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RESEARCH ARTICLE

Non-Daily Cigarette Smokers: Mortality Risks in the U.S.

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Introduction: Worldwide, an estimated 189 million adults smoke tobacco "occasionally" but not every day. Yet few studies have examined the health risks of non-daily smoking.

Methods: Data from the 1991, 1992, and 1995 U.S. National Health Interview Surveys, a nationally representative sample of 70,913 U.S. adults (aged 18−95 years) were pooled. Hazard ratios and 95% CIs for death through 2011 were estimated from Cox proportional hazards regression using age as the underlying time metric and stratified by 5-year birth cohorts in 2017.

Results: Non-daily smokers reported smoking a median of 15 days and 50 cigarettes per month in contrast to daily smokers who smoked a median of 600 cigarettes per month. Compared with never smokers, lifelong nondaily smokers who had never smoked daily had a 72% higher mortality risk (95% CI=1.36, 2.18): higher risks were observed for cancer, heart disease, and respiratory disease mortalities. Higher mortality risks were observed among lifelong non-daily smokers who reported 11−30 (hazard ratio=1.34, 95% CI=0.81, 2.20); 31−60 (hazard ratio=2.02, 95% CI=1.17, 3.29); and >60 cigarettes per month (hazard ratio=1.74, 95% CI=1.12, 2.72) than never smokers. Median life-expectancy was about 5 years shorter for lifelong non-daily smokers than never smokers. As expected, daily smokers had even higher mortality risks (hazard ratio=2.50, 95% CI=2.35, 2.66) and shorter survival (10 years less).

Conclusions: Although the mortality risks of non-daily smokers are lower than daily smokers, they are still substantial. Policies should be specifically directed at this growing group of smokers.
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INTRODUCTION

Approximately 17% of the world's 1.1 billion smokers (189 million) are occasional smokers who smoke on only some days of the month.[1] Such non-daily smokers constitute a growing proportion of current smokers in the U.S. Whereas the number of daily cigarette smokers decreased from 37 million to 28 million from 2005 to 2015 in the U.S., the number of non-daily smokers who smoke on only some days of the month increased slightly.[2] In 2015, an estimated 8.9 million people in the U.S. were non-daily cigarette smokers.[2] Because long-term non-daily smoking was once an uncommon pattern, few studies have assessed its health effects.[3−11] Indeed, many non-daily smokers in the U.S. and elsewhere consider themselves to be non-smokers and further believe that their level of smoking is harmless.[12]

The limited existing literature suggests that regular non-daily cigarette smokers may have higher mortality rates than never smokers, even if they have never smoked every day (Appendix Table 1, available online).[3−11,13,14] However, these prior studies are limited by small sample size, inconsistent definitions of non-daily smoking, lack of lifetime cigarette use information, and lack of detailed current usage patterns, precluding assessment of a dose response.

The National Health Interview Survey (NHIS) offers the advantage of detailed cigarette smoking assessment,

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including days smoked in the past 30 days, number of cigarettes used on days smoked, and whether non-daily smokers had ever smoked daily, a nationally representative U.S. sample, and linked mortality follow-up data. These data allow for the examination of the association of non-daily cigarette smoking with mortality throughout the age range and across racial/ethnic groups.

METHODS

Study Population

The NHIS, an annual national household survey, uses a complex stratified multistage cluster sample design with sample weights to account for differential sampling and nonresponse rates of sampled individuals and post-stratification adjustments to U.S. population totals. The NHIS collects comprehensive information on demographics, behaviors, socioeconomic, and health status among the U.S. civilian non-institutionalized population. In each survey year, interviewers visit about 35,000 to 50,000 households nationwide and collect data from ≅75,000 to 130,000 individuals. NHIS is designed by the Centers for Disease Control and Prevention's National Center for Health Statistics and administered by the U.S. Census Bureau. Prior to the public release, the contents of the public-use data file went through an extensive review by the National Center for Health Statistics Disclosure Review Board. Data and detailed information on the NHIS including procedures for informed consent can be found at the NHIS website (www.cdc.gov/nchs/nhis.htm).

Measures

In addition to the core questionnaires assessing health and demographic information, each NHIS includes one or more supplements, which either stand alone or are embedded in the core questionnaire, that respond to public health concerns. Tobacco use questions for adults aged ≥18 years have been included in the supplements since 1965.

