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RESEARCH ARTICLE

Association of Smoking and Smoking Cessation With Overall and Cause-Specific Mortality

Di Zhu, MPH,[1] Gang Zhao, MD, PhD,[2] Xia Wang, MD, PhD[1,3]

Introduction: Smoking remains a strong risk factor for premature death. This study examines the associations of nondaily smoking, daily smoking, and smoking cessation with the risks of mortality from all causes, cardiovascular disease, and cancer.

Methods: This study used data from the National Health and Nutrition Examination Survey, a population-based, cross-sectional study. Data analysis was conducted in the U.S. from January to October 2020. Cox proportional hazard regression models were used to obtain adjusted hazard ratios.

Results: During 255,100 person-years of follow-up, 2,008 participants died (347 from cardiovascular diseases and 501 from cancer). A significant increase in the risk of all-cause mortality was observed for nondaily smokers (hazard ratio=1.50, 95% CI=1.08, 2.08) compared with that for those who had never smoked. For daily smokers, the adjusted hazard ratios for all-cause mortality were 1.54 (95% CI=1.24, 1.90) for those smoking <20 cigarettes per day, 2.09 (95% CI=1.65, 2.63) for those smoking 20−40 cigarettes per day, and 2.78 (95% CI=1.75, 4.43) for those smoking ≥40 cigarettes per day. An increased risk of cardiovascular disease and cancer mortality was also observed for daily smokers. Former smokers with ≥5 years since cessation had a lower risk of all-cause mortality than current smokers.

Conclusions: This study suggests that nondaily smokers have a higher risk of all-cause mortality. The association of daily smoking with the risk of mortality increased as the number of cigarettes smoked per day increased. Among former smokers, the risk decreased with longer cessation. Tobacco control efforts should be targeted not only toward daily smokers but also toward nondaily smokers to reduce the risk of premature death owing to smoking.

INTRODUCTION

Smoking remains the most significant preventable cause of death in the U.S. In 2018, an estimated 34.2 million adults (13.7% of adults) were currently smoking cigarettes in the U.S.[1] Smoking prevalence remains higher among people aged 25−64 years. Smoking significantly increases the risk of various diseases, including cancers of several organs, respiratory diseases, diabetes, and cardiovascular diseases (CVDs)[2−4]; it can also lead to premature mortality. More than 16 million Americans are currently living with a smoking-related disease.[5]

Smoking behaviors have changed significantly in recent decades. The proportion of current smokers has decreased from 20.9% in 2005 to 13.7% in 2018, and the proportion of former smokers who have quit has increased in the U.S.[1] Because of these changes, the impact of smoking and cessation on mortality risk must

From the [1]Department of Maternal and Child Health, School of Public Health, Cheeloo College of Medicine, Shandong University, Jinan, China; [2]Department of Cardiology, Shandong Provincial Hospital affiliated to Shandong First Medical University, Jinan, China; and [3]Department of Epidemiology, University of Iowa College of Public Health, Iowa City, Iowa

Address correspondence to: Xia Wang, MD, PhD, Department of Maternal and Child Health, School of Public Health, Cheeloo College of Medicine, Shandong University, No. 44 Wenhuaxi Road, Jinan, Shandong 250012, China. E-mail: wangxiaes@sdu.edu.cn.

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be updated, although existing studies have indicated that smoking is associated with both all-cause and cause-specific mortality.[6−13]

Furthermore, although the rates of current smoking have decreased in the U.S., the incidence of nondaily smoking (smoking some days but not every day) is significantly increasing.[14,15] Existing data on the relationship between some-day cigarette smoking and the risk of mortality are limited, especially in a nationally representative sample from the U.S.

Therefore, the primary objective of this study is to evaluate the association between nondaily smoking, daily smoking, and smoking cessation and the risks of all-cause, CVD, and cancer mortality using the latest representative data. This study also aims to compare the risks of current smokers according to the number of cigarettes smoked per day, the risks of former smokers with respect to the duration of smoking cessation, and the risks in smokers who smoke some days but not every day.

