Association between e-cigarette use behaviors and perceived harmfulness of e-cigarettes and anxiety/depression symptoms among Black/African American Adults

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ABSTRACT
Black/African American adults are at greater risk of experiencing negative health outcomes stemming from tobacco use, yet little research has examined e-cigarette use behavior in the Black/African American adult-only population. We examined the association between e-cigarette use behaviors (never, former, and current use) and perceived harmfulness of e-cigarette use and anxiety/depression symptoms among Black/African American adults. This cross-sectional study was a secondary analysis of nationally representative data from the 2011–2020 Health Information National Trends Survey (n = 6,268). Multinomial logit models were used to examine differences in e-cigarette use behaviors (reference group = never used e-cigarettes), given the risk factors named above. The prevalence of former and current e-cigarette use among Blacks/African Americans was 11.65 % and 3.52 %, respectively. There was a significant interaction between the perceived harmfulness of e-cigarette use and anxiety/depression. Moderate or severe anxiety/depression symptoms were associated with a higher likelihood of current e-cigarette use, but not former e-cigarette use. Compared to individuals who perceived e-cigarette use as less harmful than smoking cigarettes, those who perceived e-cigarette use as just as harmful were less likely to be current e-cigarette users. Those who perceived e-cigarette use as more harmful or were uncertain were less likely to be former or current e-cigarette users. Anxiety/depression and perceived harmfulness of e-cigarette use and their interactions were significantly associated with e-cigarette use behaviors. These findings provide an opportunity to offer tobacco cessation and prevention interventions to subgroups in this population and inform development of content for the same.

1. Introduction
Electronic cigarette (e-cigarette) use may be harmful for any racial group, especially for Black/African American adults aged 18 years or more who have the highest negative health outcomes associated with tobacco use, including e-cigarette use (CDC, 2020a; Henley et al., 2016; Ho and Elo, 2013). E-cigarette use is concerning because e-cigarettes, like other tobacco products (e.g., cigarettes, pipes, and smokeless tobacco), contain nicotine and other chemicals such as volatile organic compounds, heavy metals, carbonyls, tetrahydrocannabinol, and cannabinoid, which are highly addictive and harmful to the cardiovascular and pulmonary systems (CDC, 2020b,c; Singh et al., 2020; US Department of Health and Human Services, 2016; Williams et al., 2013). However, e-cigarette use among adults in the United States (U.S.), including Black/African American adults, is high, with increasing prevalence across all e-cigarette use behaviors, such as former and current use (Delnevo et al., 2016; Villarroel et al., 2020). In 2014, there were 8.9 % former users and 3.7 % current users (Delnevo et al., 2016), while there were 14.9 % ever (former = 10.4 %) and 4.5 % current users in 2018–2019 (Cornelius et al., 2020; Villarroel et al., 2020). These patterns of increased e-cigarette use have also been observed among racial groups. Black/American adults, compared to White American adults (former = 10.3 %–13.2 % & current = 4.5 %–5.1 %), had a lower increase in the prevalence of former (5.6 %–10 %) and current (1.9 %–
that e-cigarette use may vary between and within sociodemographic groups (et al., 2020; Jaber et al., 2018; Owusu et al., 2019; Pericot-Valverde et al., 2017). South or Midwest are also more likely to use e-cigarettes (Cornelius et al., 2017; Wheldon and Wiseman, 2019). These findings suggest that e-cigarette use may vary between and within sociodemographic groups. However, the extent to which these differences exist among Black/African American adults remains unknown.

This study analyzed nationally representative data to examine e-cigarette use behaviors among Black/African American adults to augment the literature on this population. Our study specifically assessed e-cigarette use behaviors and their associated perceived health harmlessness, anxiety/depression, and sociodemographic factors among this population. We also evaluated whether anxiety/depression moderated the association between e-cigarette use behaviors and the perceived harmlessness of e-cigarette use.