Data on cigarette smoking from the 1991 Health Promotion and Disease Prevention Supplement, the 1992 Cancer Control Supplement, and the 1995 Year 2000 Objectives Supplement that included detailed questions regarding cigarette use during the past month and additional questions for non-daily smokers allowing determination of prior daily use were harmonized.[15] Participants who reported that they had smoked ≥100 cigarettes in their lives were identified as ever cigarette smokers, and further categorized as former or current smokers. Current smokers were those who had smoked either occasionally (non-daily smokers) or every day (daily smokers) in the last 30 days.[16] Former smokers who reported smoking daily at some point were categorized as "former daily smokers" and former smokers who had never smoked daily were "former never-daily smokers." Current non-daily smokers were further categorized into those who had previously smoked every day and those who were always non-daily smokers (lifelong non-daily smokers).

Additional information varied by survey year, including age at first trying cigarettes (1995); age starting to smoke regularly (1992); number of days smoked in the past 30 days (all); cigarettes used on days smoked (all); number of months since last smoked daily (1991 and 1992); age at cessation (1992 and 1995); and number of years since cessation (1992 and 1995). Ever use of cigar, pipe, and smokeless tobacco were assessed in 1991 and 1992. Ever users were defined as participants who had used pipes ≥50 times, cigars ≥50 times, chewing tobacco ≥20 times, or snuff ≥20 times.

Mortality risks among non-daily smokers were assessed by number of days smoked in the past 30 days and number of cigarettes on days smoked among 961 lifelong non-daily smokers who provided such information. Four categories of cigarettes smoked per 30-day month were created: ten or fewer, 11–30, 31–60, and >60 cigarettes per 30-day month. Current non-daily smokers who previously smoked daily were not included in these analyses because information on their prior daily smoking pattern, such as cigarettes smoked per day, was not available. Daily smokers were also categorized into ≤60, 61–300, 301–600, 601–900, and >900 cigarettes smoked per 30-day month.

The NHIS has been linked to mortality data through probabilistic record matching with the National Death Index. Mortality through 2011 were identified using the NHIS–Linked Mortality Files. In addition to all-cause mortality, mortality from smoking-related causes of death (ICD-10 codes: cancer, C00–C97; heart disease, I00–I09, I11, I13, I20–I51; cerebrovascular disease, I60–I69; and respiratory disease including chronic lower respiratory diseases, J40–J47, and influenza and pneumonia, J09–J18) and all other causes available in the public-use NHIS–Linked Mortality Files were examined.[17,18]

Statistical Analysis

A total of 73,084 individuals aged ≥18 years responded to the supplements and the core questionnaires in 1991, 1992, and 1995: overall response rates for the core questionnaire was about 95% and for the tobacco supplements were 87.8% (1991); 87.0% (1992); and 80.9% (1995). Of these individuals, participants who were not eligible for mortality follow-up (n=908); had unknown cause of death (n=82); had unknown cigarette smoking

status (n=1,125); were aged <18 years (n=8) or ≥96 years (n=45) at the time of survey; or reported smoking ≥96 cigarettes per day (n=3) were excluded, resulting in 70,913 individuals (42,454, 11,664, and 16,795 from 1991, 1992, and 1995, respectively).

Participants were followed from the date of interview through the date of death, the date before they turned age 96 years, or December 31, 2011, whichever came first. Hazard ratios (HRs) and 95% CIs for each mortality outcome were estimated using Cox proportional hazards regression using age as the underlying time metric. Baseline hazards in the Cox regression were stratified by 5-year birth cohort. Covariates included sex; race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic other); education (less than high school, high school, some college/associate degree, and bachelor degree or higher); and survey year (1991, 1992, and 1995), based on literature review. Categories were created for missing values. Subgroup analyses were stratified by within or after 5 years of follow-up, sex, and race/ethnicity. Sensitivity analyses included (1) excluding participants who reported ever using other tobacco (available in 1991 and 1992) and additionally adjusting for (2) secondhand smoke exposure (1991 and 1992); (3) physical activity (1991 and 1995); and (4) family income and alcohol intake (1991).

Adjusted survival curves by smoking status were also created using these Cox proportional hazards models. However, for the survival curves to reflect the mortality rates of the combined birth cohorts of the U.S. population represented by the surveys, the baseline hazards in these models were not stratified by 5-year birth cohort. Analyses were conducted in 2017 using SAS-callable SUDAAN, release 11.0.1, to account for the sample weighted complex survey sample design for the NHIS.[19] The adjusted survival curves were computed using the PHREG procedure in SAS/STAT Proc, version 13.2, with the weight option including the NHIS sample weights.