METHODS

Study Population

This study used data from the National Health and Nutrition Examination Survey (NHANES), which is conducted by the National Center for Health Statistics (NCHS) to provide information on health and nutrition in the U.S. The NHANES is a population-based, representative survey and a multistage stratified cluster sample of the non-institutionalized civilian population of the U.S. More information about the data collection procedures has been described in detail elsewhere.[16,17] The survey protocols were approved by the NCHS Ethics Review Board. Written informed consent was provided by all participants before the survey.

This study used NHANES data from 1999 to 2000 through 2013−2014. Participants with a history of CVD or cancer at baseline were excluded. The analytic population included adults aged 20−79 years who had information on mortality follow-up involving the underlying cause of death. Participants with missing information on smoking status and covariate data were also excluded. A total of 30,674 participants were included in the final analytic sample (Appendix Figure 1, available online).

Measures

The interviews utilized standardized questionnaires to collect information on smoking status. The participants were asked questions about smoking ≥100 cigarettes during their lifetime and whether they were currently smoking. The participants were categorized as nonsmokers, former smokers, or current smokers on the basis of their responses to those questions. Nonsmokers were defined as those who reported at baseline that they had smoked <100 cigarettes in their lives. Former smokers were defined as those who had previously smoked >100 cigarettes in their lifetime but were not currently smoking.

Current smokers were also asked to recall the average number of cigarettes they smoked daily. The participants were classified into the following groups: <20, 20−40, and ≥40 cigarettes per day and smoking some days. For former smokers, the time since quitting smoking was converted into the variable years since cessation, which was used as the exposure in the analysis. Time since quitting smoking was divided into the following groups: <5, 5−10, 10−20, and >20 years.

The main outcome was death from any causes, CVD, or cancer. Death records data linked by the NCHS provided the mortality status.[18,19] The public-use linked mortality files of NHANES for 1999−2014 were obtained from the NCHS. The underlying causes of death were checked for case definition according to the ICD-10. The mortality-specific outcomes included CVD-specific mortality (Codes I00−I78) and cancer-specific mortality (Codes C00−C97). However, deaths from CVD were defined as deaths from heart disease (054−064) because cerebrovascular diseases (070) were not provided by the NCHS for 2007−2014 NHANES. Person-years of follow-up were accrued from the date of the NHANES examination until either the date of death or the end of the mortality follow-up period (December 31, 2015).

The evaluated covariates included age, race/ethnicity (Hispanic −Mexican American, non-Hispanic White, non-Hispanic Black, or other), educational level (less than high school, high school graduate, or more than high school), BMI (<25.0, 25.0−29.9, or ≥30.0 kg/m^2), alcohol consumption (none, moderate, or heavy), the ratio of family income to poverty (<1.0, 1.0−2.0, 2.0−4.0, or >4.0), and physical activity (inactive, moderate, or vigorous). Overall diet quality was calculated using the Healthy Eating Index −2010 (scores range from 0 to 100), with higher scores indicating a higher-quality diet.[20]

The participants were categorized as diabetic if they had been diagnosed with diabetes, were currently taking glucose-lowering medication, or had HbA1c ≥6.5% or fasting serum glucose level ≥126 mg/dL. They were considered hypertensive if they had a mean systolic blood pressure (BP) ≥140 mmHg, had a mean diastolic BP ≥90 mmHg, or were taking antihypertensive medications. Those with dyslipidemia were defined according to a physician's diagnosis, current consumption of lipid-lowering medications, or having a total cholesterol level ≥240 mg/dL.

