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Smoking cessation and mortality risk reduction in older adults with long-term smoking history

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Abstract

Background The association between smoking cessation and decreased mortality existed among former smokers has been well documented. However, evidence is limited for smokers with long-term exposure. This study aims to quantify the association between smoking cessation and mortality by years since quitting in older adults with long-term smoking history.

Methods Data from Beijing Healthy Aging Cohort Study (BHACS), conducted among communities aged over 55 years old at recruitment, were collected via questionnaire between July 2009 and September 2015 and followed up for all-cause and cancer mortality until March 2021. Self-reported smoking status and years since quitting were collected at baseline. Cox proportional hazards models were used to examine the association between smoking cessation and all-cause and cancer mortality.

Results A total of 11 235 participants (43.9% male) were included, with a mean age of 70.35 (SD 7.71) years. Former smokers comprised 31.7% of the cohort, with a median smoking duration of 43 (IQR: 34–50) years. During 71 573 person-years of follow-up, there were 1 617 deaths (14.4% of the total cohort), of which 872 (17.7%) occurred among male participants. Compared with never smokers, HR (95%CI) for participants who current smoked was 2.898 (2.092–4.013); quit smoking less than 10 years (medians [quartiles] 4 [1, 7] years) before recruitment was 2.738(1.972–3.802); 10 to 20 years (16 [13, 20] years), 1.807(1.286–2.540); and 20 years or more (30 [25, 37] years), 1.293(0.981–1.705). The risk of all-cause and cancer mortality decreased gradually over years since quitting. Quitting less than 10 years, 10 to 20 years and 20 years or more, former smokers avoided an estimated 8.4%, 57.5% and 84.6% of excess all-cause mortality associated with current smoking, respectively. The association between smoking cessation and decreased mortality was observed among former smokers regardless of smoking history.

Conclusions In this study, current smoking was associated with nearly triple the mortality risk compared to never smoking. Smoking cessation, even after a long-term smoking history, was associated with significant decreases in the relative excess mortality linked to continuing smoking. The association were more pronounced in men.

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What this paper adds

What is already known on this topic.

Accumulating evidence has shown an association between smoking cessation and decreased mortality among former smokers in general or older populations. However, little evidence exists for smoker with long-term exposure.

What this study adds.

This study demonstrates significant relative benefits of smoking cessation among older populations, even those with long-term smoking exposure. Notably, participants who quit over 20 years ago showed a reduction in excess risk of all-cause mortality to levels comparable with never smokers.

How this study might affect research, **practice or policy**.

These findings highlight the substantial benefit of smoking cessation in reducing mortality risk, even after long-term exposure. Public health efforts in China should focus on encouraging smokers to quit as early as possible to mitigate the hazard of smoking. This research may inform smoking cessation policies and interventions targeting older long-term smokers.

Keywords Smoking cessation, Mortality, Long-term smokers, Older adults

Background

Smoking accounted for the highest number of disability-adjusted life years and the second highest rate of premature mortality in China [1]. It is estimated to cause over 1 million annual deaths and is associated with elevated risks of morbidity and mortality from a wide range of diseases [2]. However, China continues to be the world's largest producer and consumer of tobacco, with men comprising almost all of the country's tobacco usage in 2019 [3]. Despite the implementation of the Framework Convention on Tobacco Control in 2005 and overwhelming evidence of the health risk of smoking and the benefits of quitting [4–6], smoking prevalence among Chinese men remains high at 50.8% in 2018, with an increasing trend from 40.2 to 52.1% (2007 to 2018) among rural males born after 1990 [7]. Therefore, research on the prevention and control of tobacco-related health risks has become increasingly crucial in light of aging population, longer lifespans, and the pursuit of better quality of life and healthy aging.

Quitting smoking is strongly associated with a decreased risk of death [8–11]. Accumulating evidence from the USA, UK and China has consistently reported the benefits of smoking cessation in reducing total and major cause mortality [12, 13]. However, current studies on the association between smoking cessation and the risk of all-cause mortality have mainly focus on the general population [14], with less attention given to the elderly population. Modified risk factors like smoking for noncommunicable diseases, which account for the majority of the disease burden, are crucial targets for health promotion among older adults [15]. Furthermore, the benefits of smoking cessation remain controversial among older and long-term smokers, who have been historically underreported in current research [16]. Evidence regarding the benefits of smoking cessation may be critical for planning health policies and providing effective smoking cessation messages for the Chinese older population with long-term smoking history.

Therefore, we sought to evaluate the impact of smoking cessation on subsequent all-cause and cancer mortality and to further quantify the mortality reduction by years since cessation among the Chinese older population using data from Beijing Healthy Aging Cohort Study (BHACS).

Methods

Study design and subjects

In this prospective cohort study, we used data from the BHACS which consisted of three cohorts: the Beijing Longitudinal Study of Aging (BLSA), the Cardiovascular and Cognitive Health Study in Middle-Aged and Elderly Residents of Beijing (CCHS-Beijing), and the Beijing Elderly Comprehensive Health Cohort Study (BECHCS). The methodologies used in our study has been described elsewhere [17]. Briefly, the study was carried out between July 2009 and September 2015 to collect baseline data from communities over 55 years old at recruitment. The baseline assessment included face-to-face questionnaires, physical measurements, and laboratory analyses for each subject. Through linkage with local Centers for Disease Control and Prevention and civil registry offices or community health centers, all participants in the BHACS were followed up for mortality until March 2021. All eligible participants were included in the current study, and there were no losses to follow-up. Specifically, the study included 2,468 participants from BLSA, 4,268 from CCHS-Beijing, and 4,499 from CHCCS, totaling 11,235 individuals. All data were anonymizedto protect participants' privacy in the research. Prior to the study, participants were given oral and written information about the study and signed informed consent forms. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Exposure and outcome

Information on smoking and quitting was assessed by the self-reported questionnaire from the three cohorts. The details of smoking-related questions and corresponding answers are listed in eTable 1. Smoking status was categorized as "Never smokers", "Former smokers" and "Current smokers". "Ever smokers" refers to participants who were former smokers or current smokers. Years since quitting was evaluated as continuous value and then divided into ≤10 years, 10–20 years and >20 years based on its distribution (median:10, IQR:3–20 years) and linear association with mortality (eFigure 1). Similarly, years of smoking, age at smoking initiation and quitting were obtained as continuous variables, and then categorized into groups (years of smoking: ≤35 years, 35–45 years and >45 years; age at smoking initiation: ≤20 years and >20 years; and age at quitting: ≤50 years, 50–60 years and >60 years) (eFigure 2).