RESULTS

The median age of the 70,913 participants (29,943 men and 40,970 women) was 41 years. There were 36,013 (51.0%) never; 16,315 (23.2%) former; and 18,585 (25.8%) current smokers. About 17% (n=3,166) of current smokers were non-daily smokers, of whom 2,039 (64.7%) reported previously smoking daily and 1,127 (35.3%) reported never smoking daily. Among former smokers, 88.6% had ever smoked daily.

Per 30-day month, non-daily smokers reported smoking a median of 15 days and 50 cigarettes. By contrast, daily smokers smoked a median of 600 cigarettes per 30-day month (20 cigarettes per day). A broad range of cigarette usage patterns during the month were observed among lifelong non-daily smokers (Appendix Table 2, available online). Those who smoked >60 cigarettes in the past 30 days smoked a median of eight cigarettes per day and 20 days per 30-day month, whereas those who smoked ten or fewer cigarettes in the past 30 days smoked a median of two cigarettes per day and three days per 30-day month.

Compared with current daily smokers, current non-daily smokers were younger and more likely to belong to racial/ethnic groups other than non-Hispanic white, and have higher educational achievement (Table 1). These patterns were also observed when comparing current lifelong non-daily smokers with those who had previously smoked daily, as well as comparing former never-daily smokers with former daily smokers. Current non-daily smokers started smoking at a slightly older age than current daily smokers. Among current non-daily smokers, those who previously smoked daily smoked on more days in the past 30 days than lifelong non-daily smokers (15 vs 10 days).

A total of 16,761 deaths were identified through the end of 2011, including deaths from cancer (n=4,114); heart disease (n=3,830); cerebrovascular disease (n=1,121); respiratory disease (n=1,361); and other causes (n=6,335). All-cause mortality risks were higher among current lifelong non-daily smokers than never smokers (HR=1.72, 95% CI=1.36, 2.18; Table 2). As expected, current daily smokers had even higher risk of all-cause mortality (HR=2.50, 95% CI=2.35, 2.66). Higher risks of all-cause mortality were observed for current non-daily and daily smokers relative to never smokers across subgroups of follow-up time (≤5 or >5 years); sex; and race/ethnicity, although the number of deaths were small in some strata. Associations were also similar when stratified by survey year (Appendix Table 3, available online). In sensitivity analyses, similar associations were observed after excluding ever regular users of other tobacco products, and also after additionally adjusting for secondhand smoking, physical activity, or alcohol intake and income.

In addition to all-cause mortality, associations for mortalities from cancer, heart disease, and particularly respiratory disease were observed. The HR for respiratory disease mortality was 6.06 (95% CI=3.84, 9.58) among current non-daily smokers who had previously smoked daily and 3.04 (95% CI=1.14, 8.07) among current lifelong non-daily smokers.

Next, survival from age 18 to 95 years by cigarette smoking status was examined (Figure 1). Median survival was 85 years in never smokers, 80 years in lifelong non-daily smokers, and 75 years for daily smokers.

Table 1. Demographic and Smoking Characteristics, National Health Interview Survey, 1991, 1992, 1995