Statistical Analysis

The summary baseline demographic and clinical characteristics were calculated and stratified by smoking status. Weights were used in the data analysis process. The NOMCAR option was used. Design variables with missing values were used in the analysis to estimate variances using the Taylor series linearization method. This study used Cox proportional hazard regression models to estimate multivariable-adjusted hazard ratios (HRs) for all-cause, CVD, and cancer mortality across the categories of smoking status, number of cigarettes smoked per day, and years since quitting smoking. To adjust for calendar effects, age was used as the time scale and stratified the model by birth year in 5-year intervals. Those who had never smoked were defined as the reference group for the analyses of smoking status and the duration of smoking cessation. There was no evidence of violations of the proportionality assumption (p>0.05). A total of 3 sets of multivariate models were developed. The models were sequentially adjusted for age, sex, and race/ethnicity (Model 1); for family income level, education level, alcohol intake, physical activity, total energy intake, and overall diet quality indicated by the Healthy Eating Index−2010

(Model 2); and for BMI, diabetes mellitus, hypertension, and dyslipidemia (Model 3). A 2-tailed p-value < 0.05 indicated statistical significance. Analyses were conducted using SAS, version 9.4.

RESULTS

This study included 30,674 participants aged 20−79 years (mean age=42.7 years, 48.8% male). During a total of 255,100 person-years of follow-up (mean follow-up=8.3 years, maximum follow-up=16.8 years), 2,008 deaths occurred, including 347 from CVD and 501 from cancer.

Table 1 shows the baseline characteristics of the participants according to smoking status. The participants who smoked every day or some days were more likely to be male, have a higher energy intake, and have a lower dietary quality. They were also less likely to have moderate and vigorous physical activity levels, had lower education levels, and had lower incomes than those who had never smoked. As shown in Table 1, compared with those who smoked every day, those who had never smoked were more likely to have lower systolic BP and fasting blood glucose levels, lower triglyceride levels, lower low-density lipoprotein cholesterol and total cholesterol levels, and higher high-density lipoprotein cholesterol levels.

Table 2 and Figure 1 show the risk of mortality from all causes, CVD, and cancer with respect to nondaily smoking and daily smoking. In Model 1, compared with those who had never smoked, nondaily smokers had higher risks of mortality from all causes (HR=1.57, 95% CI=1.22, 2.04), CVD (HR=1.28, 95% CI=0.63, 2.64), and cancer (HR=1.07, 95% CI=0.58, 1.97). In Model 3, the multivariable-adjusted HR for all-cause mortality in participants smoking some days was 1.50 (95% CI=1.08, 2.08) compared with that in those who had never smoked. The authors did not observe statistically significant associations with CVD and cancer mortality for nondaily smokers in Model 3.

In current smokers, smoking intensity was associated with an increased risk of all-cause mortality in Model 3. Compared with the multivariable-adjusted HRs for all-cause mortality for those who had never smoked, the multivariable-adjusted HRs for all-cause mortality were 1.54 (95% CI=1.24, 1.90) for those smoking <20 cigarettes per day, 2.09 (95% CI=1.65, 2.63) for those smoking 20−40 cigarettes per day, and 2.78 (95% CI=1.75, 4.43) for those smoking ≥40 cigarettes per day.

A statistically significant association between CVD mortality and smoking intensity was also found after adjusting for additional confounders. In the fully adjusted model (Model 3), compared with the adjusted HRs for CVD mortality for those who had never smoked, the adjusted HRs for CVD mortality were 1.70 (95% CI=1.01, 2.87) for those smoking <20 cigarettes per day, 1.97 (95% CI=1.17, 3.29) for those smoking 20−40 cigarettes per day, and 0.52 (95% CI=0.11, 2.42) for those smoking ≥40 cigarettes per day.

Compared with the risks of cancer mortality for participants who had never smoked, there were increased risks of cancer mortality for people smoking <20 cigarettes per day (HR=1.45, 95% CI=1.01, 2.09), for those smoking 20−40 cigarettes per day (HR=2.66, 95% CI=1.75, 4.03), and for those smoking ≥40 cigarettes per day (HR=3.25, 95% CI=1.34, 7.87) in Model 3.