2. Methods

2.1. Study design and population/sample

This cross-sectional study uses nationally representative secondary data from the Health Information National Trends Survey (HINTS). The data are de-identified and publicly available. HINTS assesses health-related behaviors such as e-cigarette use, perceptions about e-cigarette and cigarette use, and mental health information among a nationally representative sample of U.S. civilian, noninstitutionalized adults aged 18 years or more. It also collects sociodemographic information on the participants. The HINTS has been administered annually since 2002/2003 by Westat, a research company in Maryland, through the sponsorship and contract of the U.S. Department of Health and Human Services (Finney Rutten et al., 2020; National Cancer Institute, 2022; Westat, 2020). While the 2011–2020 surveys used self-administered mailing questionnaires based on a national listing of addresses, the previous surveys used computer-assisted telephone interviews using list-assisted random-digit-dial (RDD) telephone numbers. Based on these methodological differences and data recency, we only used HINTSs that used the mailing method in this study.

The analysis included only Black/African American adult data in the pooled datasets to answer our research questions. There are 5,389 (not accounting for missing data) Black/African American adults out of the 36,017 samples of U.S. adults in the combined dataset. A data analysis protocol was submitted to the Institutional Review Board (IRB) at The University of Texas Health Science Center at Houston (UTHealth), and exempt from ethical compliance was obtained before conducting the data analysis.

2.2. Measures

2.2.1. Dependent variable

E-cigarette use behaviors involve never, former, and current use of e-cigarettes. They were measured by two questions: 1) Have you ever used an e-cigarette, even one or two times? Yes/No; 2) Do you now use an e-cigarette every day, some days, or not at all? With response options as every day, some days, or not at all. Participants who have never used an e-cigarette were categorized as never users; those who have ever used an e-cigarette but do not currently use it were categorized as former users, and those that have ever used an e-cigarette and currently use it were considered as current users.

2.2.2. Independent variables

Perceived harmfulness of e-cigarette use and anxiety/depression were the independent variables. The perceived harmfulness of e-cigarette use encompasses the relative harm discussion of e-cigarette use to smoking cigarettes. To measure this variable, participants were asked, “compared to smoking cigarettes, would you say that electronic cigarettes are much less harmful, less harmful, just as harmful, more harmful, much more harmful, or you don’t know?” For this analysis, the response options were encoded as less harmful (i.e., much less harmful or less harmful), just as harmful, more harmful (i.e., more harmful or much more harmful), or don’t know/uncertain.

The second independent variable, the status of anxiety/depression symptoms, was derived from the Patient Health Questionnaire-4 (PHQ-4), a four-question instrument on a four-point Likert-type scale, with total scores ranging from 0 to 12 (Kroenke et al., 2009; Löwe et al., 2010). Based on the scores, the categories of the anxiety/depression status include normal/no anxiety/depression (total scores = 0–2), mild (total scores = 3–5), moderate (total scores = 6–8), and severe (total scores = 9–12) (Kroenke et al., 2009; Löwe et al., 2010).

2.2.3. Covariates

Based on the existing studies, the following six sociodemographic characteristics were adjusted for in the analysis to understand their influence on the dependent variable. Age (18–25, 26–34, 35–49, 50–64, or 65 or more years), biological sex (female or male), level of education completed (less than High School, High School graduate, some college, or college graduate or higher), income (less than $20,000, $20,000 to < $35,000, $35,000 to < $50,000, $50,000 to < $75,000, or $75,000 or more), and the U.S. census region (Northeast, Midwest, West, or South). General health status was determined by asking the participants whether they considered their overall health to be excellent, very good, good, fair, or poor. Based on the literature (Al Rifai et al., 2020), general health status was dichotomized into excellent/very good/good and fair/poor for this analysis.

2.3. Data analysis

STATA software version 16.1 was used to conduct all the statistical analyses.
analyses because it is affordable and easy to use for weighted data and sufficient statistical analyses (StataCorp, 2019). To ensure nationally representative estimates and offset non-response bias, the HINTS survey weights were applied to all analyses (Finné Rutten et al., 2020; Westat, 2020), except the frequencies to enhance replication of the results by other researchers. Because our analyses were based on a ten-year pooled dataset, the survey weight was calibrated by dividing the weight by ten years to achieve average or population estimates across the ten years and adjust for the year effects (Westat, 2020). Additionally, the svy subpop command in STATA was used to conduct the analysis among only Black/African American adults.

