Cardiovascular disease outcomes among established cigar users 40 years and older: Findings from the population assessment of tobacco and health (PATH) study, waves 1–5 (2013–2019)

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ABSTRACT

This study examined associations between established cigar use and prevalence and incidence of cardiovascular diseases (CVD; congestive heart failure, stroke, or heart attack/needed bypass surgery) among U.S. adults, 40 years or older. Using Waves 1–5 (2013–2019) of the Population Assessment of Tobacco and Health (PATH) Study, incidence ($N_{individuals}$ (N_{ind}) = 6,692; $N_{observations}$ (N_{obs}) = 23,738) and prevalence (N_{ind} = 7,819; N_{obs} = 33,952) of CVD outcomes were examined using weighted generalized estimating equations (WGEEs) among adults who were exclusive current/former established cigar smokers (ever cigar smokers who have smoked fairly regularly), exclusive current/former established cigarette smokers (lifetime smokers of 100 or more cigarettes), dual current/former established cigarette and cigar smokers compared with never smokers of cigars or cigarettes, adjusting for covariates. The population-averaged incidence of CVD from one wave to next among exclusive current/former established cigar smokers during a six-year period based on WGEEs was low (overall average rate of 3.0 %; 95 % CI: 1.2, 7.0). Compared with never users, exclusive current/former established cigar smokers (OR = 1.67, 95 % CI: 1.11, 2.51) and exclusive current/former established cigarette smokers (OR = 2.12, 95 % CI: 1.45, 3.09) were more likely to have any CVD outcome in unadjusted analyses. When adjusted for covariates, only exclusive current/former established cigarette use was associated with CVD outcomes (AOR = 1.60, CI: 1.07, 2.40). Results suggest that exclusive established use of cigars or duration of exclusive cigar use was not associated with lifetime CVD prevalence compared with never cigar or cigarette smokers, which is important in understanding health outcomes in cigar users.

1. Introduction

Mechanisms by which cigarette smoking increases the risk of cardiovascular diseases (CVD) have been extensively evaluated (U.S. Department of Health and Human Services. How Tobacco Smoke Causes Disease, 2010); however, much less is known about the risks associated

with smoking cigars. As a combustible tobacco product, cigars may have cardiovascular health risks similar to cigarette smoking (Centers for Disease Control. Perspectives in Disease Prevention and Health Promotion Smoking and Cardiovascular Disease, 1998; National Cancer Institute. Cigars, 1998; Chang et al., 2015). However, there are differences in constituents of cigars and cigarettes and how they are smoked, which could lead to differences in exposure. For example, cigars differ from cigarettes in that they use different tobaccos and wrappers (National Cancer Institute, 1998). Cigars contain more tobacco per unit compared with cigarettes, and the lower porosity of cigar wrappers results in more carbon monoxide per gram of tobacco burned, and higher concentrations of some carcinogens (National Cancer Institute, 1998).

While cigarette smokers are known to have a two-to-four-fold greater likelihood of CVD and about a 70 percent greater probability of dying from them compared with nonsmokers, (Centers for Disease Control. Perspectives in Disease Prevention and Health Promotion Smoking and Cardiovascular Disease, 1998) very few studies have examined CVD in cigar smokers. Using 1985–2011 data from the National Longitudinal Mortality Study, Christiansen et al. found that current exclusive cigar smokers have a higher mortality risk compared with never cigar smokers (Christensen et al., 2018). A study among exclusive cigar smokers showed that former exclusive cigar smokers ages 35 and older were more likely to have had heart conditions and stroke compared with never cigar smokers of the same age group; however, the associations were not significant for current exclusive cigar smokers (Rostron et al., 2019). Understanding health risks of cigar smoking is important because even though cigarette smoking rates have decreased over the years, cigar smoking rates have remained fairly constant, if not increased (Edwards et al., 2020). According to the Centers for Disease Control and Prevention (CDC; Wang et al., 2016) between 2000 and 2015, cigarette consumption decreased 38.7 % while during the same period consumption of non-cigarette combusted products such as cigars and pipe tobacco increased by 117.1 % and consumption of cigars specifically increased by 85.2 %. More recently, data from the 2020 National Health Interview Survey (NHIS) showed that in 2020, 3.5 % of U.S. adults were current cigar smokers and cigar smoking rates were highest among adults aged 25–44 (5.0 %) compared with adults aged 45–64 (2.8 %) and 65 and older (1.8 %) (Cornelius et al., 2022). Understanding patterns of cigar smoking may inform associated health risks from cigars.

Using the first five waves (2013–19) of the Population Assessment of Tobacco and Health (PATH) Study adult data, the main purpose of this study was to investigate prevalence (proportion who have CVD at a given time period) and incidence (proportion who have *new* CVD since Wave 1) of CVD by cigar use status among U.S. adults. The study was restricted to adults 40 years and older as prevalence of CVD outcomes is very low among younger adults (Mahoney et al., 2021; Nahhas et al., 2021). Specifically, the first aim of the study was to describe incidence of CVD in the PATH Study Waves 1–5 among established cigar smokers (adults who have ever smoked cigars "fairly regularly") who had not reported CVD at Wave 1. The second aim was to describe prevalence of CVD outcomes in the PATH Study by cigar and cigarette smoking patterns and the third aim was to explore if duration of cigar use, measured in years of use, is associated with CVD prevalence. Examining CVD related to cigar smoking is salient, given the public health concerns of these products.

2. Methods

This study analyzed 5 waves of PATH Study data, from Wave 1 (2013–2014), Wave 2 (2014–2015), Wave 3 (2015–2016), Wave 4 (2016–2018) and Wave 5 (2018–2019)[1] from adult respondents 40 years and older at each wave, using longitudinal statistical methods.

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[1] The interview interval for Waves 1–4 was approximately one year, while the interval for Waves 4–5 was approximately two years.

The PATH Study is an ongoing, nationally representative, longitudinal cohort study of adults and youth in the U.S. that collects information on tobacco-use patterns and associated health behaviors. The PATH Study recruitment for the Wave 1 Cohort employed a stratified address-based, area-probability sampling design at Wave 1 (2013) that oversampled adult tobacco users, young adults (aged 18–24), and African American adults. The total unweighted attrition rate among the Wave 1 sample was 16 % at Wave 2, 21 % at Wave 3, 27 % at Wave 4, and 30 % at Wave 5. Differences in the number of completed interviews between Wave 1 and subsequent waves reflect attrition (e.g., nonresponse, mortality). Full-sample and replicate weights were created to adjust for the complex sample design (e.g., oversampling of particular demographic groups) and nonresponse. Weighted estimates from Waves 1–5 of the PATH Study Wave 1 Cohort represent the resident population of the U.S. ages 12 years and older at the time the specific data examined were collected who were part of the U.S. civilian, noninstitutionalized population (CNP) at Wave 1. Further details regarding the PATH Study design and methods for the Wave 1 Cohort are published elsewhere (Hyland et al., 2017; Tourangeau et al., 2019; Piesse et al., 2021). Details on interview procedures, questionnaires, sampling, weighting, response rates, and accessing the data are described in the *PATH Study Restricted Use Files User Guide* at 10.3886/Series606. The study was conducted by Westat and approved by the Westat Institutional Review Board. All respondents ages 18 and older provided informed consent. Missing data on age, sex, race, Hispanic ethnicity, and education were imputed at Wave 1 as described in the PATH Study Restricted Use Files User Guide (10.3886/Series606).

