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Brief Original Contribution

Mortality Risks Associated With Dual– and Poly–Tobacco-Product Use in the United States

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Increasing numbers of adults in the United States use more than 1 tobacco product. Most use cigarettes in combination with other tobacco products. However, little is known about the all-cause and cancer-specific mortality risks of dual– and poly–tobacco-product use. We examined these associations by pooling nationally representative data from the 1991, 1992, 1998, 2000, 2005, and 2010 National Health Interview Surveys (n = 118,144). Mortality information was obtained through linkage to the National Death Index. Cigarette smokers who additionally used other tobacco products smoked as many if not more cigarettes per day than exclusive cigarette smokers. Furthermore, cigarette smokers who additionally used other tobacco products had mortality risks that were as high as and sometimes higher than those of exclusive cigarette smokers. As tobacco use patterns continue to change and diversify, investigators in future studies need to carefully assess the impact of noncigarette tobacco products on cigarette use and determine associated disease risks.

cigarettes; dual– and poly–tobacco-product use; mortality; smoking; tobacco products; tobacco use

Abbreviations: CI, confidence interval; HR, hazard ratio.

While cigarettes remain the most commonly used tobacco product among adults in the United States, a growing number of people smoke cigarettes in combination with the use of other tobacco products (1). However, few data on the mortality risks of dual– and poly– tobacco-product use are available. On the one hand, it seems possible that using other tobacco products would result in reduced cigarette smoking among dual users. Yet, recent data from the National Health and Nutrition Examination Survey suggest that most dual users of cigarettes and other tobacco products instead smoke at least as many cigarettes per day as people who use cigarettes alone and have nicotine and tobacco-specific nitrosamine levels as high as or higher than those of people who use cigarettes alone (2). These results suggest that cigarette smokers who additionally use other tobacco products may have even higher disease risks than exclusive cigarette smokers. In this study, we examined associations between tobacco use patterns (i.e., never tobacco use, current exclusive cigarette use, dual tobacco use, poly–tobacco-product use) and all-cause and cancer-specific mortality by pooling data from the 1991, 1992, 1998, 2000, 2005, and 2010 National Health Interview Surveys. Data from these years were used because data on use of noncigarette tobacco products were collected and sufficient time had passed to result in mortality.

METHODS

The National Health Interview Surveys are a series of cross-sectional surveys using different cohorts of adults in the United States. The design and sampling approach are detailed elsewhere (3). Briefly, an area probability design was used to obtain a representative sample of households and noninstitutional group quarters. Data were collected through a personal household interview by trained interviewers at the US Census Bureau. Participants reported their use of cigarettes, cigars, pipes, and smokeless tobacco (chewing tobacco or snuff). Pipe use was not assessed in the 2010 survey. Ever tobacco users were defined as those who reported using ≥100 cigarettes, ≥50 cigars, pipes ≥50 times, snuff ≥20 times, or chewing tobacco ≥20 times in their lifetime. Current users were those who met the ever-use threshold and reported past-30-day tobacco use; they were categorized into "exclusive cigarette users," "dual users of cigarettes and cigars/pipes," "dual users of cigarettes

Table 1. Demographic Characteristics and Tobacco-Use Behavior Patterns of Current Cigarette Smokers in the National Health Interview Survey, 1991, 1992, 1998, 2000, 2005, and 2010