Table 3 and Appendix Figure 2 (available online) show the risk of mortality from all cause, CVD, and cancer with respect to the duration of smoking cessation. There was a reduced risk of all-cause mortality for those who had quit smoking ≥5 years ago in Model 3. For those who had quit <5 years ago, the association between smoking cessation and the risk of mortality from all causes, CVD, or cancer did not reach statistical significance in any of the models. In Model 3, compared with the HRs of all-cause mortality for continuing smokers, the HRs of all-cause mortality were 0.45 (95% CI=0.32, 0.65) for those who had quit 5−10 years ago, 0.53 (95% CI=0.41, 0.67) for those who had quit 10−20 years ago, and 0.45 (95% CI=0.36, 0.58) for those who had quit ≥20 years ago.

DISCUSSION

This study observed a significant increase in the risk of all-cause mortality for participants who smoked some days. Compared with the effect of never smoking, the effect of current smoking on the risk of all-cause, CVD, and cancer mortality increased as the number of cigarettes consumed per day increased. Within 5 years of quitting, former smokers did not show a significant reduction in the risk of all-cause mortality compared with those who continued to smoke.

Previous studies have indicated that the number of nondaily smokers is increasing,[21−23] although there is a substantial decline in the proportion of adults who smoke owing to the growing realization of the adverse effects of smoking. In this study, the proportion of nondaily smokers increased from 3.8% in 1999−2000 to 4.1% in 2013−2014, whereas the proportion of current smokers decreased from 25.3% in 1999−2000 to 20.8% in 2013−2014. A prospective cohort study indicated that nondaily smokers have substantially higher mortality risks than those who have never smoked.[24] Another study showed that nondaily smokers are at a lower risk of mortality than daily smokers.[25] This study also found that nondaily smokers have a higher all-cause mortality

Table 1. Baseline Characteristics of the Study Participants According to Smoking Status

Characteristics	Never smokers (*n*=17,109)	Former smokers (*n*=6,529)	Current smokers		*p*-value
			Some days (*n*=1,302)	Everyday (*n*=5,734)	
Age, years, mean (SD)	42.8 (15.8)	51.3 (15.7)	37.5 (13.5)	42.4 (14.3)	<0.01
Gender, %					<0.01
Male	43.3 (0.5)	55.0 (0.9)	62.1 (1.7)	55.1 (0.7)	
Female	56.7 (0.5)	45.0 (0.9)	37.9 (1.7)	44.9 (0.7)	
Race/ethnicity, %					<0.01
Hispanic—Mexican American	16.5 (1.0)	12.2 (0.9)	26.7 (1.8)	8.9 (0.9)	
Non-Hispanic White	62.9 (1.4)	76.2 (1.3)	54.6 (2.2)	72.6 (1.5)	
Non-Hispanic Black	12.9 (0.8)	6.9 (0.5)	13.2 (1.1)	13.2 (0.9)	
Other	7.7 (0.5)	4.8 (0.4)	5.5 (0.8)	5.2 (0.5)	
Ratio of family income to poverty, %					<0.01
<1.0	11.8 (0.6)	8.7 (0.5)	17.6 (1.2)	22.5 (0.9)	
1.0—2.0	17.3 (0.5)	16.8 (0.6)	21.0 (1.4)	22.6 (0.8)	
2.0—4.0	26.9 (0.7)	29.8 (1.0)	26.5 (1.8)	28.5 (0.9)	
>4.0	38.2 (1.0)	39.5 (1.1)	28.4 (2.0)	20.7 (1.0)	
Missing	5.8 (0.3)	5.2 (0.4)	6.5 (0.9)	5.7 (0.5)	
Physical activity, %					<0.01
Inactive	34.7 (0.7)	34.3 (0.8)	35.0 (1.8)	40.1 (0.8)	
Moderate	17.6 (0.4)	17.0 (0.6)	14.1 (1.1)	13.8 (0.7)	
Vigorous	47.7 (0.7)	48.4 (1.0)	50.9 (1.7)	46.1 (0.9)	
Missing	0.0 (0.0)	0.3 (0.1)	0.0 (0.0)	0.0 (0.0)	
Alcohol drinking status, %					<0.01
Nondrinker	65.3 (0.8)	57.1 (1.2)	48.9 (1.9)	54.0 (1.3)	
Moderate drinking	8.1 (0.3)	8.7 (0.5)	8.9 (1.2)	6.6 (0.4)	
Heavy drinking	13.6 (0.5)	20.5 (0.8)	27.5 (1.6)	24.0 (0.9)	
Missing	13.0 (0.6)	13.7 (1.2)	14.7 (1.8)	15.4 (1.0)	
Education, %					<0.01
Less than high school	13.6 (0.5)	15.2 (0.7)	21.6 (1.2)	26.2 (0.9)	
High school	20.5 (0.5)	23.5 (0.8)	24.6 (1.5)	33.4 (0.8)	
More than high school	65.9 (0.8)	61.3 (1.1)	53.8 (1.9)	40.4 (1.0)	
Mean HEI—2010, mean (SD)	50.5 (14.6)	50.7 (14.4)	45.8 (13.1)	42.8 (12.8)	<0.01
Mean total energy intake, kcal/day, mean (SD)	2,104.0 (961.4)	2,195.1 (972.7)	2,398.8 (1,141.5)	2,403.9 (1,243.4)	<0.01
BMI categories					
<25.0	31.9 (0.7)	25.9 (0.9)	35.3 (1.8)	39.9 (0.9)	<0.01
25.0—29.9	32.8 (0.5)	37.1 (0.7)	33.0 (1.9)	30.9 (1.0)	<0.01
≥30.0	34.5 (0.7)	36.1 (0.9)	31.1 (1.7)	28.1 (0.7)	<0.01
Missing	0.8 (0.1)	0.9 (0.1)	0.6 (0.3)	1.1 (0.2)	
Hypertension, %	37.7 (0.6)	47.9 (1.0)	32.2 (1.8)	35.7 (0.8)	<0.01
SBP, mmHg	120.8 (17.6)	124.7 (17.9)	120.5 (15.6)	121.9 (18.0)	0.02
DBP, mmHg	70.8 (11.5)	71.4 (11.6)	70.8 (11.9)	70.8 (12.0)	0.10
Diabetes, %	6.7 (0.3)	10.0 (0.5)	4.6 (0.7)	6.7 (0.4)	<0.01
Fasting glucose, mg/dL	103.3 (32.6)	108.5 (32.6)	105.7 (39.1)	104.4 (33.8)	<0.01
Dyslipidemia, %	21.8 (0.5)	30.6 (0.9)	18.2 (1.5)	22.7 (0.8)	<0.01