3. Measures

3.1. CVD outcomes

Respondents who self-reported that they were told they had congestive heart failure, stroke, or heart attack/needed bypass surgery were classified as ever having that cardiovascular condition and a dichotomous variable was created to indicate any cardiovascular outcome (ever reported "yes" to least one cardiovascular condition). See Appendix A for details.

3.2. CVD risk factors

Cardiovascular risk factors defined in Mahoney et al. were used (Mahoney et al., 2021). The risk factors included self-reported high blood pressure, high cholesterol, diabetes, body mass index (BMI) >=35, and family history of premature heart disease. Responses to risk factors were used to create a risk factor summary score ranging from 0 (none reported) to 5 (all 5 reported) and to create a dichotomous variable to indicate "any risk factor" (a score of at least 1).

3.3. Exposure

For cigars, at each wave, respondents were asked about past 12 month, past 30 day, and current use (everyday, some days, not at all) of three cigar types: traditional cigars, cigarillos and filtered cigars. Responses from each cigar type were combined to represent "any cigar" use, such that if a respondent indicated smoking at least one cigar type, they were considered an "any cigar" smoker. Current established cigar smoking was defined as ever using any cigar fairly regularly and now smoking every day or some days, and former established cigar smoking was defined as ever using cigars fairly regularly and not having smoked in the past 12 months or now not smoking at all. Current established cigarette use was defined as having smoked at least 100 cigarettes in one's lifetime and now smoking every day or some days and former established use was defined as having smoked at least 100 cigarettes in one's lifetime and not having smoked in the past 12 months or now not smoking at all. A four-category variable was created to measure how

CVD varied by cigarette and cigar use, 1) never smokers of cigars or cigarettes (could use other tobacco products), 2) exclusive current/former established cigar smokers (not established cigarette smokers), 3) exclusive current /former established cigarette smokers (not established cigar smokers), and 4) dual current/former established smokers of cigars and cigarettes (Nahhas et al., 2021). We combined current and former user groups because CVD are long term outcomes and studies have shown that former cigar smokers are also at risk of CVD (Christensen et al., 2018; Rostron et al., 2019).

3.4. Duration of cigar use

Duration of cigar use was created to approximate years of use. If multiple cigar products were used, the maximum duration was taken. The variable was recoded as an ordinal variable, based on frequency distribution, ranging from 0 to 6: $0 = 0$ years of use; $1 = 1$ to less than 10 years of use, $2 = 10$ to less than 20 years of use, $3 = 20$ to less than 30 years of use, $4 = 30$ to less than 40 years of use, $5 = 40$ to less than 50 years of use, and $6 = 50$ or more years of use.[2] A 20-year interval 4-level categorical variable was also created. Never users were assigned "0 years" and were used as the reference category for comparison with user groups.

3.5. Other covariates

Sociodemographic variables included age, sex, race/ethnicity, education, and past 12-month any blunt use (smoked a cigar as a blunt in the past 12 months). See Appendix A.

4. Statistical analyses

The current study conducted longitudinal analyses of five waves of the PATH Study (2013–19) data in two ways, using weighted generalized estimating equations (WGEEs).

1) analysis that included data from Waves 1–5 to examine new incidence of CVD outcomes that occurred during the PATH Study period Waves 2–5 among adults 40 and older who did not have CVD *at baseline waves* of the wave pairs (Wave 1 to Wave 2, Wave 2 to Wave 3, Wave 3 to Wave 4, and Wave 4 to Wave 5; $N_{individuals}$ (N_{ind}) = 6,692; total[3] $N_{observations}$ (N_{obs}) = 23,738 observations used in longitudinal analyses of the wave pairs, designed to account for the time-varying measures of user groups and covariates, measured at baseline waves of each of the wave pairs, one wave before the outcome, to ensure time precedence in incidence analyses; Fig. 1a, Table 2), weighted percentages with 95 % confidence intervals (CIs) were calculated for the outcome using unadjusted WGEEs.

2) population-averaged prevalence of CVD outcomes at Waves 1–5, restricted to adults age 40 and older at any wave and provided data at every wave (N_{ind} = 7,819; N_{obs} = 33,952; Fig. 1b). The prevalence of CVD outcomes were examined among exclusive current/former established cigarette smokers, exclusive current/former established cigar smokers, and dual current/former established cigarette and cigar smokers compared with never users of cigars and cigarettes using five waves of repeated measures nested within person design, controlling for age, sex, race/ethnicity, education level, use of other tobacco products, cardiovascular disease risk factors (high blood pressure, high cholesterol, diabetes, body mass index (BMI) >=35, and family history of

premature heart disease), and blunt use. Respondents with missing data on cigarette pack-years or who had less than one cigarette pack-year, and those who had less than one year of cigar or cigarette use were excluded to distinguish relatively long-term established users from not established smokers (Nahhas et al., 2021).

Weighted GEEs were also used to evaluate user group differences in CVD outcomes and to obtain statistically valid population estimates. The GEE is a longitudinal statistical method that performs population average models and produces population-averaged estimators (Hubbard et al., 2010; Liang and Zeger, 1986). It allowed inclusion of all five waves of time-stable and/or time-varying data, while statistically controlling for interdependence among observations contributed by the same individuals (Liang and Zeger, 1986; Hilbe and Hardin, 2008). All analyses were weighted using Wave 5 all-waves weights (including full-sample and 100 replicate weights) to produce nationally representative estimates. Variances were computed using the balanced repeated replication method (McCarthy, 1969) (BRR) with Fay's adjustment set to 0.3 to increase estimate stability (Judkins, 1990). Weighted odds ratios (ORs) and 95 % CI were reported for unadjusted and adjusted ORs (from a few sequential models) to examine group differences in CVD outcomes (Table 3) or associations between duration of cigar use and CVD outcomes (Table 4). Statistical modeling for GEE analyses were performed using SAS 9.4 (SAS Institute, Cary, NC) and Stata survey data procedures, version 16.1 (StataCorp LLC, College Station, TX) were used for descriptive analysis.

5. Results

Characteristics of adults 40 years and older at Wave 1 by tobacco user groups and other covariates are shown in Table 1.

5.1. Population-averaged incidence and prevalence of CVD by user groups across waves among adults 40 and older

As shown in Table 2, sample sizes for CVD incidence among adults who did not have the outcome at baseline, overall and by wave pairs, were too low and did not allow for examination of lagged associations between user groups measured at baseline waves and CVD incidence at the follow-up waves, while controlling for time effects and covariates at all baseline waves. New cases of CVD outcomes (total unweighted n = 390 cases) among exclusive current/former established cigarette smokers (n = 263; 1.6 %; 95 % CI: 1.3, 1.9), exclusive current/former established cigar smokers (n = 12; 3.0 %; 95 % CI: 1.2, 7.0), dual current/former established cigarette smokers and cigar smokers (n = 65; 1.8 %; 95 % CI: 1.3, 2.4) and never smokers of cigars and cigarettes (n = 50; 1.1 %; 95 % CI: 0.8, 1.6) were very low between Waves 2 and 5. Population-averaged prevalence across five waves of any CVD outcome among exclusive current/former established cigar smokers was 7.3 % (95 % CI: 4.9, 10.8), among exclusive current/former established cigarette smokers was 10.8 % (95 % CI: 9.4, 12.3), and was 13.6 % (95 % CI: 12.1, 15.3) among dual users of cigars and cigarettes.