The main outcomes of this study were all-cause mortality and mortality from cancer (C00-C97), based on the *International Statistical Classification of Diseases and Related Health Problems*, *Tenth Revision*. Follow-up time was computed as time from the date of enrolment to the date of death, loss-to-follow-up, or end of follow-up, whichever came first. The methods used in the 3 cohort studies are listed in eTable 2.

Statistical analysis

A detailed description of statistical analyses including the handling missing data is provided in eFile 1. Briefly, using multivariate Cox proportional hazards regression, with age at risk as the time scale, we calculated the mortality HRs and 95% CIs for deaths among current and former smokers (categorized by years since quitting: ≤10 years, 10–20 years and >20 years) compared to never smokers. Analyses were adjusted for sex (men/ women), residence (urban/ rural), ethnic group (Han/ others), education (less than primary school/ primary school/ middle school/ high school/ college degree), occupation (professional and technical staff/ functionary/ worker/ famer/ others), marital status (married/ widowed/ others), BMI (continuous), alcohol consumption (never/ former/ current) and years of smoking (continuous). Restricted cubic splines were fitted to delineate the non-linear association of years since quitting with risk of mortality. Excess Mortality Avoided (EMA) for all-cause and cancer mortality was calculated using $(RR^a - RR^b)/(RR^a-1)\times100\%$, where RR^a and RR^b are the RR for mortality of current and former smokers vs. never smokers, respectively. We further used current smoking as a reference for validation. Several sensitivity analyses were conducted to address potential reverse causality, these included: (1) excluding participants with years of smoking or years since quitting less than 1 year; (2) excluding participants that died or were censored within the first year or 3 years of follow-up; (3) including or excluding participants diagnosed with any disease at baseline survey; (4) additionally adjusting for pack-years in the multivariate Cox regression. Subgroup analysis was performed according to baseline covariates to assess the effect of multiplicative interaction. Stratified analyses were performed to explore the benefits of smoking cessation in different smoking exposure categories.

Analyses were conducted using SPSS version 26.0 (SPSS Inc., IBM) and R version 4.3.2 (The R Foundation for Statistical Computing). Two-sided *P*-values of <0.05 were considered statistically significant.

Results

Participants characteristics

Table 1 shows a total of 11 235 participants from BHACS were included in the main analyses. The mean (SD) age was 70.35 (7.71) years at recruitment (range from 55 to 101 years) and 76.72 (7.82) years at follow-up; 4930 (43.9%) were men, 6281 (55.9%) were from urban areas, and 2191 (19.5%) were current smokers. Men were more common among current smokers (1883 [85.9%]) and former smokers (1123 [82.0%]), whereas women were more likely to be never smokers (5750 [74.9%]). The differences across smoking statuses in sex, residence, ethnic group, education, occupation, marital status, BMI, alcohol consumption was statistically significant.

Among 3 561 ever smokers in BHACS, the median years of smoking and median age at smoking initiation were 43 (IQR: 34–50) years and 20 (IQR: 18–25) years, respectively. Among 1 370 former smokers in BHACS, the median years of quitting and median age at quitting were 10 (IQR: 3–20) years and 60 (IQR: 51–67) years, respectively (eFigure 1 & eFigure 2).

Association analysis

During 71 573.07 person-years of follow-up (mean [SD] follow-up time per person: 6.37[0.02] years), there were 1 617 (14.4%) deaths among participants in BHACS. Of the total participants, 17.7% (872) of men and 11.8% (745) of women died during the study period. Most deaths occurred in men among current smokers (309 [86.8%]) and former smokers (225 [80.4%]); similar pattern was observed for cancer mortality.

Table 2 presents the all-cause and cancer mortality HRs for current and former smokers, with a focus on overall and men by years since quitting. Overall, the all-cause mortality HR for current smokers vs. never smokers was 2.898 (95%CI 2.092–4.013). Compared with never smokers, HR (95%CI) for participants who quit smoking less than 10 years (median [quartiles] 4 [1, 7] years) before recruitment was 2.738(1.972–3.802); for those who quit 10 to 20 years (16 [13, 20] years), it was