			Current smokers			Former smokers	
				Non-daily			
Characteristics	**All**	**Never smokers**	**Daily**	**Previously daily**	**Lifelong non-daily**	**Ever daily**	**Never daily**
n	70,913 (100)	36,013 (100)	15,419 (100)	2,039 (100)	1,127 (100)	14,580 (100)	1,735 (100)
Survey year							
1991	42,454 (32.7)	21,343 (32.3)	9,457 (33.7)	1,124 (29.2)	673 (32.2)	8,908 (34.0)	949 (27.7)
1992	11,664 (33.1)	5,873 (32.6)	2,582 (33.9)	299 (30.8)	246 (40.6)	2,308 (32.2)	356 (39.9)
1995	16,795 (34.2)	8,797 (35.1)	3,380 (32.4)	616 (40.0)	208 (27.1)	3,364 (33.8)	430 (32.4)
Age at interview, years	41 (30–57)	38 (28–55)	40 (31–52)	38 (29–49)	32 (25–41)	52 (40–66)	43 (32–59)
Sex							
Male	29,943 (47.7)	12,607 (40.7)	7,236 (52.6)	902 (49.5)	517 (53.9)	7,813 (58.1)	868 (57.2)
Female	40,970 (52.3)	23,406 (59.3)	8,183 (47.4)	1,137 (50.5)	610 (46.1)	6,767 (41.9)	867 (42.8)
Race[a]							
Non-Hispanic white	52,707 (76.7)	25,303 (72.2)	11,962 (81.0)	1,379 (72.0)	586 (53.5)	12,190 (85.6)	1,287 (77.2)
Non-Hispanic black	9,140 (10.9)	5,007 (12.2)	2,124 (10.9)	368 (14.5)	259 (19.1)	1,193 (6.8)	189 (8.5)
Hispanic	6,735 (8.4)	4,227 (10.5)	958 (5.2)	227 (9.4)	227 (19.1)	890 (5.1)	206 (11.0)
Other	2,082 (3.7)	1,329 (4.7)	320 (2.5)	60 (3.9)	49 (7.3)	273 (2.3)	51 (3.0)
Education[b]							
Less than high school	15,335 (19.9)	7,166 (17.7)	4,106 (26.0)	398 (19.0)	262 (21.7)	3,116 (19.6)	287 (13.9)
High school	25,709 (37.2)	12,073 (34.3)	6,689 (44.6)	733 (36.3)	397 (34.7)	5,217 (36.9)	600 (36.6)
Some college	15,059 (21.5)	7,820 (22.3)	2,986 (19.2)	515 (23.9)	269 (23.6)	3,090 (21.5)	379 (22.1)
College	14,639 (21.2)	8,872 (25.5)	1,599 (9.9)	388 (20.5)	196 (19.3)	3,118 (21.7)	466 (27.1)
Smoking characteristics							
Age (years) when first started smoking fairly regularly (1992; *n*=5,545)	17 (15–20)	—	17 (15–19)	18 (16–20)	18 (16–22)	17 (15–19)	18 (16–20)
Age (years) when first tried smoking cigarettes (1995; *n*=7,862)	16 (13–18)	—	15 (13–18)	16 (14–18)	16 (14–18)	16 (13–18)	16 (14–18)
Number of days smoked in the past 30 days[c]	15 (5–20)	—	—	15 (8–20)	10 (4–15)	—	—
Number of cigarettes smoked per day[d]	20 (12–20)	—	20 (12–20)	—	—	—	—
Number of cigarettes smoked per day on days smoked[e]	4 (2–7)	—	—	4 (2–10)	3 (2–5)	—	—
Number of months since the last time smoking daily[f] (1991 and 1992)	12 (3–60)	—	—	12 (3–60)	—	—	—

(*continued on next page*)

Table 1. Demographic and Smoking Characteristics, National Health Interview Survey, 1991, 1992, 1995 (*continued*)

Characteristics	All	Never smokers	Current smokers			Former smokers	
			Daily	Non-daily		Ever daily	Never daily
				Previously daily	Lifelong non-daily		
Age (years) at cessation[g] (1992 and 1995)	36 (26–49)	—	—	—	—	37 (28–50)	26 (21–36)
Number of years since cessation[g] (1992 and 1995)	10 (4–20)	—	—	—	—	10 (4–20)	12 (4–25)
Ever use of other tobacco products[h] (1991 and 1992)	7,567 (15.7)	1,733 (7.1)	2,180 (21.1)	245 (18.6)	103 (12.5)	3,003 (29.4)	303 (26.0)

Note: Weighted median and IQR for continuous variables; *n* (weighted %) for categorical variables.
[a]Missing values were identified for 249 individuals (0.4%).
[b]Missing values were identified for 171 individuals (0.3%).
[c]Only for current non-daily smokers (*n*=2,915).
[d]Only for current daily smokers (*n*=15,294).
[e]Only for current non-daily smokers (*n*=2,918).
[f]Only for current non-daily smoker who ever smoked daily (*n*=1,288).
[g]Only for former smokers (*n*=5,213).
[h]Reporting ever using cigars at least 50 times, pipe at least 50 times, chewing tobacco at least 20 times, or snuff at least 20 times on the 1991 and 1992 surveys (completed by 54,118 participants).

Thus, relative to never smokers, median survival was about 5 years shorter for lifetime non-daily smokers in the cohort. Survival was 10 years shorter for daily smokers than never smokers.