5.2. Associations between prevalence of any CVD and tobacco user groups

Table 3 presents unadjusted and adjusted odds ratio estimates (ORs and AORs) for associations between cigar and cigarette user groups and CVD prevalence. The unadjusted and adjusted results showed that all user groups had higher prevalence of CVD compared with never users of cigarettes or cigars (See Models 1, 2, and 3). Specifically in Model 3 (adjusted for all covariates except CVD risk score), compared with never smokers, exclusive current/former established cigar smokers were 52 % more likely (AOR = 1.52, 95 % CI: 1.02, 2.26) and exclusive current/former established cigarette users were 73 % more likely (AOR = 1.73, 95 % CI: 1.16, 2.57) to have any CVD. However, with the CVD risk scores in adjusted models (Model 4), the AOR for exclusive cigar was no longer significant compared with never smokers, though the dual current/

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[2] We chose these intervals based on exploratory analyses of the distribution of "Cigar use in years" and exploring relationship between "Cigar use in years" and CVD using different cutoffs.

[3] Data were cumulative from never CVD respondents at the baseline wave of each of the wave pairs (i.e., Wave 1 to Wave 2, Wave 2 to Wave 3, Wave 3 to Wave 4, and Wave 4 to Wave 5) and incidences of CVD outcomes were at the second wave of each of the wave pairs.
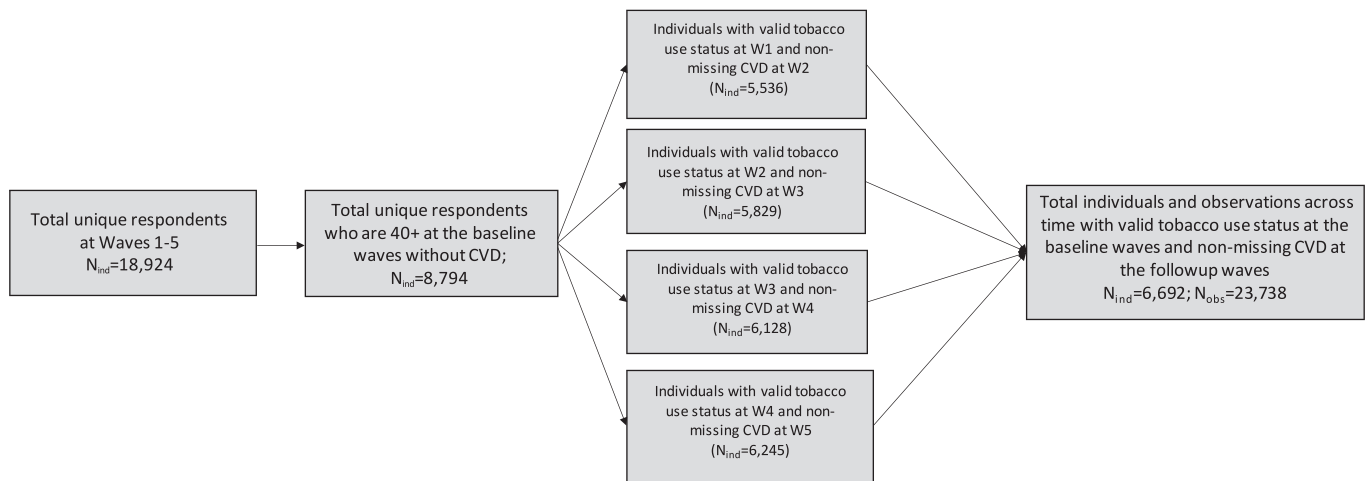
Fig. 1a. Flow chart of analytic sample for incident CVD, among adults 40 years and older who did not have any CVD at baseline wave using WGEEs ($N_{ind} = 6,692$; $N_{obs} = 23,738$).
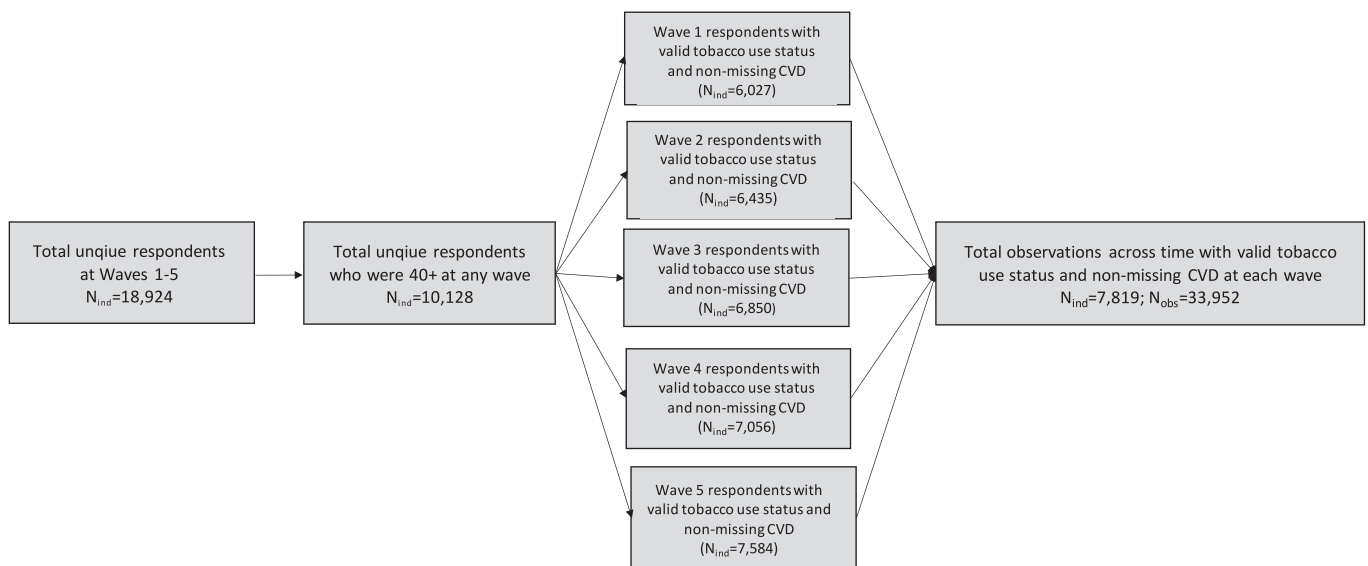

Fig. 1b. Flow chart of Waves 1–5 analytic sample (adults of 40 years and older), for prevalence analysis using WGEEs ($N_{ind} = 7,819$; $N_{obs} = 33,952$).

former established cigarette and cigar model remained significant (AOR = 1.57, 95 % CI: 1.06, 2.34), as did the current/former established cigarette model (AOR = 1.60, 95 % CI: 1.07, 2.40). Adjusted ORs for the cigar user groups were no longer significant compared to never smokers.

5.3. Effects of duration of cigar use on prevalence of any CVD

Table 4 presents AORs for duration of cigar use on the prevalence of any CVD, comparing different cigar user groups (exclusive cigar users or dual users of cigars and cigarettes) with never users by ten- and twenty-year intervals in separate models. None of the AORs were significant.