Characteristic	Tobacco-Use Behavior									
	Never Tobacco Use (n = 83,972)		Exclusive Cigarette Use[a] (n = 32,038)		Dual Use With Cigars or Pipe[b] (n = 1,291)		Dual Use With Smokeless Tobacco[c] (n = 612)		Poly-Use With Cigars/Pipe and Smokeless Tobacco (n = 231)	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Demographic characteristics										
Age, years[d]	40.4 (28.8–55.4)		39.9 (29.9–51.2)		42.6 (31.3–52.7)		29.8 (23.6–39.5)		34.6 (25.0–46.1)	
Sex[e]										
Male	38.4	38.0, 38.9	43.0	42.2, 43.7	89.4	87.3, 91.2	96.8	95.2, 97.9	97.5	92.8, 99.2
Female	61.6	61.2, 62.0	57.0	56.3, 57.8	10.6	8.8, 12.7	3.2	2.1, 4.8	2.5	0.8, 7.2
Race/ethnicity[e]										
Non-Hispanic white	67.6	67.0, 68.3	74.9	74.0, 75.7	74.8	71.8, 77.6	89.1	85.5, 91.8	87.7	81.9, 91.8
Non-Hispanic black	12.9	12.5, 13.4	12.8	12.2, 13.5	12.9	11.0, 15.1	5.9	3.9, 8.9	3.9	1.9, 7.8
Hispanic	13.9	13.4, 14.4	8.9	8.4, 9.4	10.1	8.2, 12.2	3.4	2.2, 5.2	4.5	1.9, 10.4
Other	5.4	5.1, 5.7	3.3	3.0, 3.7	2.3	1.4, 3.8	1.6	0.8, 3.2	3.9	2.1, 7.3
Education[e]										
Less than high school	15.8	15.4, 16.2	23.0	22.4, 23.7	24.2	21.2, 27.4	25.8	20.9, 31.5	33.8	26.9, 41.6
High school	28.3	27.9, 28.8	39.4	38.7, 40.2	36.2	32.7, 39.7	39.0	34.4, 43.9	36.2	29.4, 43.7
More than high school	55.4	54.9, 56.0	37.1	36.4, 37.9	39.4	36.2, 42.6	35.1	30.2, 40.4	29.4	23.0, 36.8
Cigarette-use pattern										
Age (years) at starting to smoke cigarettes regularly[d,f,g]			17 (15–20)		16 (14–18)		17 (15–19)		16 (13–18)	
Frequency of cigarette use[e]										
Daily			81.4	80.8, 82.0	79.3	76.0, 82.3	74.4	70.0, 78.4	78.3	70.7, 84.4
Nondaily			18.6	18.1, 19.3	20.7	17.7, 24.0	25.6	21.6, 24.0	21.7	15.6, 29.3
No. of cigarettes smoked in past 30 days[d,f]			450 (300–600)		600 (300–600)		510 (210–600)		600 (300–900)	
Frequency of noncigarette tobacco use[e]										
Daily					16.1	13.3, 19.1	33.2	28.5, 38.3	28.5	21.7, 36.6
Nondaily					83.9	81.0, 86.4	66.8	61.7, 71.5	71.5	63.5, 78.3

Abbreviation: CI, confidence interval.
[a] Never used any other form of tobacco (cigar, pipe, chewing tobacco, or snuff).
[b] Never used smokeless tobacco (chewing tobacco and snuff). The 2010 survey did not assess pipe use.
[c] Chewing tobacco or snuff. Never used a pipe or cigars.
[d] Values are expressed as weighted median (interquartile range).
[e] Values are expressed as weighted percentage. Percentages include missing values.
[f] Results were based on the public-use files of the corresponding National Health Interview Surveys instead of the restricted-use files.
[g] Data were not collected in the 1991 survey.

and smokeless tobacco," and "poly-users who used cigarettes, cigars/pipes, and smokeless tobacco."

Mortality was determined through linkage to the National Death Index using the restricted-use National Health Interview Surveys Linked Mortality Files. The final analytical cohort contained 118,144 adults aged 18–95 years. Participants were followed from the date of interview through the date of death, age 96 years, or December 31, 2015, whichever came first. We used *International Classification of Diseases, Tenth Revision*, codes to identify deaths that were caused by cancer (codes C00–C97). Hazard ratios and 95% confidence intervals for all-cause and cancer-specific mortality were computed using Cox proportional hazards regression with age as the underlying time metric and baseline hazards stratified by 5-year birth cohort, adjusted for demographic characteristics (see Table 1) and survey year. Cox regression models used either 1) never tobacco users or 2) exclusive cigarette users as the reference group. Analyses of all-cause mortality were further stratified by frequency of tobacco product use (daily vs. nondaily). In a sensitivity analysis, we additionally adjusted for annual household income and alcohol intake. Since the additional adjustments produced little attenuation of the associations of interest, we decided to report findings without adjusting for annual household income and alcohol intake. Analyses were conducted using SAS-callable (SAS Institute, Inc., Cary, North Carolina) SUDAAN, release 11.0.1 (RTI International, Research Triangle Park, North Carolina), with appropriate weighting (4).