(*continued on next page*)

Table 1. Baseline Characteristics of the Study Participants According to Smoking Status (*continued*)

Characteristics	Never smokers (*n*=17,109)	Former smokers (*n*=6,529)	Current smokers		*p*-value
			Some days (*n*=1,302)	Everyday (*n*=5,734)	
TC, mg/dL	**196.8 (41.3)**	**202.1 (43.0)**	**197.0 (44.2)**	**197.4 (43.4)**	**<0.01**
LDL-c, mg/dL	**116.1 (34.9)**	**119.5 (35.5)**	**115.2 (36.2)**	**116.8 (36.7)**	0.16
HDL-c, mg/dL	**53.9 (15.6)**	**53.0 (16.1)**	**51.6 (16.0)**	**50.6 (16.8)**	**<0.01**
TG, mg/dL	**127.2 (110.7)**	**147.4 (133.7)**	**143.8 (157.4)**	**148.3 (130.7)**	**<0.01**

Source: National Health and Nutrition Examination Survey.
Note: Boldface indicates statistical significance ($p<0.05$). Values are weighted mean (SD) for continuous variables or weighted % (SD) for categorical variables.
DBP, diastolic blood pressure; HDL-c, high-density lipoprotein cholesterol; HEI–2010, Healthy Eating Index–2010; LDL-c, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride.

risk than those who have never smoked. A previous study examined the effects of light (low-volume) smoking, indicating that even low exposure levels cause substantial risks.[26] Nevertheless, nondaily smoking has not been recognized as an important stable pattern of tobacco use. Regardless of how frequently they smoke, people who continue to smoke are more likely to die than those who have never smoked.