6. Discussion

Our findings showed that the estimates of CVD were similar among current/former exclusive established cigarette smokers and current/former exclusive established cigar smokers but higher compared with never smokers of cigarettes and cigars. No significant associations were found between exclusive cigar use and CVD compared with never use,

Table 1
Characteristics of adults 40 years and older at Wave 1 in the US, Waves 1–5 of the PATH Study (2013–2019), by exposure (cigar and cigarette user groups; unweighted total N = 6,049).

Measures	Never cigar or cigarette users[a]			Current/former established exclusive cigar users[a]			Current/former established exclusive cigarette users[a]			Dual current/former established cigar and cigarette users[a]		
	(n = 1,212)			(n = 160)			(n = 4,066)			(n = 611)		
	Unweighted n	Weighted %	Weighted 95 % CI	Unweighted n	Weighted %	Weighted 95 % CI	Unweighted n	Weighted %	Weighted 95 % CI	Unweighted n	Weighted %	Weighted 95 % CI
Mean age in years (SD)	57.06 (8.61)			57.71 (14.97)			57.89 (12.40)			57.90 (13.46)		
Age groups												
40–49	441	32.5	29.5–35.7	61	32.6	23.8–42.7	1,380	25.7	24.3–27.1	203	27.1	23.0–31.7
50–59	360	28.3	25.2–31.5	52	26.2	19.1–34.8	1,472	32.2	30.3–34.1	215	27.0	23.6–30.8
60–69	249	22.7	20.0–25.6	34	20.9	13.6–30.7	859	25.2	23.4–27.1	139	31.4	26.1–37.2
70+	162	16.5	14.2–19.1	13	20.3	10.1–36.8	355	16.9	15.3–18.8	54	14.5	10.3–20.0
Sex												
Male	427	36.2	34.0–38.5	126	85.4	78.5–90.4	1,862	48.1	46.2–50.0	460	83.4	79.4–86.7
Female	785	63.8	61.5–66.0	34	14.6	9.6–21.5	2,204	51.9	50.0–53.8	151	16.6	13.3–20.6
Educational level												
Less than high school or GED	218	16.8	15.1–18.7	32	14.0	9.3–20.7	937	18.7	17.3–20.1	146	21.2	17.4–25.6
High school graduate	254	27.2	24.7–29.8	37	35.6	25.4–47.3	896	27.4	25.5–29.3	116	25.0	19.8–30.9
Some college or associate degree	344	25.7	23.5–28.0	47	29.7	20.2–41.5	1,389	30.1	28.4–31.9	229	31.9	27.2–37.0
Bachelor's or advanced	396	30.3	27.7–33.1	44	20.6	13.7–29.7	844	23.8	21.8–25.9	120	21.9	17.5–27.1
Race/Ethnicity												
Non-Hispanic White	651	59.3	56.8–61.7	90	65.8	55.8–74.6	2,891	78.1	76.4–79.7	445	81.0	77.4–84.2
Non-Hispanic Black	243	13.5	11.9–15.2	38	19.3	13.6–26.8	565	9.2	8.3–10.2	91	11.1	8.6–14.1
Non-Hispanic Other	86	9.5	7.7–11.6	8	3.3	1.2–9.3	207	4.5	3.6–5.6	47	4.1	2.7–6.3
Hispanic	232	17.7	15.8–19.8	24	11.5	7.0–18.4	403	8.2	7.2–9.2	28	3.8	2.3–6.1
Mean pack-year cigarette history (SD)	N/A			0.003 (0.004)			28.84 (60.17)			40.08 (79.67)		
Mean duration of Cigar use in years (SD)	N/A			25.14 (18.75)			7.03 (12.97)			22.98 (18.45)		
Ever cardiac outcomes												
Congestive Heart Failure	19	1.3	0.8–2.1	5	4.7	1.6–13.0	115	2.7	2.2–3.4	23	2.9	1.7–4.8
Stroke	31	2.3	1.5–3.5	11	8.6	4.0–17.8	136	3.2	2.5–4.1	31	5.4	3.1–9.2
Heart attack/needed bypass surgery	24	2.1	1.3–3.3	8	6.1	2.5–14.1	166	4.3	3.4–5.4	30	4.5	2.9–7.1
Any of the above	61	4.9	3.8–6.3	17	11.6	6.3–20.4	326	8.2	6.8–9.8	68	10.9	7.9–15.0
Cardiovascular disease risk factors												
High blood pressure	464	38.4	35.3–41.6	69	46.4	37.7–55.3	1,595	40.1	37.9–42.2	275	50.4	44.0–56.8
High cholesterol	260	20.6	18.2–23.2	34	26.4	17.9–37.2	819	20.6	18.7–22.6	148	23.0	19.0–27.5
Diabetes	331	28.2	25.8–30.8	60	36.0	28.1–44.6	1,384	37.7	35.7–39.8	214	41.5	36.0–47.3
Family history of premature heart disease	130	10.4	8.7–12.5	20	13.7	8.4–21.7	522	11.6	10.5–12.8	86	14.9	11.0–19.8
BMI >= 35	197	14.5	12.6–16.7	33	20.2	12.7–30.4	542	13.5	11.9–15.2	106	18.9	14.4–24.4
Any of the above	718	60.0	56.6–63.2	119	73.4	64.0–81.1	2,614	66.8	64.7–68.8	422	74.2	69.4–78.5
Number of cardiovascular disease risk factors												
0	468	41.1	37.8–44.4	41	26.8	19.1–36.2	1,398	33.7	31.7–35.8	183	26.1	21.8–31.0
1	287	25.0	22.2–28.0	56	30.2	21.8–40.1	1,148	29.4	27.3–31.5	176	28.1	23.3–33.5
2	216	18.7	16.1–21.6	34	24.7	17.0–34.5	811	21.3	19.8–22.9	114	24.6	18.8–31.5
3+	186	15.2	13.3–17.4	27	18.3	11.8–27.3	596	15.6	13.9–17.5	118	21.1	17.2–25.7

(continued on next page)

Table 1 (*continued*)

Measures	Never cigar or cigarette users[a] (n = 1,212)			Current/former established exclusive cigar users[a] (n = 160)			Current/former established exclusive cigarette users[a] (n = 4,066)			Dual current/former established cigar and cigarette users[a] (n = 611)		
	Unweighted n	Weighted %	Weighted 95% CI	Unweighted n	Weighted %	Weighted 95% CI	Unweighted n	Weighted %	Weighted 95% CI	Unweighted n	Weighted %	Weighted 95% CI
Use of other tobacco products (current or former)[b]	39	1.1	0.7–1.8	75	57.3	47.0–67.0	779	15.1	13.6–16.8	265	46.5	40.8–52.3
Blunt use												
Past 12-month[c]	N/A	N/A	N/A	20	8.8	5.9–13.0	193	2.7	2.2–3.3	73	8.5	6.4–11.3

Notes.

Percents are weighted using the Wave 1 Cohort all-waves longitudinal weights (R05_A_A01WGT and 100 replicate weights). To be included in the analysis, respondents must have participated in all 5 waves.

† Estimate should be interpreted with extra caution because it has low statistical precision. It is based on a denominator sample size of less than 50, or the coefficient of variation of the estimate or its complement is larger than 30%.

Past 12-month blunt use is not shown for never cigar or cigarette users due to low sample size.