Generally higher risks with higher numbers of cigarettes smoked per 30-day month were also observed (Table 3). Compared with never smokers, HRs were 1.08 (95% CIs=0.62, 1.90) for lifelong non-daily smokers who smoked ten or fewer, 1.34 (95% CIs=0.81, 2.20) for 11–30, 2.02 (95% CIs=1.17, 3.49) for 31–60, and 1.74 (95% CI=1.12, 2.72) for >60 cigarettes per month. Despite lack of statistical power because of a small number of daily smokers who smoked ≤60 cigarettes per month (two or fewer cigarettes per day), this level of smoking was also associated with mortality in the context of daily smoking (HR=1.42, 95% CI=0.95, 2.10), although not reaching statistical significance. The number of cigarettes smoked per 30-day month was also modeled as a continuous variable and found a statistically significant inverted quadratic relationship with the log hazard of mortality, such that the increase in mortality risk with each additional cigarette smoked per month was higher at low cigarettes per month than it was at higher cigarettes per month.

Next, mortality risks among former smokers was examined, but no clear pattern with time since cessation was observed among former never-daily cigarette smokers (Appendix Table 4, available online). However, it should be noted that there were few former never-daily smokers in the analytic data set, nearly all of whom quit at a young age. Among daily smokers, participants who had quit smoking had lower risks than those who continued to smoke, with lower risks observed among those who quit smoking earlier.

Among current non-daily smokers who reported previously smoking daily, no clear pattern was observed for the association of time since last smoking daily with mortality. Participants who had switched from daily to non-daily smoking >10 years before baseline had 1.77 (95% CI=1.31, 2.40) times the mortality risk of never smokers.

DISCUSSION

In this nationally representative U.S. study, current non-daily smokers smoked a median of 50 cigarettes per month, far fewer than the median 600 cigarettes per month smoked by current daily smokers. Nevertheless, lifelong non-daily smokers had a 72% higher risk of mortality during follow-up than never smokers. Associations were observed across a range of smoking-related causes of death, in men and women, and among different racial/ethnic groups. Median survival was about 5 years shorter for current non-daily smokers than never

Table 2. Cigarette Smoking and Mortality Among Current Smokers in the National Health Interview Survey

Variable	Never	Current daily	Current non-daily	
			Previously daily	Lifelong non-daily
All-cause mortality				
All participants (N=70,913)				
n	36,013	15,419	2,039	1,127
Death	6,808	4,178	366	147
HR (95% CI)[a]	1.00	2.50 (2.35, 2.66)	1.62 (1.35, 1.93)	1.72 (1.36, 2.18)
Excluding ever users of cigars, pipes, chewing tobacco, or snuff (*n*=46,551)[b]				
n	25,483	9,859	1,178	816
Death	4,961	2,594	200	116
HR (95% CI)	1.00	2.47 (2.29, 2.68)	1.75 (1.39, 2.21)	1.66 (1.22, 2.26)
Additionally adjusted for second-hand smoke exposure (*n*=53,834)[c]				
n	27,049	11,993	1,419	917
Death	5,410	3,366	272	129
HR (95% CI)	1.00	2.19 (2.01, 2.39)	1.41 (1.11, 1.79)	1.59 (1.21, 2.08)
Additionally adjusted for physical activity level (*n*=55,034)[d]				
n	28,027	12,004	1,633	826
Death	4,779	3,057	258	103
HR (95% CI)	1.00	2.49 (2.34, 2.65)	1.62 (1.37, 1.92)	1.72 (1.34, 2.21)
Additionally adjusted for income and alcohol intake (*n*=42,454)[e]				
n	21,343	9,457	1,124	673
Death	4,324	2,648	212	97
HR (95% CI)	1.00	2.39 (2.25, 2.54)	1.61 (1.35, 1.92)	1.62 (1.26, 2.09)
First 5 years of follow-up (*n*=70,913)				
n	36,013	15,419	2,039	1,127
Death	1,545	850	1,963	1,094
HR (95% CI)	1.00	2.23 (1.95, 2.55)	1.47 (1.09, 1.97)	2.05 (1.32, 3.19)
After 5 years of follow-up (*n*=66,991)				
n	34,382	14,568	1,963	1,094
Death	5,263	3,328	1,673	980
HR (95% CI)	1.00	2.58 (2.41, 2.75)	1.66 (1.36, 2.02)	1.65 (1.26, 2.17)
Men (*n*=29,943)				
n	12,607	7,236	902	517
Death	1,864	2,144	181	51
HR (95% CI)	1.00	2.54 (2.33, 2.77)	1.47 (1.13, 1.92)	1.99 (1.39, 2.86)
Women (*n*=40,970)				
n	23,406	8,183	1,137	610
Death	4,944	2,034	185	96
HR (95% CI)	1.00	2.49 (2.31, 2.68)	1.81 (1.46, 2.24)	1.55 (1.12, 2.14)
Non-Hispanic white (*n*=52,707)				
n	25,303	11,962	1,379	586
Death	5,277	3,306	245	68
HR (95% CI)	1.00	2.69 (2.51, 2.88)	1.71 (1.42, 2.06)	1.38 (1.02, 1.88)
Non-Hispanic black (*n*=9,140)				
n	5,007	2,124	368	259

