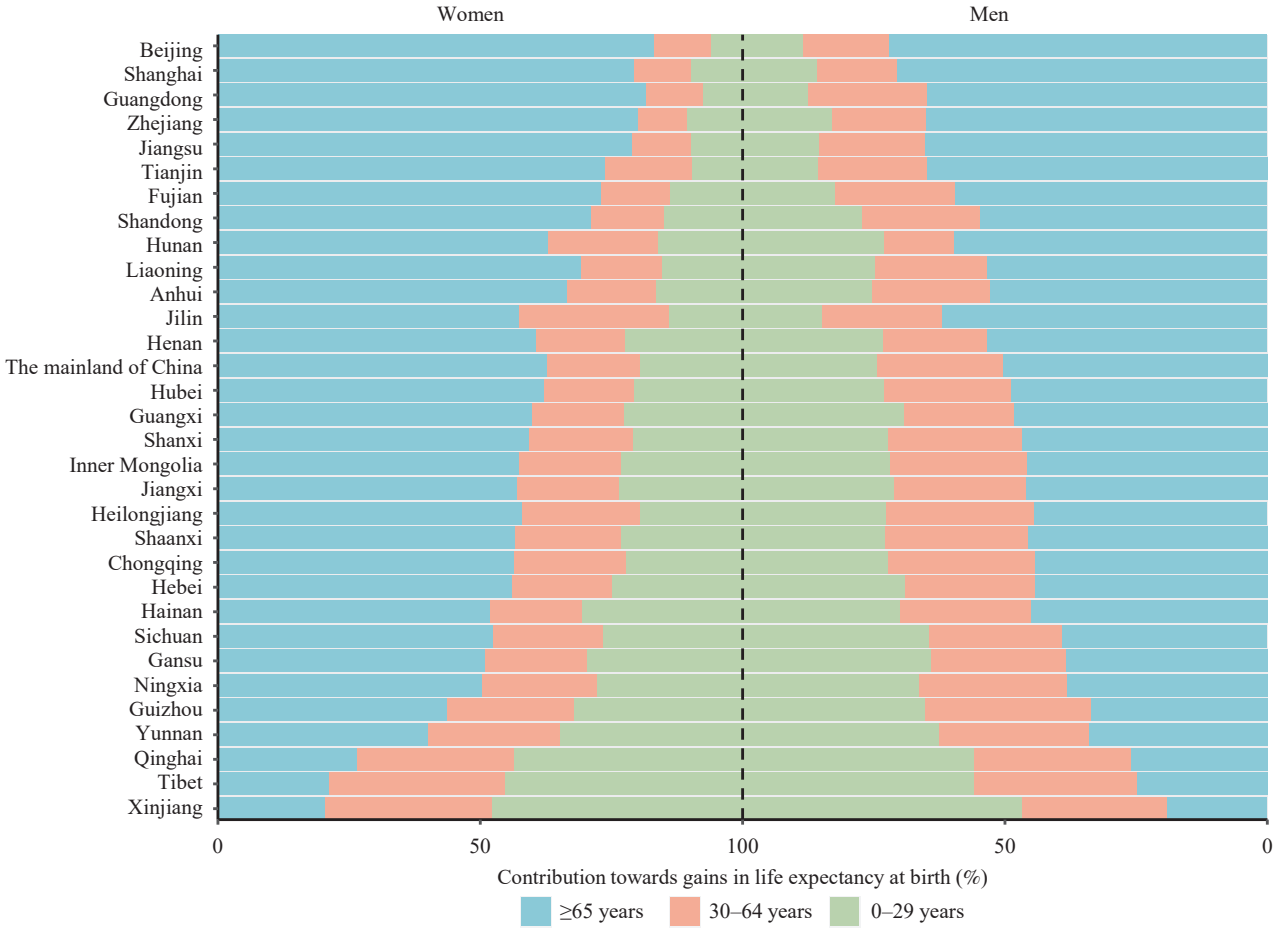

FIGURE 1. Contribution of the projected decline in mortality in three age groups toward the gains in life expectancy at birth in China, 2015–2030.

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