Table 1 Baseline characteristics of the BHACS stratified by smoking status

Characteristic	Total	Current smoker	Former smoker, years since quitting			Never smokers	*P*
			≤ 10	10–20	>20		
Mean (SD)							
Age at baseline	70.35 (7.71)	68.98 (7.51)	70.77 (7.20)	72.48 (7.01)	74.90 (7.38)	70.42 (7.75)	< 0.001
Age at follow-up	76.72 (7.85)	74.90 (7.57)	76.97 (7.31)	79.23 (7.18)	81.87 (7.33)	76.89 (7.88)	< 0.001
Height (cm)	160.50 (8.09)	165.14 (7.42)	164.59 (7.51)	164.74 (7.45)	164.53 (7.85)	158.44 (7.52)	< 0.001
Weight (kg)	63.91 (10.73)	65.48 (10.93)	67.65 (10.69)	68.46 (10.54)	67.31 (10.32)	62.77 (10.48)	< 0.001
BMI (kg/m^2)	24.78 (3.62)	23.96 (3.37)	24.94 (3.34)	25.20 (3.41)	24.83 (3.14)	24.98 (3.71)	< 0.001
N (%)	11,235	2191 (19.5)	720 (6.4)	324 (2.9)	326 (2.9)	7674 (68.3)	
Sex							
Men	4930 (43.9)	1883 (85.9)	592 (82.2)	266 (82.1)	265 (81.3)	1924 (25.1)	< 0.001
Women	6305 (56.1)	308 (14.1)	128 (17.8)	58 (17.9)	61 (18.7)	5750 (74.9)	
Residence							
Urban	6281 (55.9)	944 (43.1)	375 (52.1)	214 (66.0)	239 (73.3)	4509 (58.8)	< 0.001
Rural	4954 (44.1)	1247 (56.9)	345 (47.9)	110 (34.0)	87 (26.7)	3165 (41.2)	
Ethnic group							
Han	10,364 (92.2)	2026 (92.5)	684 (95.0)	302 (93.2)	308 (94.5)	7044 (91.8)	0.013
Other	871 (7.8)	165 (7.5)	36 (5.0)	22 (6.8)	18 (5.5)	630 (8.2)	
Education							
Less than primary school	2659 (23.7)	437 (19.9)	130 (18.1)	49 (15.1)	57 (17.5)	1986 (25.9)	< 0.001
Primary school	3412 (30.4)	775 (35.4)	272 (37.8)	100 (30.9)	90 (27.6)	2175 (28.3)	
Middle school	2539 (22.6)	599 (27.3)	178 (24.7)	72 (22.2)	76 (23.3)	1614 (21.0)	
High school	1332 (11.9)	206 (9.4)	71 (9.9)	40 (12.3)	38 (11.7)	977 (12.7)	
College degree	1293 (11.5)	174 (7.9)	69 (9.6)	63 (19.4)	65 (19.9)	922 (12.0)	
Occupation							
Professional and technical staff	1042 (9.3)	134 (6.1)	60 (8.3)	26 (8.0)	30 (9.2)	792 (10.3)	< 0.001
Functionary	1272 (11.3)	210 (9.6)	89 (12.4)	76 (23.5)	88 (27.0)	809 (10.5)	
Woker	1189 (10.6)	229 (10.5)	84 (11.7)	44 (13.6)	29 (8.9)	803 (10.5)	
Farmer	4717 (42.0)	1147 (52.4)	309 (42.9)	95 (29.3)	78 (23.9)	3088 (40.2)	
Other	3015 (26.8)	471 (21.5)	178 (24.7)	83 (25.6)	101 (31.0)	2182 (28.4)	
Marital status							
Married	8839 (78.7)	1783 (81.4)	597 (82.9)	261 (80.6)	259 (79.4)	5939 (77.4)	< 0.001
Widowed	1857 (16.5)	317 (14.5)	99 (13.8)	47 (14.5)	42 (12.9)	1352 (17.6)	
Other	539 (4.8)	91 (4.2)	24 (3.3)	16 (4.9)	25 (7.7)	383 (5.0)	
Alcohol consumption							
Never	7720 (68.7)	766 (35.0)	270 (37.5)	124 (38.3)	151 (46.3)	6409 (83.5)	< 0.001
Former drinker	550 (4.9)	156 (7.1)	147 (20.4)	65 (20.1)	53 (16.3)	129 (1.7)	
Current drinker	2965 (26.4)	1269 (57.9)	303 (42.1)	135 (41.7)	122 (37.4)	1136 (14.8)	

BHACS: Beijing Healthy Aging Cohort Study

BMI: Body Mass Index

1.807(1.286–2.540); and for those who quit 20 years or more (30 [25, 37] years), it was 1.293(0.981–1.705). Similarly, compared with never smokers, the cancer mortality HR (95%CI) for current smokers and former smokers who quit less than 10 years, 10 to 20 years, and 20 years or more were 3.849(2.008–7.380), 3.148(1.622–6.108), 2.267(1.165–4.410), and 1.604(0.914–2.813), respectively. The all-cause and cancer mortality risks associated with current and former smoking showed generally similar patterns among men.

Restricted cubic splines demonstate that the risk of all-cause and cancer mortality decreased progressively over years since quitting, regardless of the reference group (eFigures 3 & 4). Compared with current smokers, the HR (95%CI) for all-cause and cancer mortality was 0.624 (0.467–1.149) and 0.589(0.334–1.037) for quitting between 10 and 20 years prior; 0.446(0.330–0.604) and 0.417(0.226–0.767) for quitting over 20 years; 0.345(0.249–0.478) and 0.260(0.136–0.498) for never smokers (eTable 3).

Figure 1 illustrates that former smokers who quit less than 10 years, 10 to 20 years and 20 years or more, averted an estimated 8.4%, 57.5% and 84.6% of excess all-cause mortality associated with current smoking, respectively. Analogously, for cancer mortality, the same group evaded an estimated 24.6%, 55.5% and 78.8% of

Table 2 All-cause and cancer mortality hazard ratios by years since quitting compared with never smokers

Smoking status	*N*	All-cause Mortality		Cancer Mortality	
		Death	HR(95%CI)	Death	HR(95%CI)
Total (*n* = 11235)					
Current	2191	356	**2.898(2.092, 4.013)**	92	**3.849(2.008, 7.380)**
Quitting					
≤ 10 years	720	146	**2.738(1.972, 3.802)**	34	**3.148(1.622, 6.108)**
10–20 years	324	60	**1.807(1.286, 2.540)**	16	**2.267(1.165, 4.410)**
>20 years	326	74	1.293(0.981, 1.705)	18	1.604(0.914, 2.813)
Never	7674	981	1.000(reference)	186	1.000(reference)
Men (*n* = 4930)					
Current	1883	309	**3.384(2.275, 5.033)**	86	**7.174(3.353, 15.352)**
Quitting					
≤ 10 years	592	126	**3.321(2.244, 4.913)**	33	**6.083(2.859, 12.942)**
10–20 years	266	46	**1.811(1.213, 2.705)**	12	**2.996(1.373, 6.539)**
>20 years	265	53	1.201(0.860, 1.678)	13	1.868(0.946, 3.688)
Never	1924	338	1.000(reference)	53	1.000(reference)

N and Death refer to the number of participants at recruitment and the number of deaths at follow-up in smoking exposure categories. Adjusted for sex, residence, ethnic group, education, occupation, Marital status, BMI, alcohol consumption and years of smoking

excess cancer mortality associated with current smoking, respectively. The proportion of excess mortality avoided relative to current smoking was generally similar among men, with additional benefits accumulating over years since quitting.