SD = standard deviation; CI = 95 % Confidence intervals; GED = General Educational Development; BMI = Body Mass Index.

a Never cigar or cigarette user is defined as a never user of both cigarettes and cigars. Exclusive current/ former established cigar user is defined as a current established or former established user of traditional cigars, cigarillos, or filtered cigars and is not a current established or former established user of cigarettes. Exclusive current/ former established cigarette user is defined as a current established or former established user of cigarettes and not a current established or former established user of cigars. Dual current/former established cigar and cigarette user is defined as a current established or former established user of cigarettes and at least one cigar product. These user groups do not consider use of other tobacco products.

b Use of other tobacco products is defined as a current or former established user of at least one of the following products: ENDS, pipe, hookah, smokeless, snus pouches.

c Past 12-month blunt use is defined as using a cigar as a blunt in the past 12 months. Blunt users could have also been cigar users.

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when adjusted for covariates that included CVD risk scores.[4] However, significant associations were seen between CVD and exclusive cigarette use and dual use compared to never use. The significant relationship between dual use and CVD was likely due to the influence of cigarette use which can be further studied. Our findings suggest that CVD risk factors attenuated cigar use effects on the CVD outcome thus extending findings from previous studies (Christensen et al., 2018; Rostron et al., 2019) on cigar use and cardiovascular health outcomes.

Cigar related findings of this study are consistent with previous studies that explored cigar use and CVD outcomes (Chang et al., 2015; Christensen et al., 2018; Rostron et al., 2019; Rodu and Plurphanswat, 2021). Christensen et al. did not find elevated associations between current or former exclusive cigar smoking and cardiovascular death compared with never tobacco users. Similar to our study, they found an association with CVD and cigarette smoking with higher risk of dying from CVD among current and former cigarette smokers compared with never combustible tobacco users (Christensen et al., 2018). Rodu and Plurphanswat also found an increased heart disease mortality in both current and former exclusive cigar smokers compared with never cigarette or cigar smokers, but findings were not significant (Rodu and Plurphanswat, 2021). Using the NHIS, Rostron et al. found significant associations with prevalence of heart conditions and stroke only among former cigar smokers (having smoked ≥ 50 cigars and currently not smoking at all) but similar to our current study, they did not find associations among current smokers (having smoked ≥ 50 cigars and currently smoking every day or some days) compared with never smokers (Rostron et al., 2019). In a review of 22 studies, Chang et al. found that mortality outcomes were significantly associated with cigar smoking (current, exclusive cigar smoking with no history of previous use of combustibles like cigarettes or pipes) and coronary heart disease, specifically in men aged 30–74 years but not in men 75 years and older compared with never users (Chang et al., 2015). Stroke mortality risk was not significantly associated with cigar smoking.

While the current study found no significant associations between prevalence of CVD among exclusive cigar users compared with never users, as discussed earlier, we found that CVD risk factors accounted for the attenuation of cigar use effects. One possible reason why we did not find a significant association may be because we could not consider intensity of cigar smoking, such as cigars per day or pack-years equivalent, in addition to duration of smoking. As seen with cigarette smoking and CVD, cigarettes per day and duration alone can provide an incomplete characterization of smoking-related risks (Lubin et al., 2016). Furthermore, even though estimating incidence rates of CVD among cigar smokers was one of the main aims of the study, new cases across five waves of data were not high enough to understand associations of CVD incidence and cigar use. A longer follow-up period is needed to further investigate CVD and patterns of cigar smoking that may contribute to health risks related to CVD.

This study further explored the dose–response relationship between prevalence of CVD by duration of cigar use measured as years of use. In adjusted models, there was no dose–response relationship between duration of cigar use and CVD prevalence. This is consistent with Chang et al. that showed a weak dose–response relationship between coronary

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[4] Risk Scores and age were significant in sequentially adjusted GEE models, and sex was a significant predictor in most models. We also conducted GEE analyses among males and did not find significant associations between CVD and exclusive cigar use or dual use with cigars and cigarettes, compared with never use. Female sample was small and did not support BRR weighted GEE models with the sex by group interaction among exclusive or dual use with cigarettes compared with never use. However, female dual users appeared to be more likely to have any CVD than female never users. More data will be needed to allow sequentially adjusted GEE models to run through all BRR weights under different scenarios and thus we presented adjusted models without modeling any two-way and/or higher order interaction effects.

Table 2

Incidence and prevalence of any CVD outcomes across waves of the PATH Study by exposure (cigar and cigarette user groups), among adults 40 years and older at Wave 1 in the US, Waves 1–5 of the PATH Study (2013–2019).

Exposure (user groups[a])	Waves 2–5 *Incidence* of any CVD outcome = yes (n = 390) Unweighted N (Weighted N)	Waves 2–5 *Incidence* of any CVD outcome = no (n = 23,348) Unweighted N (Weighted N)	Row total (n = 23,738)	Weighted % (Weighted 95 % CI)
Never cigar or cigarette users	**50 (1,492,161)**	**4,650 (128,678,262)**	**4,700 (130,170,424)**	**1.1 (0.8, 1.6)#**
W1-W2	6 (158,986)	1135 (31,622,148)	1,141 (31,781,135)	0.5† (0.2, 1.2)
W2-W3	10 (342,136)	1,158 (32,021,994)	1,168 (32,364,131)	1.1† (0.5, 2.1)
W3-W4	13 (403,384)	1,179 (32,612,680)	1,192 (33,016,065)	1.2† (0.6, 2.4)
W4-W5	21 (587,654)	1,178 (32,421,440)	1,199 (33,009,094)	1.8 (1.0, 3.0)
Exclusive current/former established cigar users	**12 (177,214)**	**581 (5,736,302)**	**593 (5,913,516)**	**3.0† (1.2, 7.0)#**
W1-W2	N/A	N/A	142 (1,372,133)	N/A
W2-W3	6 (96,613)	130 (1,331,484)	136 (1,428,097)	6.8† (2.3, 18.0)
W3-W4	N/A	N/A	146 (1,375,351)	N/A
W4-W5	3 (20,067)	166 (1,717,867)	169 (1,737,934)	1.2† (0.3, 3.9)
Exclusive current former established cigarette users	**263 (2,795,425)**	**15,032 (173,469,245)**	**15,295 (176,264,670)**	**1.6 (1.3, 1.9)#**
W1-W2	65 (679,060)	3,648 (42,295,545)	3,713 (42,974,605)	1.6 (1.1, 2.4)
W2-W3	60 (691,972)	3,707 (42,832,944)	3,767 (43,524,916)	1.6 (1.0,2.4)
W3-W4	61 (699,940)	3,877 (44382647)	3,938 (45,082,587)	1.6 (1.1, 2.2)
W4-W5	77 (724,453)	3,800 (43,958,109)	3,877 (44,682,562)	1.6 (1.2, 2.2)
Dual current/former established cigarette and cigar users	**65 (547,994)**	**3,085 (29,897,515)**	**3,150 (30,445,509)**	**1.8 (1.3, 2.4)#**
W1-W2	4 (39,523)	536 (5,156,278)	540 (5,195,801)	0.8† (0.3, 2.1)
W2-W3	14 (127,268)	744 (7,274,084)	758 (7,401,352)	1.7† (0.9, 3.3)
W3-W4	13 (136,339)	839 (8,128,899)	852 (8,265,237)	1.6† (0.8, 3.5)
W4-W5	34 (244,864)	966 (9,338,255)	1,000 (9,583,119)	2.6 (1.8, 3.7)