(continued on next page)

Table 2. Cigarette Smoking and Mortality Among Current Smokers in the National Health Interview Survey (*continued*)

			Current non-daily	
Variable	**Never**	**Current daily**	**Previously daily**	**Lifelong non-daily**
Death	982	637	91	51
HR (95% CI)	1.00	1.82 (1.56, 2.12)	1.27 (0.86, 1.89)	2.21 (1.47, 3.32)
Hispanic (*n*=6,735)				
n	4,227	958	227	227
Death	420	162	22	23
HR (95% CI)	1.00	2.14 (1.67, 2.75)	1.76 (0.91, 3.41)	2.05 (1.27, 3.32)
Non-Hispanic other (*n*=2,082)				
n	1,329	320	60	49
Death	111	61	8	5
HR (95% CI)	1.00	2.02 (1.30, 3.15)	2.19 (0.87, 5.49)	0.64 (0.28, 1.45)
Cause-specific mortality				
Cancer (Death=4,114)				
Death	1,343	1,323	118	31
HR (95% CI)[a]	1.00	3.25 (2.89, 3.66)	2.37 (1.79, 3.14)	1.50 (0.96, 2.34)
Heart disease (Death=3,830)				
Death	1,669	782	75	37
HR (95% CI)	1.00	2.06 (1.81, 2.35)	1.26 (0.92, 1.73)	1.69 (1.08, 2.64)
Cerebrovascular disease (Death=1,121)				
Death	574	196	14	13
HR (95% CI)	1.00	1.86 (1.49, 2.30)	1.14 (0.58, 2.24)	1.82 (0.85, 3.90)
Respiratory disease (Death=1,361)				
Death	319	480	43	7
HR (95% CI)	1.00	7.55 (6.13, 9.29)	6.06 (3.84, 9.58)	3.04 (1.14, 8.07)
Other cause (Death=6,335)				
Death	2,903	1,397	116	59
HR (95% CI)	1.00	1.94 (1.77, 2.12)	1.07 (0.80, 1.42)	1.69 (1.18, 2.41)

[a]HR and 95% CI adjusted for sex; race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other, and missing); education (less than high school, high school, some college, college or higher, and missing); and survey year (1991, 1992, and 1995). Age was the underlying time metric, baseline hazards were stratified by 5-year birth cohort, and never smokers were the referent group.
[b]Participants of the 1991 or 1992 surveys after excluding 7,567 participants who reported having ever used cigars at least 50 times, pipe at least 50 times, chewing tobacco at least 20 times, or snuff at least 20 times.
[c]Participants of the 1991 or 1992 surveys who reported whether anybody in their household smoked cigarettes.
[d]Participants of the 1991 or 1995 surveys who reported physical activity information. Additionally adjusted for physical activity (active, insufficient, and inactive).
[e]Alcohol intake was assessed only in the 1991 survey.
HR, hazard ratio.

smokers, illustrating the substantial impact of non-daily smoking on mortality.

Results from the current study are generally consistent with the limited number of previous studies of the association (Appendix Table 1, available online).[5,6,9–11,14] Four previous cohort studies reported increased mortality risks of non-daily smoking, although were limited by a small sample size, lack of information on the number of days smoked and the number of cigarettes smoked per month, and inconsistent definitions for non-daily smoking; most lacked information as to whether non-daily smokers had ever previously smoked daily.[5,9,11,14] In the NIH-AARP study, participants who reported consistently smoking fewer than one cigarette per day over their lifetime had 1.64 times higher mortality risk than never smokers.[9] In the U.S. National Longitudinal Mortality Surveys, current non-daily cigarette smokers had 1.6 times higher all-cause mortality compared with never tobacco users.[14] Doll and Peto[20] previously reported a decrease in survival by 10 years among active smokers compared with never smokers in a large British cohort and similar findings have been observed elsewhere,[21,22] which are consistent with the current finding for daily smokers.