In a Japanese study, the all-cause mortality was more than double for current smokers, compared with that for those who had never smoked.[27,28] In an Australian study, death rates for current smokers were 3 times higher than for those who had never smoked.[29] This study indicates that the risk of mortality from all causes among current smokers significantly increased with increasing numbers of cigarettes smoked per day, which aligns with previous studies on mortality risk.[30] Furthermore, smoking status and mortality risk may vary depending on ethnicity and SES.[31–33] Cultural effects (e.g., healthier diets, lower alcohol consumption, and fewer environmental tobacco smoke exposures) could lead to decreased smoking-related comorbidities.[34,35] Considering that potential variables may attenuate the association between smoking and mortality outcomes, this study adjusted for sociodemographic factors, dietary factors, and health-related problems.

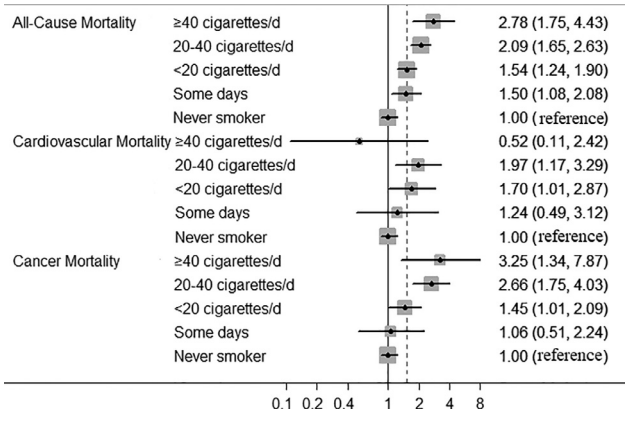

Figure 1. Multivariate-adjusted HRs for mortality from all cause, cardiovascular disease, and cancer based on nondaily smoking and daily smoking.
Note: HRs were adjusted for age, sex, race, education level, BMI, family income level, smoking status, alcohol intake, total energy intake, overall diet quality indicated by Healthy Eating Index–2010, hypertension, diabetes mellitus, and dyslipidemia. Horizontal lines represent 95% CIs.
d, day; HR, hazard ratio.

Numerous studies have indicated that the risk of CVD mortality is associated with smoking.[36] This study also found an increased risk of CVD mortality with smoking intensity. Nicotine can increase heart rate and BP, which is related to endothelial dysfunction. Burning tobacco cigarettes can result in the production of nitrosamine and polycyclic aromatic hydrocarbons, which are known carcinogens and CVD risk enhancers.[37] Ample evidence supports the association between smoking and cancer mortality.[38] This study demonstrated an increased risk of cancer mortality for people smoking every day. Some chemicals in tobacco smoke can cause damage specifically to a portion of DNA that normally protects the cells in the body from cancer.[39]

This study also indicates that the mortality risk for former smokers decreases gradually over time. Most CVD risks can be eliminated within the first few years of cessation.[40,41] A study of Japanese workers indicated that decreased HRs for all-cause mortality and total CVD events were associated with cessation within the previous 4 years.[42] In this study, there was a reduced risk of all-cause mortality for those with long-term cessation (≥5 years), although within 5 years of quitting, the association between smoking cessation and the risk of mortality from all causes, CVD, or cancer did not reach statistical significance compared with that for continuing smokers. Research shows that smoking cessation also effectively reduces mortality risk even at older ages.[43–45]

Table 2. Risk of Mortality From All Cause, Cardiovascular Disease, and Cancer With Respect to Nondaily Smoking and Daily Smoking