Frequencies with corresponding percentages were estimated and reported to describe the prevalence of e-cigarette use behaviors. To assess the differences in e-cigarette use behaviors among groups at the bivariate analysis level, chi-squared tests were used to describe the sociodemographic characteristics and the main independent variables according to the e-cigarette use behaviors. Because the dependent variable has more than two nominal categories, a multinomial logistic regression analysis was conducted to assess the association between e-cigarette use behaviors and the perceived harmfulness of e-cigarette use and anxiety/depression symptoms, adjusting for sociodemographic characteristics. To determine whether anxiety/depression symptoms moderate the association between e-cigarette use behaviors and perceived harmfulness of e-cigarette use, an effect modification was tested based on the interaction between anxiety/depression symptoms and perceived harmfulness of e-cigarette use, adjusting for sociodemographic characteristics. The margins analysis in STATA was used to decipher the marginal effect modification, and the results were presented graphically using a marginsplot in STATA. Statistically significant results were determined at a p < 0.05 for the 2-sided inference test and relative risk ratio (RRR) with 95% confidence intervals (CIs).

Multiple imputations by chained equations (MICE) were conducted (with the assumption that the data are missing at random) to address the missingness and improve the statistical power (Lee and Huber, 2021; Schafer, 1999; Toutenburg, 1990). The MICE was used to account for missingness and improve the statistical power (Lee and Huber, 2021; Schafer, 1999; Toutenburg, 1990). The imputations resulted in a sample of 6,268 Black/African American adults out of the 36,017 samples in the pooled dataset. Multicollinearity was also assessed to determine whether there was a significant correlation between the independent variables using the variance inflation factor (VIF); the mean VIF was 1.14, which is less than the 10 thresholds to suggest no serious multicollinearity (Bayman and Dexter, 2021).

3. Results

3.1. Sociodemographic characteristics of study population

The descriptive statistics of the sociodemographic characteristics of the Black/African American adults are presented in Table 1. A majority of the Black/African American adults were 50–64 years of age (31.43%), female (56.84%), completed some college education (30.03%), had a total annual family income of less than $20,000 (35.82%), and reside at the southern US census region (57.05%). About 21.76% of them reported fair or poor general health status. There were 17.89%, 7.82%, and 7.95% prevalence of mild, moderate, and severe current anxiety/depression symptoms, respectively, among the population. Most of the population perceived e-cigarette use as being just as harmful as smoking cigarettes (34.60%) or were uncertain about the perceived harmfulness of e-cigarette use compared to smoking cigarettes (33.06%).

3.2. Differences in e-cigarette use behaviors by subgroups

The bivariate analysis results of the differences in e-cigarette use behaviors by the sociodemographic characteristics, the perceived harmfulness of e-cigarette use, and anxiety/depression are also