The observed association between non-daily cigarette smoking and mortality is plausible. Cigarette smoke

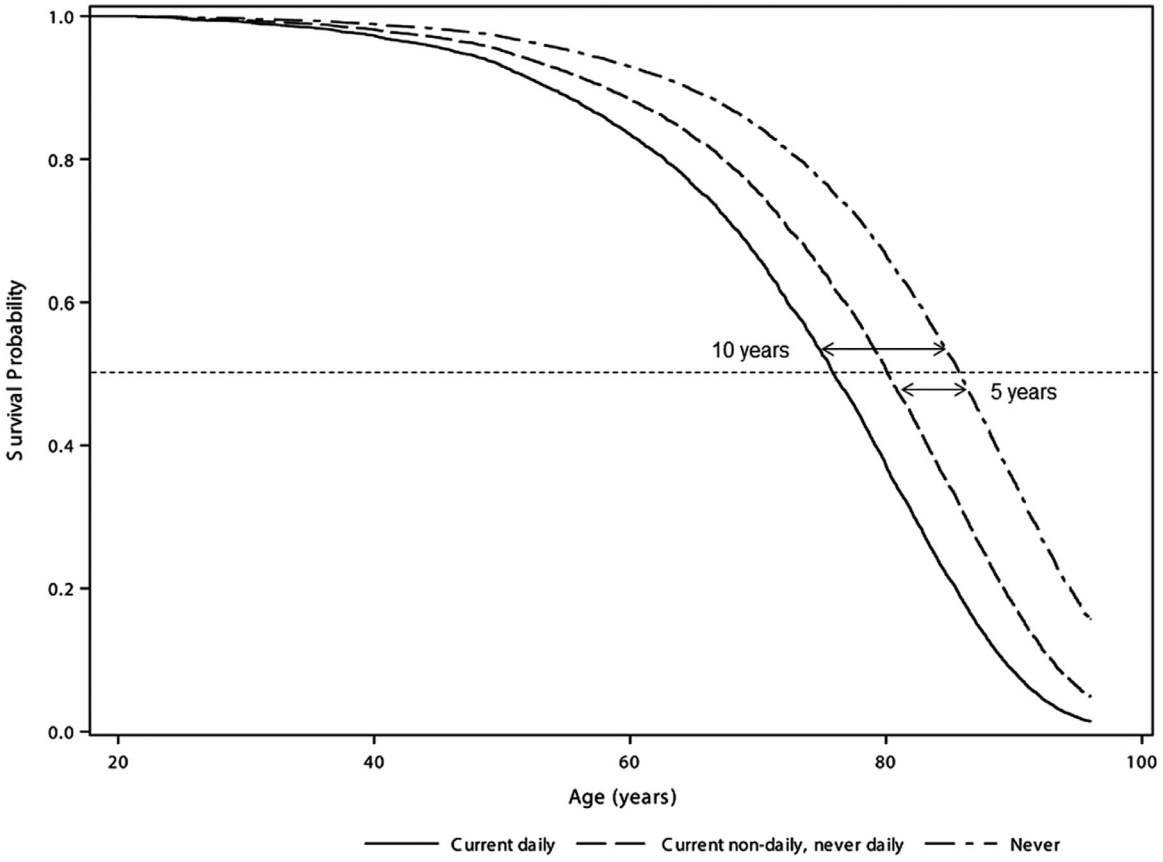

Figure 1. Survival curves among never and current cigarette smokers aged 18–95 years.

contains at least 7,000 chemical compounds; of these, hundreds are harmful, including many carcinogens.[23] Smoking even one cigarette exposes a user to substantial levels of these chemicals. Despite smoking substantially fewer cigarettes per month than most daily smokers, non-daily smokers in the U.S. population still typically

Table 3. Number of Cigarettes Smoked in the Past 30-day Month[a] and All-Cause Mortality

Variable	*n*	Death	HR (95% CI)[b]
Never smokers	36,013	6,808	1.00
Current lifelong non-daily smokers			
≤10	248	21	1.08 (0.62, 1.90)
11–30	244	27	1.34 (0.81, 2.20)
31–60	206	27	2.02 (1.17, 3.49)
>60	263	35	1.74 (1.12, 2.72)
Current daily smokers			
≤60 (≤2 CPD)	160	45	1.42 (0.95, 2.10)
61–300 (3–10 CPD)	3,748	878	2.07 (1.86, 2.30)
301–600 (11–20 CPD)	7,690	1,934	2.34 (2.16, 2.54)
601–900 (21–30 CPD)	2,043	648	3.28 (2.86, 3.76)
>900 (>30 CPD)	1,653	612	3.33 (2.96, 3.76)