RESULTS

Overall, after weighting, 71.6% (n = 83,972) of the population had never used tobacco, 26.5% (n = 32,038) used cigarettes exclusively, 1.1% (n = 1,291) used other combustible tobacco products in addition to cigarettes, 0.6% (n = 612) used smokeless tobacco in addition to cigarettes, and 0.2% (n = 231) used cigarettes, other combustible tobacco products, and smokeless tobacco (poly-use). Compared with exclusive cigarette smokers, dual users of cigarettes and smokeless tobacco and poly-users of cigarettes, cigars/pipes, and smokeless tobacco appeared to be younger and more likely to be non-Hispanic white (Table 1). While over half of the exclusive cigarette smokers were women, the vast majority of dual and poly-users were men (at least 89% in each dual and poly use group). Poly-users also had the highest proportion of persons with less than a high school education. Most dual and poly-users used cigarettes daily and used other tobacco products nondaily. They also tended to smoke as many cigarettes per day, if not more, as exclusive cigarette smokers.

Compared with that in never tobacco users, all-cause mortality was higher in exclusive cigarette smokers (hazard ratio (HR) = 2.26, 95% confidence interval (CI): 2.16, 2.37), dual users of cigarettes and combustible tobacco (HR = 2.36, 95% CI: 1.99, 2.80), dual users of cigarettes and smokeless tobacco (HR = 2.28, 95% CI: 1.79, 2.90), and poly-users (HR = 2.49, 95% CI: 1.76, 3.53) (Table 2). Similar associations were observed for cancer mortality; the hazard ratios were 2.75 (95% CI: 2.53, 3.00) for exclusive cigarette smokers, 2.71 (95% CI: 1.97, 3.73) for dual users of cigarettes and combustible tobacco, and 2.91 (95% CI: 1.72, 4.92) for dual users of cigarettes and smokeless tobacco. The association did not reach statistical significance among poly–tobacco-product users (HR = 1.69, 95% CI: 0.85, 3.36).

When stratified by frequency of tobacco product use (daily vs. nondaily), daily cigarette users had higher all-cause mortality than never tobacco users, including when they additionally used other tobacco products ($P < 0.05$; Table 3). Similar findings were observed among nondaily cigarette users, although results in some tobacco-product-use groups did not reach statistical significance because of the low number of deaths. Moreover, compared with exclusive cigarette users, dual– and poly–tobacco-product users had similar risks of all-cause mortality, although higher risk was observed in daily poly-users of cigarettes, cigars/pipes, and smokeless tobacco (HR = 1.75, 95% CI: 1.02, 2.99) than in daily users of cigarettes alone.

Results were also similar after additional adjustment for household income and alcohol intake or after exclusion of data from the 2010 survey, which did not assess pipe use.

DISCUSSION

In this nationally representative study, cigarette smokers in the United States who additionally used other tobacco products smoked at least as many cigarettes per day as exclusive cigarette smokers and had mortality risks that were at least as high as those of exclusive cigarette smokers. Few prior data were available. Nevertheless, similar or higher cigarette consumption among dual users as among exclusive cigarette smokers supports the plausibility of findings for mortality. Additionally, in a prior study using data from the National Health and Nutrition Examination Survey, Choi et al. (2) found levels of tobacco biomarkers among dual users of cigarettes and other products that were as high as or higher than those of exclusive cigarette smokers.

One limitation of the current study is that we lacked information on lifetime usage patterns for various tobacco products, such as age at initiation and frequency and intensity of use prior to and after completing the survey. Data from the Population Assessment on Tobacco and Health (PATH) Study showed that among adults aged 25 years or older, 74% of exclusive cigarette smokers remained exclusive cigarette smokers and 53% of cigarette and other tobacco users continued their tobacco-use behaviors over a 1-year observation period (5). These findings suggest that dual– and poly–tobacco-product use is a somewhat stable behavior. We also lacked

Table 2. Hazard Ratios for All-Cause and Cancer-Specific Mortality According to Tobacco-Use Behavior Pattern in the National Health Interview Survey Linked Mortality File, 1991, 1992, 1998, 2000, 2005, and 2010