| Table 1 | Weighted prevalence of e-cigarette use among Black/African American adults (n = 6,268) by their sociodemographic characteristics and perceived harmfulness of e-cigarettes and anxiety/depression. |
| Overall sample | Never used e-cigarettes | Former e-cigarette use | Current e-cigarette use | P-value |
| N(%) | n (%) | N(%) | n (%) | N(%) | n (%) |
|---|---|---|---|---|---|
| Overall | 5,547 | (94.83) | 533 | (11.65) | 188 | (3.52) |
| Age | | | | | | <0.0001 |
| 18–25 | 217 | (11.60) | 170 | (75.79) | 32 | (17.98) | 15 | (6.23) |
| 26–34 | 536 | (13.61) | 417 | (74.48) | 92 | (20.31) | 27 | (5.21) |
| 35–49 | 1,423 | (1.27) | 141 | (83.17) | 141 | (13.08) |
| 50–64 | 2,393 | (31.43) | 2,117 | (89.36) | 197 | (7.97) | 79 | (2.66) |
| 65 or older | 1,699 | (13.52) | 1,616 | (96.14) | 71 | (2.87) | 12 | (0.99) |
| Sex | | | | | | 0.0004 |
| Female | 4,234 | (56.84) | 3,791 | (87.98) | 325 | (8.74) | 118 | (3.28) |
| Male | 2,034 | (26.40) | 1,756 | (80.68) | 208 | (15.47) |
| Level of education completed | | | | | | 0.0538 |
| Less than High School | 760 | (16.56) | 670 | (80.89) | 67 | (16.53) | 23 | (2.58) |
| High School graduate | 1,463 | (27.01) | 1,299 | (85.11) | 121 | (10.29) | 43 | (4.60) |
| Some college | 1,914 | (30.03) | 1,659 | (83.21) | 179 | (12.59) | 76 | (4.20) |
| College graduate or higher | 2,131 | (26.40) | 1,919 | (88.87) | 166 | (8.90) | 46 | (2.23) |
| Total family annual income | | | | | | 0.5004 |
| Less than $20,000 | 2,312 | (35.82) | 1,985 | (82.50) | 251 | (13.87) | 77 | (10.18) | 40 | (6.49) |
| $20,000 to $35,000 | 1,071 | (15.40) | 954 | (85.19) | 77 | (10.18) | 40 | (6.49) |
| $35,000 to $50,000 | 859 | (13.91) | 767 | (85.26) | 65 | (11.61) | 27 | (3.14) |
| $50,000 to $75,000 | 901 | (14.61) | 803 | (83.74) | 70 | (12.21) | 28 | (4.06) |
| $75,000 or more | 1,125 | (20.26) | 1,038 | (89.19) | 70 | (8.50) | 17 | (2.31) |
| General health status | | | | | | 0.0850 |
| Excellent/very good | 4,807 | (78.24) | 4,311 | (85.95) | 367 | (10.73) | 129 | (3.32) |
| Fair or poor | 1,461 | (21.76) | 1,236 | (80.83) | 166 | (11.53) | 59 | (4.23) |
| US census region | | | | | | 0.0329 |
| Midwest | 1,051 | (16.77) | 929 | (89.47) | 80 | (8.97) | 42 | (3.56) |
| Northeast | 945 | (15.08) | 828 | (84.48) | 77 | (10.77) | 40 | (4.75) |
| West | 696 | (11.10) | 602 | (77.06) | 76 | (19.88) | 18 | (3.06) |
| South | 3,576 | (57.02) | 3,188 | (85.98) | 602 | (16.93) | 88 | (3.19) |

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displayed in Table 1. The prevalence of former and current e-cigarette use among the population was 11.65 % and 3.52 %, respectively. There were statistically significant differences in e-cigarette use behaviors based on age (p < 0.0001), sex (p = 0.0004), US census region (p = 0.0329), current anxiety/depression status (p < 0.0001), and perceived harmfulness of e-cigarette use (p < 0.0001). Individuals aged 18–25 years reported higher former (20.31 %) and current (6.23 %) e-cigarette use. Males also reported higher former (15.47 %) and current (3.84 %) e-cigarette use. A higher proportion of the population that were former e-cigarette users reside in the Northeast (4.75 %). Males were significantly more likely to be former e-cigarette users (RRR = 2.45, 95 % CI = 1.26, 4.61). Individuals with mild (former = 12.96 %; current = 2.62 %), moderate (former = 14.85 %; current = 9.30 %), or severe (former = 17.13 %; current = 10.00 %) anxiety/depression symptoms reported higher former and current e-cigarette usage. Those who perceived e-cigarette use as less harmful compared to smoking cigarettes represented a higher proportion of former (18.53 %) and current (12.94 %) e-cigarette users.

### 3.3. Association between e-cigarette use behaviors and sociodemographic characteristics, the perceived harmfulness of e-cigarettes, and anxiety/depression

The multinomial logistic regression analysis results for the factors associated with e-cigarette use behaviors are presented in Table 2. The reference e-cigarette use group was never users. Individuals aged 50–64 years, compared to those aged 18–25 years, were less likely to be former e-cigarette users (RRR = 0.42, 95 % CI = 0.21, 0.82), while those aged 65 years or older were less likely to be former e-cigarette users (RRR = 0.14, 95 % CI = 0.07, 0.20) and current (RRR = 0.21, 95 % CI = 0.05, 0.90) e-cigarette users. Males were significantly more likely to be former e-cigarette users (RRR = 1.99, 95 % CI = 1.40, 2.83) compared to their female counterparts. Individuals who reside in the West, compared to those who reside in the Midwest, had a higher likelihood of being former e-cigarette users (RRR = 2.42, 95 % CI = 1.13, 5.19).