[a]Based on reported number of days smoked in the past 30 days and number of cigarettes smoked per day on the days they smoked.
[b]HR and 95% CI adjusted for sex; race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other, and missing); education (less than high school, high school, some college, college or higher, and missing); and survey year (1991, 1992, and 1995). Age was the underlying time metric, baseline hazards were stratified by 5-year birth cohort, and never smokers were the referent group.
CPD; cigarettes per day; HR, hazard ratio.

smoke for many years and thus smoke a substantial number of cigarettes over their lifetime. For example, a person smoking 50 cigarettes per month for 35 years will end up smoking more than 20,000 cigarettes in his or her lifetime. Long-term exposure to cigarette smoke is known to be an important determinant of disease, both among active smokers[24–26] and among people exposed to secondhand cigarette smoke.[27]

Among lifelong non-daily smokers, increased mortality risks were observed even at very low levels of cigarette use. As the number of non-daily smokers in this study was relatively small, future larger studies are needed to refine the associations, particularly among non-daily smokers using 30 or fewer cigarettes per month. Yet, these findings provide additional evidence that even very low levels of smoking are hazardous and that all smokers, no matter how few cigarettes they smoke, should quit, as recommended by current guidelines.[28]

In this study, more than a third of current non-daily smokers reported never smoking daily. These lifelong non-daily smokers were more likely to be young and racial/ethnic minorities than current non-daily smokers who reported previously smoking daily, as well as current daily smokers. A higher prevalence of non-daily smoking among racial/ethnic minorities has been noted previously.[29,30] Racial/ethnic minorities have been shown to have relatively higher risks of smoking-related disease at the same cigarettes per day, although few such studies have examined occasional, non-daily smoking.[29,31] It will be important to carefully compare a dose–response association among non-daily smokers across ethnic groups in future studies. Unfortunately, the authors lacked sufficient case numbers to perform such analyses in the current study. Relatively less is known about other important aspects of non-daily smoking including levels of nicotine addiction and dependency,[32] as well as optimal strategies for cessation. Future studies are needed to answer these questions.

Key strengths of the current study are the availability of detailed data on smoking frequency and intensity, the nationally representative sample of more than 70,000 U.S. adults, and nearly complete follow-up. High response rates in the NHIS also strengthened the study design: Overall response rates in 1991, 1992, and 1995 were approximately 95% to the core questionnaires and 81%–88% for the tobacco supplement questionnaires. Appropriate survey weights were applied in this analysis, making these findings representative of the U.S. civilian non-institutionalized adult population. This analysis included a wide age range and allowed the authors to examine associations by sex and across racial/ethnic groups. Associations in each survey were also assessed separately, and consistent results were found.

Limitations

The smoking data relied on participants' recalling their tobacco use, and therefore is potentially subject to misclassification. However, the validity of both non-daily and daily self-reported smoking have been shown to be good, correlating with biomarkers, such as nicotine and its metabolites.[33–36] Non-daily smokers may have taken up daily smoking during the follow-up. However, similar patterns were observed in mortality associations within and after 5 years of follow-up. Additionally, in the previous analysis in the NIH-AARP cohort, older smokers who reported consistently smoking fewer than one cigarette per day throughout their lifetime had increased risk of mortality.[9] Yet, the statistical power was limited for some analyses. Finally, as in all observational studies, uncontrolled and residual confounding is a potential limitation.

CONCLUSIONS

In the U.S. nationally representative NHIS-mortality follow-up study, lifelong non-daily cigarette smokers had 72% higher mortality risk than never smokers, with about 5 years shorter median survival. These findings provide additional evidence that even very low amounts of cigarette smoking are hazardous and support public health recommendations that all smokers, including low-intensity and non-daily smokers, should quit.[28]

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All authors had full access to all the data in the study, had final responsibility for the decision to submit for publication, and take responsibility for the integrity of the data and the accuracy of the data analysis. Inoue-Choi and Freedman were involved in developing the study concept and design and drafting of the manuscript. All authors were involved in acquisition, analysis, or interpretation of data, and critical revision of the manuscript for important intellectual content. Inoue-Choi, Freedman, McNeel, and Graubard contributed to the statistical analysis. Freedman obtained funding and supervised the study. McNeel, Inoue-Choi, Freedman provided administrative, technical, or material support.

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SUPPLEMENTAL MATERIAL

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