Sensitivity analyses

To mitigate potential misclassification bias, the analyses were restricted to participants whose years of smoking or years since quitting exceeded 1 year, and to those who died or were censored after more than 1 year of follow-up; the results remained substantially unchanged. To account for chronic effect of smoking, the association persisted after excluding quitters who died within first year or 3 years of follow-up. No significant alterations in results were observed after excluding participants with cancer, cardiovascular, hypertensin, diabetes, cerebrovascular or respiratory disease at recruitment. Furthermore, this association remained robust when including participants diagnosed with any disease at baseline survey. To account for the impact of pack-years, the main analyses were repeated adjusted for pack-years in both the BLSA and BECHCS, and the results remained consistent (eTable 4).

Subgroup analyses

Table 3 presents the association between years of quitting and all-cause mortality risk across various subgroups. Consistent with the results in Table 2, similar associations and trends were observed in both those who were lean or normal and overweight, urban and rural residents, Han and other ethnic groups, those who with education below and above primary school, farmers and those engaged in other occupations, married individuals and individuals in other marital status, alcohol drinkers and non-drinkers. A significant interaction effect was found between smoking cessation and education level in relation to mortality risk (P for interaction 0.009). Figure 2 illustrates the association stratified by smoking related variables. A significant reduction in all-cause mortality risk was observed among former smokers than that of current smokers, regardless of their years of smoking, age at smoking initiation and age at quitting. Specifically, the analysis of point estimate reveals that benefits of smoking cessation even among individuals with long-term smoking history (smoked > 45 years), or those who initiated smoking before age 20, or individuals who quit smoking after age 60.

Discussion

In this representative cohort study of older population in Beijing, China, among former smokers with long-term smoking history, smoking cessation was associated with a substantial reduction in mortality in a dose-response manner. Compared to never smokers, current smokers had almost 3 times all-cause mortality and 4 times cancer mortality overall. However, the risk of mortality associated with smoking decreased gradually with increasing years since quitting among former smokers regardless of smoking history. Quitting smoking for over 20 years was associated with approximately an 85% reduction in excess all-cause mortality and an 80% reduction in excess cancer mortality. These associations were significant in men. Our study offers compelling evidence of the benefits of long-term smoking cessation, even for individuals with a history of prolonged smoking.

The relative benefits of smoking cessation were significant among the older population (especially in men) even with long-term smoking exposure; particularly among participants who quit over 20 years, the excess

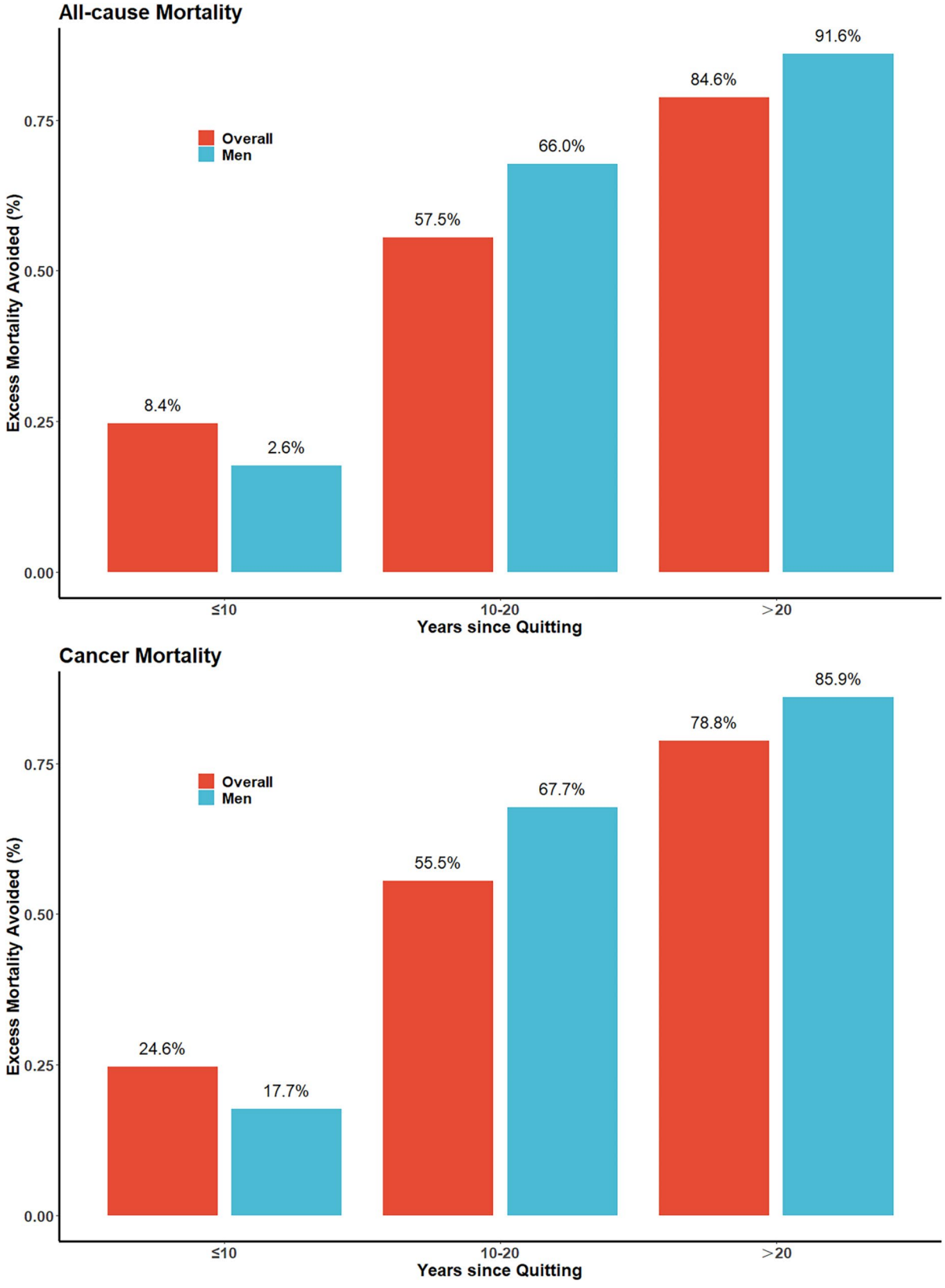

Fig. 1 All-cause and cancer excess mortality avoided among former smokers by years since quitting. Excess Mortality Avoided (EMA) was calculated as follows: EMA= $(RR^a\text{-}RR^b)/(RR^a\text{-}1)\times100\%$, where RR^a refers to the RR of current smoking versus never smoking and RR^b refers to the RR of former smoking versus never smoking. The point estimate for former and current smokers is used to calculate each excess risk