### Table 1

| Characteristic | Overall sample | Never used e-cigarettes | Former e-cigarette use | Current e-cigarette use | P-value |
|----------------|----------------|-------------------------|------------------------|-------------------------|---------|
| N(%)           |                |                         |                        |                         |         |
| Mild           | 1,109          | 948                     | 123                    | 38 (2.62)               |         |
| Moderate       | 503            | 408                     | 68 (14.85)             | 27 (9.30)               |         |
| Severe         | 422            | 325                     | 67 (17.13)             | 30 (10.00)              |         |

Data Source: Health Information National Trends Survey. Statistically significant at p < 0.05 using Chi-squared tests.

### Table 2

Weighted multinomial logistic regression analysis of factors associated with e-cigarette use behaviors among Black/African American adults.

| Age | Never used e-cigarette use versus: | RRR 95 % CI | Current e-cigarette use | RRR 95 % CI |
|-----|-------------------------------------|-------------|-------------------------|-------------|
| 18-25 | Reference | 1.26 (0.61, 2.58) | 0.74 (0.24, 2.36) |
| 26-34 |           | 0.77 (0.40, 1.49) | 0.69 (0.26, 1.86) |
| 50-64 |           | 0.42 (0.21, 0.82) | 0.44 (0.15, 1.28) |
| 65 or older | 0.14*** (0.07, 0.30) | 0.21* (0.05, 0.90) |
| Sex | Male-Reference | 1.99*** (1.40, 2.83) | 1.08 (0.65, 1.80) |
| Level of education completed | Less than High School-Reference | 0.59 (0.31, 1.12) | 1.84 (0.83, 4.11) |
| Some college | 0.74 (0.39, 1.41) | 1.53 (0.72, 3.22) |
| College graduate or higher | 0.49 (0.24, 1.00) | 0.84 (0.29, 2.46) |
| Total family annual income | Less than $20,000-Reference | 0.67 (0.39, 1.16) | 1.31 (0.57, 3.02) |
| $20,000 to < $35,000 | 0.80 (0.44, 1.44) | 0.79 (0.34, 1.84) |
| $35,000 to < $50,000 | 0.93 (0.49, 1.77) | 1.38 (0.63, 3.04) |
| $50,000 to < $75,000 | 0.55 (0.24, 0.57) | 1.26 (0.20, 6.16) |
| $75,000 or more | 1.53 (0.95, 2.45) | 1.05 (0.57, 1.93) |
| General health status | Excellent/very good/good-Reference | 1.37 (0.65, 2.88) | 1.86 (0.77, 4.51) |
| Fair or poor | 1.24* (1.13, 1.38) | 0.90 (0.34, 2.37) |
| US census region | Midwest-Reference | 1.37 (0.65, 2.88) | 1.61 (0.77, 3.37) |
| Northeast | 1.43 (0.76, 2.64) | 5.77*** (2.44, 13.65) |
| West | 2.42* (1.13, 5.19) | 0.90 (0.48, 2.34) |
| South | 1.27 (0.68, 2.34) | 0.90 (0.48, 2.34) |

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Anxiety/depression status was significantly associated with e-cigarette use behaviors: experiencing moderate (RRR = 4.04, 95 % CI = 1.88, 8.69) or severe (RRR = 5.77, 95 % CI = 2.44, 13.65) anxiety/depression symptoms, compared to no symptoms, was associated with a higher likelihood of current e-cigarette use. Similarly, the perceived harmfulness of e-cigarette use compared to smoking cigarettes was significantly associated with e-cigarette use behaviors. Compared to individuals who perceived e-cigarettes as use less harmful than smoking cigarettes, those who perceived e-cigarettes as being just as harmful were less likely to be current e-cigarette users (RRR = 0.08, 95 % CI = 0.04, 0.18). Those who perceived e-cigarette use as more harmful (former users: RRR = 0.36, 95 % CI = 0.21, 0.62; current users: RRR = 0.01, 95 % CI = 0.00, 0.09) or were uncertain (former users: RRR = 0.38, 95 % CI = 0.22, 0.66; current users: RRR = 0.11, 95 % CI = 0.05, 0.25) were less likely to be former or current e-cigarette users.

