Association of Cigarette and Electronic Cigarette Use Patterns With Levels of Inflammatory and Oxidative Stress Biomarkers Among US Adults

Population Assessment of Tobacco and Health Study

The cardiovascular toxicity of electronic cigarettes (e-cigarettes) is not well understood, and population data assessing the cardiovascular effects of e-cigarette use are sparse. In the present study, we used nationally representative data to examine the association of cigarette and e-cigarette use behaviors with biomarkers of inflammation and oxidative stress. Inflammation and oxidative stress are key contributors of smoking-induced cardiovascular disease, and related biomarkers have been studied as predictive factors for cardiovascular events.1,2

The PATH study (Population Assessment of Tobacco and Health) is a nationally representative longitudinal cohort in the United States. The Wave 1 survey was administered from 2013 to 2014 and included the collection of blood and urine samples. Additional information on PATH biospecimen procedures is given elsewhere.3 Our analysis was restricted to Wave 1 adults ≥18 years of age with nonmissing data on biomarkers and cigarette/e-cigarette use. Analytic sample sizes were dependent on the respective biomarker considered.

We classified participants into 4 categories based on cigarette/e-cigarette use behaviors in the past 30 days to assess product exposure: (1) Nonuse included respondents with no cigarette or e-cigarette use; (2) exclusive e-cigarette included individuals with no cigarette use but e-cigarette use; (3) exclusive cigarette included individuals with cigarette use but no e-cigarette use; and (4) dual use included individuals with e-cigarette and cigarette use.

We selected biomarkers of inflammation (high-sensitivity C-reactive protein, interleukin-6, fibrinogen, soluble intercellular adhesion molecule) and oxidative stress (urinary 8-isoprostane) as dependent variables. We used the PATH imputed biomarker variables in which observations under the limit of detection were replaced by limit of detection/√2. All biomarkers were right skewed and thus loge transformed for analyses.

We adjusted for covariates that may be associated with smoking behaviors or biomarkers of interest. Data on race and ethnicity were combined to classify respondents as non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic other. Additional self-reported measures included sex (male, female); age (18–24, 25–34, 35–44, 45–54, 55–64, ≥65 years); education (less than high school, high school diploma, some college, college or higher); poverty status based on household income (<100%, 100%–199%, ≥200% of poverty level); body mass index (<18.5, 18.5–24.9, 25–29.9, ≥30 kg/m²); diabetes (yes, no); heart attack (yes, no); heart failure (yes, no); stroke (yes, no); use of other tobacco products, including traditional cigar, filtered cigar, cigarillo, pipe, hookah, snus, dissolvable, smokeless (never, former, current), and marijuana/blunt (never, former, current); recreational drug (never, former, current); prescription drug (never, former, current); second-hand smoke exposure at home or at work (yes, no); and pack-year of cigarette smoking and its squared term.
We used multivariable linear models with sequential adjustments for covariates to evaluate the association of cigarette/e-cigarette use behaviors with each biomarker, and geometric mean ratios were obtained by exponentiating the coefficients. The first model was adjusted for age, sex, and race/ethnicity; the
second was additionally adjusted for other covariates listed above.

We analyzed data using Stata, version 15 (StataCorp). We applied PATH-derived blood biomarker sample weights and considered statistical significance using a 2-sided test, with a significance level of 0.05. Missing data on covariates were imputed from multiple imputation with chained equation (20 imputations). Our analysis relied on deidentified data and was therefore exempted from review by the Boston University Medical Center Institutional Review Board. To test the robustness of our results, we repeated the analyses in subgroups of respondents (1) with no past 30-day use of any other tobacco products, (2) excluding nonusers with urinary cotinine ≥ 10ng/mL, and (3) with no missing values on covariates. Analytical code for purposes of reproducing the results is available on request. Restricted-use PATH files are available through an online application.

Of the 7130 participants, 58.6% did not use cigarettes and e-cigarettes, 1.9% used e-cigarettes exclusively, 29.6% exclusively smoked, and 9.9% used both e-cigarette and cigarettes (Table). In the multivariable models, we observed no difference in the biomarker concentration of inflammatory or oxidative stress between participants who used e-cigarettes and nonusers. Exclusive smokers and dual users had higher levels across all biomarkers relative to nonusers. Compared with exclusive smokers, exclusive e-cigarette users had significantly lower levels of almost all inflammatory and oxidative stress biomarkers other than high-sensitivity C-reactive protein (geometric mean ratio, 0.91 [95% CI, 0.79–1.07]). We observed no difference between users of both products and exclusive smokers. The results were similar with all alternative analyses described above (data not shown).

In this nationally representative population study of adults, we observed no difference in inflammatory and oxidative stress biomarkers between exclusive e-cigarette users and nonusers (no cigarettes or vaping), and levels were lower in exclusive e-cigarette users relative to exclusive smokers. These findings are consistent with recent population studies of inflammatory biomarker concentration and toxicant exposure in users of e-cigarettes and cigarettes and highlight the importance of completely replacing cigarette smoking with e-cigarettes or quitting the use of both products for cigarette smokers to derive potential health benefits.