Table 3 All-cause mortality hazard ratios by years since quitting compared with never smokers: subgroup analyses

Variable	Mortality, *n*(%)	Current smoker	Former smoker, years since quitting			$P_{interaction}$
			≤10	10–20	>20	
BMI, kg/m^2						0.938
≤24	739(16.3)	**3.347(2.103, 5.327)**	**2.79(1.685, 4.619)**	**2.145(1.288, 3.574)**	1.363(0.881, 2.108)	
>24	878(13.1)	**2.546(1.603, 4.042)**	**2.721(1.754, 4.221)**	1.587(0.999, 2.521)	1.248(0.870, 1.790)	
Residence						0.161
Urban	828(13.2)	**2.428(1.442, 4.087)**	**2.485(1.490, 4.146)**	1.533(0.945, 2.488)	1.373(0.957, 1.971)	
Rural	789(15.9)	**3.136(2.042, 4.815)**	**2.708(1.744, 4.203)**	**1.972(1.177, 3.304)**	0.901(0.522, 1.553)	
Ethnic group						0.079
Han	1392(13.4)	**2.619(1.839, 3.730)**	**2.524(1.772, 3.594)**	**1.641(1.139, 2.364)**	1.239(0.927, 1.658)	
Others	225(25.8)	**5.375(2.328, 12.409)**	**4.372(1.744, 10.960)**	**3.276(1.257, 8.537)**	1.698(0.657, 4.389)	
Education						**0.009**
Below primary school	1113(18.3)	**2.784(1.892, 4.096)**	**2.669(1.807, 3.943)**	**1.812(1.182, 2.778)**	**1.443(1.031, 2.019)**	
Above primary school	504(9.8)	**2.812(1.467, 5.390)**	**2.632(1.373, 5.044)**	1.622(0.892, 2.951)	1.13(0.679, 1.879)	
Occupation						0.199
Famer	739(15.7)	**3.337(2.114, 5.265)**	**2.803(1.761, 4.462)**	**2.224(1.289, 3.838)**	0.896(0.499, 1.612)	
Others	878(13.5)	**2.262(1.398, 3.660)**	**2.335(1.446, 3.770)**	1.46(0.922, 2.314)	1.323(0.940, 1.861)	
Marital status						0.998
Married	1082(12.2)	**2.576(1.744, 3.805)**	**2.570(1.740, 3.797)**	1.516(0.998, 2.304)	1.137(0.810, 1.595)	
Others	535(22.3)	**3.722(2.037, 6.799)**	**2.918(1.565, 5.440)**	**2.605(1.443, 4.704)**	1.698(1.049, 2.751)	
Alcoholic consumption						0.275
Never	1105(14.3)	**2.487(1.555, 3.977)**	**2.461(1.525, 3.973)**	1.512(0.902, 2.536)	1.259(0.861, 1.841)	
Ever	512(14.6)	**3.42(2.111, 5.541)**	**3.214(1.996, 5.174)**	**2.108(1.303, 3.409)**	1.311(0.857, 2.006)	

Adjusted for sex, residence, ethnic group, education, occupation, Marital status, BMI, alcohol consumption and years of smoking

risk of all-cause mortality was attenuated to the level of never smokers. Previous studies have estimated that time course of mortality reduction after smoking cessation. A study from the US National Health Interview Survey found that cardiovascular mortality rate among former smokers was almost similar to that of never smokers after over 20 years of smoking cessation [18]. There is generally consistent evidence in US male physicians (22 071 physicians in Physicians' Health Study from 1982 to 2010) [19] and female nurses (104 519 participants in Nurses' Health Study with follow-up from 1980 to 2004) [20] showing that the risk of all-cause mortality after 20 years of quitting subsides to the level of never smokers. However, we didn't observe this association in women due to the limited prevalence of female smoking in China. Epidemiological data mainly derived from developed countries, indicate that the elevated risk of mortality from total or cause-specific among quitters equals that of never smokers after a certain time period following quitting. Notably, compared with developed countries, Chinese smokers exhibit distinctive smoking behavior characteristics: in addition to the varying economic status, middle-aged and elderly smokers were likely to initiate smoking relatively later consume fewer cigarettes per day and have a lower likelihood of quit [21, 22]. In China, two nationwide prospective studies reported that the relative risk of all-cause mortality among male former smokers who quit smoking on their own will<5, 5–14, and ≥15 years ago was 1.21 (1.07–1.37), 1.00 (0.90–1.11), and 0.98 (0.87–1.11), respectively, compared to never smokers [13]. In a recent pooled analysis of 16 population-based cohort studies from Asia, Yang et al. also found that elevated mortality became nonsignificant among former smokers who quit over 15 years; alarmingly, former smokers who quit more than 20 years had a similar risk of mortality as lifelong never smokers regardless of smoking history in pack-year [14]. Our findings also convey a concise public health message on the benefit of smoking cessation irrespective of past smoking history (i.e. long duration of smoking, early age at smoking initiation or later age at quitting), suggesting that even older people who smoked for over 45 years, or initiated smoking earlier than 20 years of age, or quit smoking later than 60 years of age had a chance of lowering their risk of mortality to the level of never smokers. Notwithstanding differences in smoking patterns among demographic groups, these findings provide supporting evidence in favor of the substantial benefits of quitting being broadly generalizable.