### Table 2 (continued)

| Never used e-cigarette versus: | Former e-cigarette use | Current e-cigarette use |
|--------------------------------|------------------------|------------------------|
|                                | RRR 95 % CI            | RRR 95 % CI            |
| **More harmful**               |                        |                        |
|                                | (0.40, 1.02)           | (0.04, 0.18)           |
|                                | 0.36*** (0.21, 0.62)   | 0.01*** (0.00, 0.09)   |
| **Don’t know/uncertain**       | 0.38** (0.22, 0.66)    | 0.11*** (0.05, 0.25)   |

RRR = Relative risk ratio. Ref. = Reference group. 95 % CI = 95 % confidence interval. *p < 0.05, **p < 0.01, ***p < 0.001.

3.4. Between and within-group analysis: moderation analysis using marginal analysis/marginsplot

Fig. 1 displays the results of the moderation analysis to show the differences in e-cigarette use behaviors between and within the perceived harmfulness of e-cigarette use and anxiety/depression symptoms. There was a significant interaction between the perceived harmfulness of e-cigarette use and anxiety/depression (p < 0.001). Among all the three e-cigarette use behaviors (never, former, and current use), those who experienced anxiety/depression symptoms and had any perception of e-cigarette use harmfulness were never e-cigarette users. Those who experienced severe anxiety/depression symptoms and perceived e-cigarettes as more harmful to use had the lowest probability of being current e-cigarette users than never and former e-cigarette users.

For never users, the highest probabilities of being never an e-cigarette user were found among individuals who experienced no anxiety/depression symptoms and perceived e-cigarettes as more harmful (95.47 %, p < 0.001). The lowest probability of never using e-cigarettes was revealed for those who experienced severe anxiety/depression and perceived e-cigarettes as less harmful (47.38 %, p < 0.001).

For former e-cigarette users, the highest probabilities were detected among those who experienced no anxiety/depression and perceived e-cigarettes as less harmful to use (17.59 %, p < 0.001). The lowest probability of being a former user was revealed for those who experienced no anxiety/depression and perceived e-cigarettes as more harmful to use (4.53 %, p < 0.001).

Among current e-cigarette users, those who experienced severe anxiety/depression symptoms and perceived e-cigarettes as less harmful to use had the highest probabilities of being current e-cigarette users (38.91 %, p < 0.001). Those who experienced severe anxiety/depression symptoms and perceived e-cigarettes as more harmful to use had the lowest probability of being current e-cigarette users (1.81e−13 [0.00 %], p < 0.001).
4. Discussion

This study, by focusing on a national representative sample of Black/African American adult population, was the first to examine the prevalence of e-cigarette use behaviors and their associations with perceived harmfulness of e-cigarette use and anxiety/depression symptoms among the Black/African American adult population. Among the Black/African American adults, 11.65% and 3.52% were former and current e-cigarette users, respectively, which is lower when compared to former (13.50%) and current (6.57%) White American adult e-cigarette users (Bao et al., 2018; Boakye et al., 2022; Villarreal et al., 2020). However, the prevalence of these e-cigarette use behaviors among the Black/African American adults was not different between the years (i.e., 2011–2020), which provides evidence for no fluctuations in e-cigarette use behaviors among this racial group across these years (Bao et al., 2018; Owusu et al., 2019). We observed significant differences in e-cigarette use behaviors by age, sex, and US census region; and inter-relationships between anxiety/depression symptoms, perceived harmfulness of e-cigarettes, and e-cigarette use behaviors.