Variable	Never smoker	Some days, HR (95% CI)	Cigarettes smoked per day		
			<20, HR (95% CI)	20–40, HR (95% CI)	≥40, HR (95% CI)
All-cause mortality					
Deaths/person-years	787/141,426	91/10,867	263/28,486	210/17,092	47/2,278
Model 1[a]	1 (ref)	**1.57 (1.22, 2.04)**	**1.61 (1.32, 1.96)**	**2.35 (1.88, 2.94)**	**4.36 (2.97, 4.39)**
Model 2[b]	1 (ref)	**1.39 (1.02, 1.90)**	**1.43 (1.15, 1.78)**	**2.01 (1.58, 2.56)**	**2.98 (1.85, 4.78)**
Model 3[c]	1 (ref)	**1.50 (1.08, 2.08)**	**1.54 (1.24, 1.90)**	**2.09 (1.65, 2.63)**	**2.78 (1.75, 4.43)**
Cardiovascular disease mortality					
Deaths/person-years	124/141,426	15/10,867	53/28,486	35/17,092	4/2,278
Model 1[a]	1 (ref)	1.28 (0.63, 2.64)	**1.61 (1.02, 2.55)**	**1.97 (1.22, 3.20)**	1.43 (0.49, 4.26)
Model 2[b]	1 (ref)	1.13 (0.48, 2.64)	1.56 (0.93, 2.64)	**1.86 (1.09, 3.17)**	0.60 (0.14, 2.70)
Model 3[c]	1 (ref)	1.24 (0.49, 3.12)	**1.70 (1.01, 2.87)**	**1.97 (1.17, 3.29)**	0.52 (0.11, 2.42)
Cancer mortality					
Deaths/person-years	190/141,426	20/10,867	61/28,486	55/17,092	13/2,278
Model 1[a]	1 (ref)	1.07 (0.58, 1.97)	1.37 (0.97, 1.96)	**2.58 (1.83, 3.65)**	**5.68 (2.97, 10.86)**
Model 2[b]	1 (ref)	0.98 (0.47, 2.05)	1.36 (0.94, 1.96)	**2.58 (1.71, 3.90)**	**3.44 (1.39, 8.48)**
Model 3[c]	1 (ref)	1.06 (0.51, 2.24)	**1.45 (1.01, 2.09)**	**2.66 (1.75, 4.03)**	**3.25 (1.34, 7.87)**

Source: National Health and Nutrition Examination Survey.
Note: Boldface indicates statistical significance ($p<0.05$).
[a]Model 1: adjusted for age, sex, and race/ethnicity.
[b]Model 2: adjusted for the items in Model 1 + family income level, education level, alcohol intake, physical activity, total energy intake, and overall diet quality indicated by Healthy Eating Index–2010.
[c]Model 3: adjusted for the items in Model 2 + BMI, hypertension, diabetes mellitus, and dyslipidemia.
HR, hazard ratio.

Table 3. Risk of Mortality From All Cause, Cardiovascular Disease, and Cancer With Respect to Duration of Smoking Cessation

Variable	Current smoker	Time since quitting			
		<5 years, HR (95% CI)	5–10 years, HR (95% CI)	10–20 years, HR (95% CI)	≥20 years, HR (95% CI)
All-cause mortality					
Deaths/person-years	611/58,794	71/8,010	59/7,411	155/13,161	269/18,890
Model 1[a]	(1) (ref)	0.74 (0.51, 1.07)	**0.51 (0.38, 0.69)**	**0.50 (0.41, 0.61)**	**0.37 (0.30, 0.45)**
Model 2[b]	(1) (ref)	0.79 (0.53, 1.19)	**0.45 (0.31, 0.64)**	**0.54 (0.42, 0.68)**	**0.46 (0.36, 0.58)**
Model 3[c]	(1) (ref)	0.78 (0.51, 1.19)	**0.45 (0.32, 0.65)**	**0.53 (0.41, 0.67)**	**0.45 (0.36, 0.58)**
Cardiovascular disease mortality					
Deaths/person-years	107/58,794	11/8,010	8/7,411	31/13,161	56/18,890
Model 1[a]	(1) (ref)	0.98 (0.44, 2.18)	**0.35 (0.12, 0.96)**	**0.54 (0.36, 0.80)**	**0.35 (0.21, 0.58)**
Model 2[b]	(1) (ref)	1.27 (0.52, 3.13)	0.45 (0.15, 1.38)	0.64 (0.40, 1.03)	**0.44 (0.23, 0.87)**
Model 3[c]	(1) (ref)	1.23 (0.47, 3.19)	0.46 (0.16, 1.35)	0.63 (0.38, 1.04)	**0.45 (0.23, 0.87)**
Cancer mortality					
Deaths/person-years	149/58,794	16/8,010	22/7,411	45/13,161	62/18,890
Model 1[a]	(1) (ref)	0.95 (0.44, 2.04)	0.82 (0.49, 1.39)	**0.56 (0.38, 0.83)**	**0.31 (0.21, 0.47)**
Model 2[b]	(1) (ref)	0.81 (0.32, 2.03)	0.70 (0.38, 1.28)	**0.55 (0.34, 0.87)**	**0.34 (0.21, 0.54)**
Model 3[c]	(1) (ref)	0.79 (0.31, 2.01)	0.71 (0.39, 1.29)	**0.54 (0.34, 0.86)**	**0.34 (0.21, 0.53)**