Tobacco-Use Behavior	All-Cause Mortality					Cancer Mortality				
	No. of Deaths	HR_1[a]	95% CI	HR_2[b]	95% CI	No. of Deaths	HR_1[a]	95% CI	HR_2[b]	95% CI
Never tobacco use	12,713	1.00	Referent	0.44	0.42, 0.46	2,537	1.00	Referent	0.36	0.33, 0.40
Exclusive current cigarette use	6,776	2.26	2.16, 2.37	1.00	Referent	2,008	2.75	2.53, 3.00	1.00	Referent
Current dual use of cigarettes and cigars or pipe	302	2.36	1.99, 2.80	1.04	0.88, 1.23	83	2.71	1.97, 3.73	0.99	0.72, 1.36
Current dual use of cigarettes and smokeless tobacco	78	2.28	1.79, 2.90	1.01	0.79, 1.29	25	2.91	1.72, 4.92	1.06	0.63, 1.78
Current poly-use of cigarettes and both cigars/pipe and smokeless tobacco	51	2.49	1.76, 3.53	1.10	0.78, 1.56	10	1.69	0.85, 3.36	0.61	0.31, 1.21

Abbreviations: CI, confidence interval; HR, hazard ratio.

[a] Estimated with never tobacco users as the referent group and age at interview as the time metric; adjusted for sex, race/ethnicity, education, and survey year. Results were derived from a model that included nondaily cigarette smokers, daily cigarette smokers, and never smokers.

[b] Estimated with exclusive cigarette users as the referent group and age at interview as the time metric; adjusted for sex, race/ethnicity, education, and survey year.

Table 3. Hazard Ratios for All-Cause Mortality According to Tobacco-Use Behavior Pattern and Frequency of Cigarette Use in the National Health Interview Survey Linked Mortality File, 1991, 1992, 1998, 2000, 2005, and 2010

Tobacco-Use Behavior	Frequency of Cigarette Use					
	Nondaily			Daily		
	No. of Deaths	HR_1[a]	95% CI	No. of Deaths	HR_1[a]	95% CI
Exclusive current cigarette use	891	1.73	1.56, 1.90	5,885	2.38	2.26, 2.49
Current dual use of cigarettes and cigars or pipe						
Nondaily cigar or pipe	32	1.29	0.64, 2.59	205	2.53	2.11, 3.02
Daily cigar or pipe	15	2.44	1.29, 4.60	50	2.88	2.03, 3.09
Current dual use of cigarettes and smokeless tobacco						
Nondaily smokeless tobacco	9	2.09	1.08, 4.06	37	2.53	1.75, 3.67
Daily smokeless tobacco	9	1.59	0.85, 2.97	23	2.33	1.55, 3.51
Current poly-use of cigarettes and both cigars/pipe and smokeless tobacco						
Nondaily use	—[b]	1.61	0.38, 6.88	28	2.45	1.58, 3.78
Daily use	7	1.65	0.71, 3.83	14	4.48	2.62, 7.64

Abbreviations: CI, confidence interval; HR, hazard ratio.

[a] Estimated with never tobacco users as the referent group (12,713 deaths) and age at interview as the time metric; adjusted for sex, race/ethnicity, education, and survey year. Results were derived from a model that included nondaily cigarette smokers, daily cigarette smokers, and never smokers.

[b] Value is suppressed because of the small number of deaths (<5).

information on emerging tobacco products, such as electronic nicotine delivery systems. Additionally, we could not control for lifestyle factors that were not available in National Health Interview Surveys (e.g., physical activities), although previous studies have observed minimal confounding by lifestyle factors in smoking-related mortality (6). Nevertheless, our results showing that people who use other tobacco products in addition to cigarettes continue to have substantial mortality risks are probably applicable to other products.

Tobacco-use patterns are changing and diversifying. For example, between 2002 and 2012, the prevalence of past-30-day cigarette smoking in adults declined in the United States, while the prevalence of past-30-day roll-your-own cigarette smoking and smokeless tobacco use increased (7). Furthermore, increasing proportions of adult cigarette smokers also reported using other tobacco products (from 3.8% in 1995–1996 to 5.8% in 2001–2002 to 13.7% in 2011) (8, 9). With the introduction of new tobacco products (e.g., electronic cigarettes) into the marketplace, the prevalence of adult multiple–tobacco-product use was 37.8% in 2013–2014, with 331 different combinations of tobacco-product-use patterns (10). As these trends continue to change and patterns diversify, investigators in future studies need to carefully assess the impact of noncigarette tobacco products on cigarette use and determine associated disease risks.

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