Communicating the risks of smoking and the benefits of quitting to smokers is an effective approach to promote smoking cessation in older adults. Based on data from a cohort of physicians in the United Kingdom followed for 40 years, the Attributable Fraction (AF) was calculated for the risk of death among smokers with an RR of 2 compared with that of nonsmokers, and the World Health Organization stated that "one in two smokers dies from tobacco use" [23]. The results of the Guangzhou Biobank cohort study showed that two-thirds of

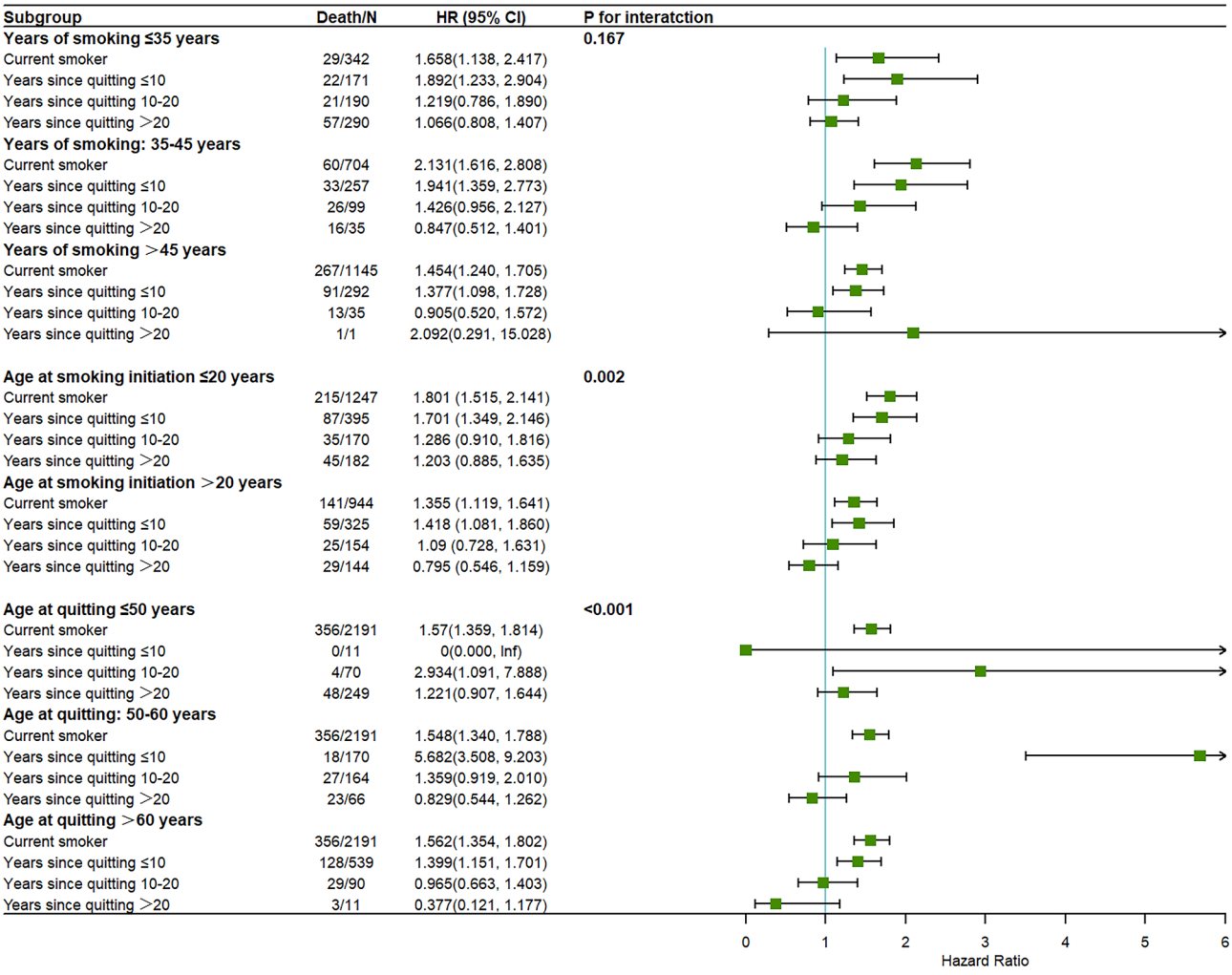

Fig. 2 All-cause mortality hazard ratios by years since quitting compared with never smokers: stratified analysis by smoking exposure. Adjusted for sex, residence, ethnic group, education, occupation, Marital status, BMI and alcohol consumption

older smokers die from smoking, which is consistent with evidence from population-based cohorts in the United States, United Kingdom, and Australia supporting the idea that older smokers are at a higher risk of death [24]. Absolute risks expressed by the AF are easier to understand and disseminate than the relative risk RRs, but dichotomizing only smoking status (smoking and non-smoking) dilutes the health benefits of quitting and thus underestimates the risk of death from continued smoking. The CHANCES Consortium calculated the ratio of smoking status coefficients to age coefficients based on multifactor-adjusted Cox regression to obtain the Risk Advancement Period (RAP) [25], and the results suggested that the mean time to all-cause mortality in the elderly population was advanced by 2.4 and 6.4 years for quitters and current smokers, respectively, compared with never smokers [26]. The results of the current study showed that quitting smoking for over 20 years was associated with approximately an 85% reduction in excess all-cause mortality and an 80% reduction in excess cancer mortality. In other words, the risk of death from all causes and cancer for smokers who quit smoking for over 20 years decreased by 85% and 80%, respectively, compared to those who continued to smoke. This indicator could be more effective in helping the public to develop an understanding of the substantial benefits of smoking cessation, which could intuitively increase public motivation to quit and support the urgent need for tobacco control to lower the burden of non-communicable illnesses, particularly in regions with high smoking rates.

In the current study, smoking cessation was associated with a substantially reduction in mortality in a dose-response manner among the general population or subgroups. However, Wei et al. included 28 643 community-dwelling people aged over 80 years from the Chinese Longitudinal Healthy Longevity Survey to report that quitting smoking in later life is associated with an elevated risk of all-cause death in older adults

who had smoked for a long period [16]. Previous studies conducted in middle-aged or younger-aged older adults consistently reported that former smokers gained health benefits compared with continuous smokers, regardless of years since quitting [5, 6, 27–29]. In our analysis, among ever smokers who smoked for less than 35 years, or who started smoking at age later than 20 years, quitters within the first decade had a higher risk of all-cause mortality than current smokers based on the point estimates. Furthermore, for those who quit smoking before 60 years of age, individuals who quit within 10 years had a significantly elevated risk of mortality compared to current smokers. Possible explanations for this phenomenon could be as follows: some quitters ceased smoking due to illness, but we did not separate them from former smokers; the longer one quit, the greater the mortality reduction; thus, those quitters gained fewer benefits in the first few years of smoking cessation. Besides, body systems could be affected by smoking cessation, such as significant weight gain to a higher risk of type 2 diabetes which led to death among the older population [30–32]. The generalization of stratified analysis in our study could be interpreted cautiously due to the limited sample size in each exposure group. In general, most evidence favors the benefits of smoking cessation even for a short period [33]. In China, smoking cessation should be implemented in health policy under any circumstance. Despite significant progress had been made in the implementation and enforcement of tobacco control policies in China in recent decades, smoking continues to be the leading avoidable cause of mortality, highlighting the need for further improvements. Effective, widespread, and equitable support for smokers to quit, as well as tobacco control laws that prevent the older smokers from smoking, might significantly reduce the rate of smoking-related deaths in the coming decades.