Exposure (user groups[a])	*Prevalence* of any CVD outcome = yes (n = 3,522) Unweighted N (Weighted N)	*Prevalence* of any CVD outcome = no (n = 30,430) Unweighted N (Weighted N)	Row total (n = 33,952)	Weighted % (Weighted 95 % CI)
Never cigar or cigarette users	**397 (11,046,842)**	**5,952 (164,697,389)**	**6,349 (175,744,232)**	**5.6 (4.2, 7.2)≠**
W1	61 (1,648,353)	1,145 (31,983,492)	1,206 (33,631,845)	4.9 (3.8—6.3)
W2	66 (1,783,568)	1,169 (32,399,242)	1,235 (34,182,810)	5.2 (4.1, 6.6)
W3	75 (2,084,039)	1,196 (33,118,599)	1,271 (35,202,638)	5.9 (4.7, 7.5)
W4	87 (2,468,277)	1,202 (33,085,806)	1,289 (35,554,083)	6.9 (5.6, 8.6)
W5	108 (3,062,605)	1,240 (34,110,250)	1,348 (37,172,856)	8.2 (6.8, 9.9)
Exclusive current/former established cigar users	**95 (971,070)**	**790 (8,068,124)**	**885 (9,039,194)**	**7.3 (4.9, 10.8)≠**
W1	17 (181,301)	143 (1,378,343)	160 (1,559,645)	11.6 (6.3, 20.4)
W2	16 (109,179)	136 (1,428,097)	152 (1,537,277)	7.1 (4.0, 12.4)
W3	19 (181,152)	147 (1,413,247)	166 (1,594,399)	11.4† (6.0, 20.4)
W4	18 (208,620)	169 (1,737,934)	187 (1,946,554)	10.7† (5.4, 20.1)
W5	25 (290,818)	195 (2,110,502)	220 (2,401,319)	12.1 (6.9, 20.3)
Exclusive current former established cigarette users	**2,309 (26,708,063)**	**19,373 (222,437,111)**	**21,682 (249,145,174)**	**10.8 (9.4, 12.3)≠**
W1	326 (3,831,440)	3,726 (43,047,762)	4,052 (46,879,202)	8.2 (6.8, 9.8)
W2	402 (4,600,509)	3,778 (43,657,076)	4,180 (48,257,585)	9.5 (8.1, 11.1)
W3	482 (5,610,398)	3,944 (45,130,408)	4,426 (50,740,806)	11.1 (9.7, 12.6)
W4	509 (5,856,764)	3,888 (44,784,786)	4,397 (50,641,550)	11.6 (10.1, 13.3)
W5	590 (6,808,951)	4,037 (45,817,079)	4,627 (52,626,030)	12.9 (11.5, 14.6)
Dual current/former established cigarette and cigar users	**721 (6,874,288)**	**4,315 (41,341,436)**	**5,036 (48,215,724)**	**13.6 (12.1, 15.3)≠**
W1	68 (638,480)	541 (5,198,485)	609 (5,836,965)	10.9 (7.9, 15.0)
W2	107 (1,074,953)	761 (7,417,896)	868 (8,492,849)	12.7 (10.0, 15.8)

Table 2 (*continued*)

Exposure (user groups)[a]	Waves 2–5 *Incidence* of any CVD outcome = yes (n = 390) Unweighted N (Weighted N)	Waves 2–5 *Incidence* of any CVD outcome = no (n = 23,348) Unweighted N (Weighted N)	Row total (n = 23,738) Unweighted N (Weighted N)	Weighted % (Weighted 95 % CI)
W3	132 (1,280,212)	855 (8,293,594)	987 (9,573,807)	13.4 (10.7, 16.6)
W4	181 (1,779,610)	1,002 (9,596,329)	1,183 (11,375,939)	15.6 (12.9, 18.9)
W5	233 (2,101,032)	1,156 (10,835,132)	1,389 (12,936,164)	16.2 (13.8, 19)

Notes.

CVD: Cardiovascular diseases.

Percents are weighted using the Wave 1 Cohort all-waves longitudinal weights (R05_A_A01WGT and 100 replicate weights). To be included in the analysis, respondents must have been 40 or older in at least one wave. W4-W5 has longer time of data collection in the PATH Study.

The overall weighted estimates and CIs in this table were produced by GEE population average models (unadjusted), with unstructured correlations, that is, they were adjusted for correlations among repeated observations.

≠ The overall weighted estimates and CIs in this table were produced by GEE population average models (unadjusted), with exchangeable correlations, that is, they were adjusted for correlations among repeated observations.

However, exercise caution when interpreting the CI here because unstructured or autoregressive correlation structures did not work here and exchangeable correlation structure is a restrictive type and interim estimates from some replicate weights did not reach convergence criteria.

† Estimate should be interpreted with extra caution because it has low statistical precision. It is based on a denominator sample size of less than 50, or the coefficient of variation of the estimate or its complement is larger than 30%.

N/A: Data were not presented to minimize the risk of disclosure of the PATH Study participants due to low sample sizes in the cell. Estimates from different wave pairs could not be simply collapsed.

a Never cigar or cigarette user is defined as a never user of both cigarettes and cigars. Exclusive current/ former established cigar user is defined as a current established or former established user of at least one of: traditional cigars, cigarillos, or filtered cigars and is not a current established or former established user of cigarettes. Exclusive current/ former established cigarette user is defined as a current established or former established user of cigarettes and not a current established or former established user of cigars. Dual current/former established cigar and cigarette user is defined as a current established or former established user of cigarettes and at least one cigar product. These user groups do not consider use of other tobacco products.

heart disease by cigars smoked per day (Chang et al., 2015).

6.1. Limitations

Several limitations need to be acknowledged. First, the CVD outcomes (i.e., congestive heart failure, stroke, and heart attack) were based on self-reported measures rather than diagnoses verified by clinicians. Also, tobacco use measures, which are inherently subjective measures, were self-reported, which could be subject to recall bias. Additionally, the PATH Study measures for cigar use patterns are less comprehensive. In contrast with cigarettes, where we were able to calculate cigarette pack years, the best we could do for cigars was duration of use with no consideration of the intensity of that use. The sample size of CVD outcomes for established exclusive cigar users for prevalence estimates was low and, even though established cigarette smokers were excluded from the group, small sample sizes did not allow for assessing CVD prevalence among exclusive cigar smokers who were never cigarette smokers. Nevertheless, the CVD outcomes were consistent with other national estimates (Christensen et al., 2018). This study was also not sufficiently powered to examine CVD outcomes by individual cigar types. Also, because of low sample sizes, users of other tobacco products were included in the never user category but were controlled for in the adjusted models. Despite these limitations, this study makes an important contribution to our understanding of cardiac health associated with cigar use in the U.S. population.

6.2. Implications

Although this study did not find a significant relationship between exclusive use of cigars and lifetime prevalence of CVD after controlling for covariates including cigarette smoking or between dual use of cigars and cigarettes and CVD prevalence over a six-year period, these data provide a baseline assessment that future studies can build on over time. Understanding how cigar use impacts cardiovascular health outcomes is important as the Food and Drug Administration (FDA) considers regulatory action to reduce the public health burden of tobacco products.

7. List of abbreviations

CVD, PATH, NHIS, CDC, GED, WGEE, BRR, CI, OR, AOR.

8. Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Department of Health and Human Services or any of its affiliated institutions or agencies.