Source: National Health and Nutrition Examination Survey.
Note: Boldface indicates statistical significance ($p<0.05$).
[a]Model 1: adjusted for age, sex, and race/ethnicity.
[b]Model 2: adjusted for items in Model 1 + family income level, education level, alcohol intake, physical activity, total energy intake, and overall diet quality indicated by Healthy Eating Index–2010.
[c]Model 3: adjusted for items in Model 2 + BMI, hypertension, diabetes mellitus, and dyslipidemia.
HR, hazard ratio.

Smoking is a preventable risk factor, and the cessation of smoking results in significant health benefits.

A major strength of this study is its use of a nationally representative sample. This study also controlled for potential confounding variables from a variety of sociodemographic factors and for dietary and health behavior factors using comprehensive data collected from NHANES data. This study also had a relatively long follow-up time for outcome development.

Limitations

The limitations of this study include exposure misclassification owing to self-reported data and potential unmeasured confounding. Furthermore, deaths from CVD were defined as deaths from heart disease because cerebrovascular diseases were not provided by the NCHS for the 2007–2014 NHANES. This classification may have affected the study results. Furthermore, because smoking status was evaluated at baseline, it is possible that current smokers at baseline changed their smoking behaviors during follow-up compared with those who continued to smoke, which could lead to an underestimation of the association between smoking and mortality outcomes. In addition, former smokers could be classified as former daily smokers and former occasional smokers. Considering that the measurement of exposure is cumulative, a more detailed exposure analysis may better reveal the objectives of the study. However, there are some difficulties in rebuilding the history of smoking throughout the life course with cross-sectional surveys, which could affect the strength of the correlations in this study. It is also possible that the treatment for hypertension and diabetes may reduce CVD risks. Participants who were receiving treatment for hypertension or diabetes were classified the same as those with untreated diabetes. This study did not consider the effect of temporary variations in the mortality rate, which may create a potential bias on the estimated risk of death. Moreover, nondaily smokers included those who had always been nondaily smokers and those who had smoked daily earlier in their lives. Given the relatively small number of nondaily smokers, this study made no further distinction, which may also have affected the study results.

CONCLUSIONS

This study found a significant increase in the risk of all-cause mortality for participants who smoked some days. The higher risk of all-cause, CVD, and cancer mortality increased with an increase in the number of cigarettes smoked per day. The risk of all-cause mortality significantly reduced for those with long-term cessation (≥5 years). This study suggests that smoking cessation is the only practicable way to avoid a substantial number of tobacco-related deaths.

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DZ and GZ contributed equally to this article.

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XW, GZ, and DZ had full access to any of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. XW, GZ, and DZ contributed to the concept and design of the study, XW, GZ, and DZ contributed to acquisition, analysis, and interpretation of data. XW and GZ contributed to the drafting of the manuscript. All the authors contributed to the critical revision of the manuscript for important intellectual content. XW and GZ conducted the statistical analysis. GZ and DZ provided administrative, technical, and material support. XW and GZ supervised the study.

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SUPPLEMENTAL MATERIAL

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