Strengths and limitations

This study utilized comprehensive data from regionally representative cohort of older residents in Beijing, featuring information on lifetime smoking history and minimal selection bias. This approach allowed for reliable estimates and generalization of findings. However, several limitations should be noted. First, smoking status information was collected only once, precluding the evaluation of quitting and reinitiation effects of after baseline survey (assuming smoking behaviors remained consistent during follow-up). Either smokers quit smoking or others initiate smoking may underestimate the authentic hazard of smoking and the true benefits of quitting. Second, the major analyses did not limit subjects free of diseases at baseline in order to increase generalizability. However, subjects with existing major diseases were more likely to quit and to die at greater risk during follow-up, which may further decrease the estimation of benefits of smoking cessation. Third, the associations were not examined in women due to the limited sample of female smokers in our study. Consequently, the main findings should be generalized more cautiously, and further researches are encouraged to address the gap. Fourth, heaviest smokers (in terms of early initiation or duration of smoking) may have died before the study began, potentially biasing our observed associations towards the null. Last, due to lack of data on forms of tobacco products and secondhand smoking or other potential contributors, such as occupational exposure, outdoor and indoor air pollution, the effects of these could not be controlled. Additionally, residual or unmeasured confounder might have influenced the risk estimates, even after adjusting several confounding factors.

Conclusions

Smoking cessation, even with long-term smoking history, was associated with significant decreases in the relative excess mortality associated with continuing smoking. Quitting smoking for over 20 years was associated with approximately an 85% in excess all-cause mortality and an 80% in excess cancer mortality. Our findings provide additional evidence for the substantial benefit of smoking cessation in reducing mortality risk. Public health efforts in China should prioritize encouraging smokers to quit as earlier as possible to mitigate the hazard of smoking. Complete dedication to implementing comprehensive smoking prevention and cessation programs is essential to address the growing health burden caused by the tobacco epidemic in China.

Abbreviations

BHACS	Beijing Healthy Aging Cohort Study
BLSA	Beijing Longitudinal Study of Aging
CCHS-Beijing	Cardiovascular and Cognitive Health Study in Middle-Aged and Elderly Residents of Beijing
BECHCS	Beijing Elderly Comprehensive Health Cohort Study
BMI	Body mass index

Supplementary Information

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Supplementary Material 1

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Author contributions

Prof. He and M. Liu had full access to all data in this study and take responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: Shimin Chen, Miao Liu, Yao HeAcquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Shimin Chen, Huaihao Li, Yueting Shi, Junhan Yang, Yinghui Bao, Jianhua Wang. Critical revision of the manuscript for important intellectual content: Haowei Li, Rongrong Li, Shanshan Yang, Shengshu Wang, Miao Liu, Yao He.

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Data availability
The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The BHACS program was approved by the Independent Ethics Committees of Chinese People's Liberation Army General Hospital(S2022-412-02). All data were anonymous to protect participants' privacy in the research. Prior to the study, participants were given oral and written information about the study and signed informed consent forms.

Competing interests
The authors declare no competing interests.

Role of the Funder/Sponsor
The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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References