9. Ethics approval and consent to participate

The study was conducted by Westat and approved by the Westat Institutional Review Board (IRB # 0000695; Project #8954). All respondents ages 18 and older provided informed consent and all methods were performed in accordance with the relevant guidelines.

10. Authors' contributions

ES conceptualized the paper and prepared the original draft along with reviewing and editing of the manuscript; ZT performed primary data analysis, prepared some tables, prepared the figures, wrote results and reviewed and edited; KL performed data analysis, prepared some tables, prepared the figures, reviewed and edited the manuscript; MS contributed to reviewing and editing; CDD contributed to reviewing and editing; KE contributed to reviewing and editing; DM contributed to reviewing and editing; DEG contributed to reviewing and editing; IZ contributed to reviewing and editing; BGG contributed to reviewing and

Table 3

Associations between cigar and cigarette use with prevalence of ever CVD outcomes (Congestive Heart Failure, Stroke, MI), among adults 40 years and older at Wave 1 in the US, Waves 1–5 of the PATH Study (2013–2019).

Tobacco User Groups	Model 1 (Unadjusted)	Model 2 (Base Models^)	Model 3 (Alternative Adjusted Models^^)	Model 4 (Full Models)
	OR (95 % CI)	AOR (95 % CI)	AOR (95 % CI)	AOR (95 % CI)
Exclusive current/former established cigar users vs. never users N = 7,170 (821 vs. 6,349)	1.67 (1.11, 2.51)*	1.58 (1.09, 2.30)*	1.52 (1.02, 2.26)[a]*	1.38 (0.91, 2.07)[a]
Exclusive current/former established cigarette users vs. never users N = 25,206 (18,857 vs. 6,349)	2.12 (1.45, 3.09)***	1.81 (1.24, 2.62)**	1.73 (1.16, 2.57)[b]**	1.60 (1.07, 2.40)[b]*
Dual current/former established cigar and cigarette users vs. never users N = 10,301 (3,952 vs. 6,349)	2.47 (1.87, 3.27)***	1.85 (1.30, 2.64)***	1.78 (1.21, 2.61)[a]**	1.57 (1.06, 2.34)[a]*
Dual current/former established cigar and cigarette users vs. exclusive current/former established cigar users N = 4,773 (3,952 vs. 821)	1.19 (0.93, 1.53)	1.17 (0.94, 1.46)	1.17 (0.93, 1.46)[a]	1.14 (0.88, 1.49)[a]
Dual current/former established cigar and cigarette users vs. exclusive current/former established cigarette users N = 22,809 (3,952 vs. 18,857)	1.08 (1.01, 1.15)*	1.03 (0.96, 1.10)	1.03 (0.96, 1.10)[a]	0.99 (0.91, 1.07)[a]
Exclusive current/former established cigar users vs. exclusive current/former established cigarette users N = 19,678 (821 vs. 18,857)	0.80 (0.48, 1.35)	0.87 (0.70, 1.10)	0.88 (0.70, 1.11)[a]	0.86 (0.66, 1.13)[a]

Notes.

CVD: Cardiovascular diseases; MI: Myocardial Infarction

The Ns of User groups in Table 3 reflect effective Ns of observations with valid outcome data and after having excluded.

1) observations with duration of cigar use missing or less than 1 year from Exclusive Cigar Users, and.

2) observations with pack years for cigarettes missing or less than 1 year from Exclusive Cigarette Users.

3) observations with duration of cigar use or pack years for cigarettes missing or less than 1 year from Dual Users.

Weighted OR and AOR estimates and CIs in Table 3 were statistically controlling for autocorrelations among observations from the same individuals in GEE models.

* P <.05; ** P <.01; *** P <.001.

^: adjusted for age and sex, directly using the 4-category grouping variable in analyses.^^: adjusted for all covariates as noted by a or b below but excluding CVD risk factor summary score, alternative (parsimonious) adjusted models.

a: adjusted for age, sex, race/ethnicity, education level, use of other tobacco products, CVD risk factor summary score, blunt use.

b: adjusted for age, sex, race/ethnicity, education level, use of other tobacco products, CVD risk factor summary score.

Table 4

Dose effects of duration of cigar use on ever CVD outcomes (Congestive Heart Failure, Stroke, MI) among adults 40 years and older at Wave 1 in the US, Waves 1–5 of the PATH Study (2013–2019).

Dose effects	Duration of cigar use in years	Exclusive current/former established cigar users and never cigar or cigarette users AOR (95 % CI) [a] (N = 7,170)		Dual current/former established cigar and cigarette users and never cigar or cigarette users AOR (95 % CI) [a] (N = 10,301)	
Categorical dose effects[b]	0	REF		REF	
	[1–10]	0.76 (0.38, 1.55)		1.46 (0.95, 2.25)	
	[10–20]	2.14 (0.75, 6.12)		0.94 (0.56, 1.59)	
	[20–30]	1.32 (0.57, 3.09)		1.11 (0.64, 1.91)	
	[30–40]	0.82 (0.31, 2.12)		1.54 (0.91, 2.59)	
	[40–50]	0.95 (0.38, 2.40)		1.55 (0.78, 3.10)	
	[50+	2.36 (0.84, 6.62)		1.30 (0.71, 2.39)	
Categorical dose effects[c]	0	REF		REF	
	[1–20]	1.05 (0.60, 1.82)		1.20 (0.80, 1.79)	
	[20–40]	1.09 (0.52, 2.30)		1.32 (0.82, 2.13)	
	[40+	1.34 (0.65, 2.74)		1.45 (0.76, 2.75)	
Continuous dose effects[d]		OR (95 % CI)	AOR (95 % CI) [a]	OR (95 % CI)	AOR (95 % CI) [a]
		(N = 6,757)		(N = 9,686)	
		1.26 (1.11, 1.41)***	1.07 (0.94, 1.21)	1.27 (1.16, 1.38)***	1.07 (0.96, 1.19)

Notes.

CVD: Cardiovascular diseases; MI: Myocardial infarction

The Ns of User groups in Table 4 reflect effective Ns of observations with valid outcome data after excluding observations with duration of cigar use missing or less than 1 year from Exclusive cigar users and Dual users.

Weighted OR and AOR estimates and CIs in Table 4 were statistically controlling for autocorrelations among observations from the same individuals in GEE models. Age was further recoded as a 3-category variable in Table 4 (40–54, 55–64, and 65 +) in order for GEE analyses to run through for all examined models.

* p <.05; ** P <.01; *** P <.001.

a: adjusted for age, sex, race/ethnicity, education level, use of other tobacco products, CVD risk factor summary score, blunt use.

b: Duration of cigar use in years was recoded as an ordinal variable ranging 0–6 (specifically, 0 = 0 among never cigar or cigarette users; for values 1–5 among users, each unit represents 10-year use interval, i.e. 1 = [01–10],2 = [10–20], 3 = [20–30],4 = [30–40], and 5 = [40–50]; and lastly 6 = [50 +.) based on frequency distribution of continuous duration of use, used as a categorical predictor (Note that the brackets [ ] include the cut-off values, while () do not).

c: Duration of cigar use in years was further recoded as a 4-level categorical variable ranging 0–3. Specifically, 0 = 0 among never cigar or cigarette users; 1 = [01–20], 2 = [20–40], and 3 = [40 +.).

d: Duration of cigar use (the recoded ordinal) was used as a continuous predictor in the model. Other covariates remained the same as in the corresponding categorical dose effect model (analyses for in this section were conducted *after* having actively implemented listwise deletion in order for the corresponding OR and AOR to have the same N accordingly).

editing; DLR contributed to reviewing and editing; OI contributed to reviewing and editing; KN contributed to reviewing and editing; RN contributed to reviewing and editing; MBT contributed to reviewing and editing; AH contributed to reviewing and editing; KMC contributed to reviewing and editing and provided supervision.