1. Zhou M, Wang H, Zeng X, Yin P, Zhu J, Chen W, Li X, Wang L, Wang L, Liu Y, et al. Mortality, morbidity, and risk factors in China and its provinces, 1990–2017: a systematic analysis for the global burden of Disease Study 2017. Lancet. 2019;394(10204):1145–58.
2. Chan KH, Wright N, Xiao D, Guo Y, Chen Y, Du H, Yang L, Millwood IY, Pei P, Wang J, et al. Tobacco smoking and risks of more than 470 diseases in China: a prospective cohort study. Lancet Public Health. 2022;7(12):e1014–26.
3. Reitsma MB, Kendrick PJ, Ababneh E, Abbafati C, Abbasi-Kangevari M, Abdoli A, Abedi A, Abhilash ES, Abila DB, Aboyans V, et al. Spatial, temporal, and demographic patterns in prevalence of smoking tobacco use and attributable disease burden in 204 countries and territories, 1990–2019: a systematic analysis from the global burden of Disease Study 2019. Lancet. 2021;397(10292):2337–60.
4. Lam TH, He Y, Li LS, Li LS, He SF, Liang BQ. Mortality attributable to cigarette smoking in China. JAMA. 1997;278(18):1505–8.
5. Lam TH, He Y, Shi QL, Huang JY, Zhang F, Wan ZH, Sun CS, Li LS. Smoking, quitting, and mortality in a Chinese cohort of retired men. Ann Epidemiol. 2002;12(5):316–20.
6. He Y, Jiang B, Li LS, Li LS, Sun DL, Wu L, Liu M, He SF, Liang BQ, Hu FB, et al. Changes in smoking behavior and subsequent mortality risk during a 35-year follow-up of a cohort in Xi'an, China. Am J Epidemiol. 2014;179(9):1060–70.
7. Zhang M, Yang L, Wang L, Jiang Y, Huang Z, Zhao Z, Zhang X, Li Y, Liu S, Li C, et al. Trends in smoking prevalence in urban and rural China, 2007 to 2018: findings from 5 consecutive nationally representative cross-sectional surveys. PLoS Med. 2022;19(8):e1004064.
8. Jha P, Ramasundarahettige C, Landsman V, Rostron B, Thun M, Anderson RN, McAfee T, Peto R. 21st-century hazards of smoking and benefits of cessation in the United States. N Engl J Med. 2013;368(4):341–50.
9. Thun MJ, Carter BD, Feskanich D, Freedman ND, Prentice R, Lopez AD, Hartge P, Gapstur SM. 50-year trends in smoking-related mortality in the United States. N Engl J Med. 2013;368(4):351–64.
10. Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. BMJ. 2004;328(7455):1519.
11. Pirie K, Peto R, Reeves GK, Green J, Beral V. The 21st century hazards of smoking and benefits of stopping: a prospective study of one million women in the UK. Lancet. 2013;381(9861):133–41.
12. Jha P. The hazards of smoking and the benefits of cessation: a critical summation of the epidemiological evidence in high-income countries. Elife 2020, 9.
13. Chen Z, Peto R, Zhou M, Iona A, Smith M, Yang L, Guo Y, Chen Y, Bian Z, Lancaster G, et al. Contrasting male and female trends in tobacco-attributed mortality in China: evidence from successive nationwide prospective cohort studies. Lancet. 2015;386(10002):1447–56.
14. Yang JJ, Yu D, Shu XO, Wen W, Rahman S, Abe S, Saito E, Gupta PC, He J, Tsugane S, et al. Reduction in total and major cause-specific mortality from tobacco smoking cessation: a pooled analysis of 16 population-based cohort studies in Asia. Int J Epidemiol. 2022;50(6):2070–81.
15. Chen X, Giles J, Yao Y, Yip W, Meng Q, Berkman L, Chen H, Chen X, Feng J, Feng Z, et al. The path to healthy ageing in China: a Peking University-Lancet Commission. Lancet. 2022;400(10367):1967–2006.
16. Wei Y, Lv Y, Zhou J, Gao X, Duan J, Zhao C, Yin Z, Kang Q, Wu B, Chen C, et al. Smoking cessation in late life is associated with increased risk of all-cause mortality amongst oldest old people: a community-based prospective cohort study. Age Ageing. 2021;50(4):1298–305.
17. Liu M, Yang J, Wang C, Yang S, Wang J, Hou C, Wang S, Li X, Li F, Yang H et al. Cohort profile: Beijing Healthy Aging Cohort Study (BHACS). Eur J Epidemiol 2024.
18. Thomson B, Islami F. Association of Smoking Cessation and Cardiovascular, Cancer, and respiratory mortality. JAMA Intern Med 2023.
19. Cao Y, Kenfield S, Song Y, Rosner B, Qiu W, Sesso HD, Gaziano JM, Ma J. Cigarette smoking cessation and total and cause-specific mortality: a 22-year follow-up study among US male physicians. Arch Intern Med. 2011;171(21):1956–9.
20. Kenfield SA, Stampfer MJ, Rosner BA, Colditz GA. Smoking and smoking cessation in relation to mortality in women. JAMA. 2008;299(17):2037–47.
21. Yang JJ, Yu D, Wen W, Shu XO, Saito E, Rahman S, Gupta PC, He J, Tsugane S, Xiang YB, et al. Tobacco Smoking and Mortality in Asia: a pooled Meta-analysis. JAMA Netw Open. 2019;2(3):e191474.
22. Yang JJ, Yu D, Shu XO, Freedman ND, Wen W, Rahman S, Abe SK, Saito E, Gupta PC, He J, et al. Quantifying the association of low-intensity and late initiation of tobacco smoking with total and cause-specific mortality in Asia. Tob Control. 2021;30(3):328–35.
23. Lam TH. Absolute risk of tobacco deaths: one in two smokers will be killed by smoking: comment on smoking and all-cause mortality in older people. Arch Intern Med. 2012;172(11):845–6.
24. Lam TH, Xu L, Jiang CQ, Zhang WS, Zhu F, Jin YL, Thomas GN, Cheng KK. High relative risk of all-cause mortality attributed to smoking in China: Guangzhou Biobank Cohort Study. PLoS ONE. 2018;13(4):e0196610.
25. Mons U, Müezzinler A, Gellert C, Schöttker B, Abnet CC, Bobak M, de Groot L, Freedman ND, Jansen E, Kee F, et al. Impact of smoking and smoking cessation on cardiovascular events and mortality among older adults: meta-analysis of individual participant data from prospective cohort studies of the CHANCES consortium. BMJ. 2015;350:h1551.
26. Müezzinler A, Mons U, Gellert C, Schöttker B, Jansen E, Kee F, O'Doherty MG, Kuulasmaa K, Freedman ND, Abnet CC, et al. Smoking and all-cause mortality in older adults: results from the CHANCES Consortium. Am J Prev Med. 2015;49(5):e53–63.
27. Mai ZM, Ho SY, Lo CM, Wang MP, Peto R, Lam TH. Mortality reduction from quitting smoking in Hong Kong: population-wide proportional mortality study. Int J Epidemiol. 2018;47(3):752–9.
28. Lim SH, Tai BC, Yuan JM, Yu MC, Koh WP. Smoking cessation and mortality among middle-aged and elderly Chinese in Singapore: the Singapore Chinese Health Study. Tob Control. 2013;22(4):235–40.

29. Lam TH, Li ZB, Ho SY, Chan WM, Ho KS, Tham MK, Cowling BJ, Schooling CM, Leung GM. Smoking, quitting and mortality in an elderly cohort of 56,000 Hong Kong Chinese. Tob Control. 2007;16(3):182–9.
30. Hu Y, Zong G, Liu G, Wang M, Rosner B, Pan A, Willett WC, Manson JE, Hu FB, Sun Q. Smoking Cessation, Weight Change, Type 2 Diabetes, and Mortality. NEJM 2018;379(7):623–632.
31. Liu G, Hu Y, Zong G, Pan A, Manson JE, Rexrode KM, Rimm EB, Hu FB, Sun Q. Smoking cessation and weight change in relation to cardiovascular disease incidence and mortality in people with type 2 diabetes: a population-based cohort study. Lancet Diabetes Endocrinol. 2020;8(2):125–33.
32. Sahle BW, Chen W, Rawal LB, Renzaho AMN. Weight Gain after Smoking Cessation and Risk of Major Chronic diseases and Mortality. JAMA Netw Open. 2021;4(4):e217044.
33. Green MJ. Potential biases when observing increased mortality risk in association with smoking cessation among older adults. Age Ageing. 2021;50(4):1069–70.

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