11. Availability of data and materials

The datasets analyzed here are available upon request to the National Addiction & HIV Data Archive Program (NAHDAP) at 10.3886/Series606.

CRediT authorship contribution statement

Eva Sharma: Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Zhiqun Tang:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Kristin Lauten:** Writing – review & editing, Formal analysis, Data curation. **Marushka L. Silveira:** Writing – review & editing. **Cristine D. Delnevo:** Writing – review & editing. **Kathryn C. Edwards:** Writing – review & editing. **Daniela Marshall:** Writing – review & editing. **Diann E. Gaalema:** Writing – review & editing. **Izabella Zandberg:** Writing – review & editing. **Bria Graham-Glover:** Writing – review & editing. **Derick L. Rivers:** Writing – review & editing. **Omoye E. Imoisili:** Writing – review & editing. **Kirstie Neal:** Writing – review & editing. **Raymond Niaura:** Writing – review & editing. **Maansi Bansal-Travers:** Writing – review & editing. **Andrew Hyland:** Writing – review & editing. **K. Michael Cummings:** .

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: K Michael Cummings provides expert testimony on the health effects of smoking and industry tactics in lawsuits filed against cigarette manufacturers. He has also received payment as a consultant to Pfizer, Inc., for services on an external advisory panel to assess ways to improve smoking cessation delivery in health care settings. Raymond Niaura receives funding from the Food and Drug Administration Center for Tobacco Products via contractual mechanisms with Westat and the National Institutes of Health. Within the past 3 years, he has served as a paid consultant to the Government of Canada via a contract with Industrial Economics Inc. and has received an honorarium for a virtual meeting from Pfizer Inc. Dr. Niaura was an unpaid grant reviewer for the Foundation for a Smoke Free World. All other authors do not have any competing interests.

Data availability

I have shared the link to my data and have provided the codes as supplemental material

Appendix A:. Table of measures

Construct	Description	Response options	Notes
CVD outcomes			
Ever congestive heart failure	Respondents who have ever been told by a doctor or other health professional they have congestive heart failure.	Yes/No	In Wave 1 respondents first asked if they have ever been told they had congestive failure. At subsequent waves, continuing participants were asked about occurrence of the outcomes in the past 12 months.
Ever stroke	Respondents who have ever been told by a doctor or other health professional they had a stroke.	Yes/No	In Wave 1 respondents first asked if they have ever been told they had stroke. At subsequent waves, continuing participants were asked about occurrence of the outcomes in the past 12 months.
Ever heart attack/needed bypass surgery	Respondents who have ever been told by a doctor or other health professional they had a heart attack/needed bypass surgery.	Yes/No	In Wave 1 respondents first asked if they have ever been told they had a heart attack or if they needed bypass surgery. At subsequent waves, continuing participants were asked about occurrence of the outcomes in the past 12 months.
Ever any heart condition	Respondents who have ever been told by a doctor or other health professional they have congestive heart failure, a stroke, or a heart attack/needed bypass surgery.	Yes/No	In Wave 1 respondents first asked if they have ever been told they had any heart condition. At subsequent waves, continuing participants were asked about occurrence of the outcomes in the past 12 months.
CVD risk factors			
High blood pressure	Respondents who have ever been told by a doctor or other health professional they have high blood pressure.	Yes/No	Respondents first asked if they have ever been told they had the condition, continuing respondents asked if they had it in the past 12 months.
High cholesterol	Respondents who have ever been told by a doctor or other health professional they have high cholesterol.	Yes/No	Respondents first asked if they have ever been told they had the condition, continuing respondents asked if they had it in the past 12 months.
Diabetes	Respondents who have ever been told by a doctor or other health professional they have diabetes, sugar diabetes, high blood sugar, or borderline diabetes.	Yes/No	Respondents first asked if they have ever been told they had the condition, continuing respondents asked if they had it in the past 12 months.
BMI $>= 35$	Respondents who have a body mass index $>=35$.	Yes/No	BMI was calculated for each participant based on their self-reported height and weight.
Family history of premature heart attack/bypass surgery	Respondents whose close biological or blood relatives have ever been told by a health professional that they had a heart attack or needed bypass surgery before the age of 50.	Yes/No	Respondents first asked if they have ever been told they had the condition, continuing respondents asked if they had it in the past 12 months.
CVD risk factor summary score	Risk factor summary score of conditions listed above ranging from 0 (none reported) to 5 (all 5 reported).	0–5	
Any CVD risk factor	Respondents who have any of the CVD risk factors listed above.	Yes/No	
Tobacco use			
Current established cigar smokers	Respondents who have smoked traditional cigars, cigarillos, and/or filtered cigars fairly regularly and currently smoke every day or some days.	Yes/No	
Former established cigar smokers	Respondents who have smoked traditional cigars, cigarillos, and/or filtered cigars fairly regularly and currently smoke not at all or have not smoked in the past 12 months.	Yes/No	
Current established cigarette smokers	Respondents who smoked 100 + cigarettes in their lifetime and currently smoke every day or some days.	Yes/No	
Former established cigarette smokers	Respondents who smoked 100 + cigarettes in their lifetime and currently smoke not at all or have not smoked in the past 12 months.	Yes/No	
Four category cigarette and cigar use	1) Never smokers of cigars or cigarettes (could use other tobacco products) 2) Exclusive current/former established cigar smokers (not established cigarette smokers) 3) Exclusive current/former established cigarette smokers (not established cigar smokers)4) Dual current/former established smokers of cigars and cigarettes		Respondents who were missing or had less than one year of cigar use were excluded from exclusive current/former established cigar smoker group, and respondents with less than one year of cigar use or with less than one cigarette pack-year or missing on either measure were excluded from the dual user group of cigars and cigarettes.
Pack-year history of cigarette smoking	Adult number of cigarette packs smoked per day multiplied by the number of years they have smoked fairly regularly.	Continuous	Variable was Winsorized to the 95th percentile to limit the influence of outliers.
Other tobacco product use	Adult respondents who are current/former established users of other tobacco products including ENDS, pipe, hookah, smokeless tobacco, or snus.	Yes/No	
Duration of cigar use	Approximation of years of cigar use. If multiple cigar types were used, the maximum duration was taken.	Continuous	Respondents with less than one year of use were not included in the duration of use analyses in this study.
Other covariates			
Past 12-month blunt use	Respondents who smoked part or all of a cigar, cigarillo or filtered cigar with marijuana in it in the past 12 months.	Yes/No	
Age-4 categories	1) 40–49 2) 50–59 3) 60–694) 70+		
Sex	1) Male2) Female		
Education-4 categories	1) Less than high school or GED 2) High school graduate 3) Some college or associate degree4) Bachelor's or advanced		

Appendix B. Supplementary data

For Tables 2, 3 and 4, see online supplementary material for the analyst developed SAS macro code used to run weighted GEE analyses and calculate adjusted percent estimates and confidence intervals. Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102569.

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