Age, sex, and place of residence disparities in e-cigarette use behaviors were observed among the Black/African American adult population. Young adults aged 18–25 years had a higher prevalence of former and current e-cigarette use and were more likely to be former and current e-cigarette users than older adults. This finding is consistent with previous studies that suggest that young adults are more likely to experiment with e-cigarettes and engage in e-cigarette use behaviors (Adzrago et al., 2022; Delnevo et al., 2016; Jaber et al., 2018; Wheldon and Wiseman, 2019). The findings also imply that while males, in general, were more likely to be former or current users than females, there was no statistically significant difference in current e-cigarette use behavior between males and females. Therefore, Black/African American adult males may be more likely to quit e-cigarette use, but their current daily or someday e-cigarette use behavior may be similar or not different from that of their female counterparts.

Place of residence significantly impacts the e-cigarette use behavior of Black/African American adults. In line with previous studies, we found that individuals who reside in the western US census region had a higher prevalence of former e-cigarette use and were also more likely to be former e-cigarette users than those who reside in the midwestern region. These differences may also explain why individuals in the West had lower cases and deaths related to tobacco use compared to those in the Northeast, West, and Southern regions (Henley et al., 2016). A possible reason is a rural–urban disparity in tobacco use, with rural residents more likely to use tobacco and less likely to quit due to lower socioeconomic conditions and increased exposure to tobacco advertisement, especially in the western region (CDC, 2020a; Lewis-Thames et al., 2020). Also, the regulation of e-cigarettes might have influenced the differences in e-cigarette use within the regions. Most states in the Great Plains region, especially midwestern ones, have fewer e-cigarette regulation policies at any level (Kadowaki et al., 2015). However, there were no statistically significant differences in current or daily e-cigarette use between the midwestern and northeastern, western, and southern US census regions, respectively. These sociodemographic disparities indicate that while previous studies reported that Black/African American adults are less likely to engage in e-cigarette use, there are differences in e-cigarette use among this population. Tobacco use cessation and prevention interventions targeting this population might need to consider these inter and intragroup differences in e-cigarette use to focus on the specific groups in the Black/African American adults than need the intervention.

Contrary to the studies on the general adult population (Cornelius et al., 2020; Jaber et al., 2018; Owusu et al., 2019; Pericot-Valverde et al., 2017; Wheldon and Wiseman, 2019), our findings indicated that the level of education completed, total family annual income, and general health status were not associated with e-cigarette use behaviors among Black/African American adult population. These results, considering racial inequalities, are not surprising because this population often experiences similar socioeconomic disadvantages, including lower educational attainment, lower level of wealth, and poor health, coupled with racism and discrimination, that have similar impacts on their behavioral outcomes (Bey et al., 2018; Braveman et al., 2010). Additional studies, including longitudinal studies, may help better understand whether e-cigarette use behaviors may vary or not based on these sociodemographic factors over time.

Similar to the literature on the general population (Farrell et al., 2021; Obisesan et al., 2019; Park et al., 2017; Saeed et al., 2020; Sung, 2021), we found significant associations between e-cigarette use and anxiety/depression symptoms among Black/African American adults. While anxiety/depression symptoms were not associated with former e-cigarette use in this population, they were associated with current daily or someday e-cigarette use. The intensity of anxiety/depression symptoms increased the risks of current e-cigarette use behavior. Individuals who experienced moderate and severe anxiety/depression symptoms had a 4-fold and 6-fold increase in risks of current e-cigarette use. These findings denote that although Black/African Americans are considered to be at a lower risk of using e-cigarettes, some are more likely to engage in frequent or daily e-cigarette use due to the severity of anxiety/depression symptoms. This association of anxiety/depression symptoms and daily usage of e-cigarettes is concerning for Black/African American adults who are already at increased risk of experiencing mental health disorder symptoms emanating from racism, discrimination, and physical violence (Bey et al., 2018). Increasing treatment of anxiety/depression symptoms and providing mental health services to Black/African American adults can be an effective step toward reducing and preventing e-cigarette use and its consequences in this population.

Individuals’ perceptions or beliefs about the health-related consequences of engaging in a health-related behavior influence their likelihood of engaging in that behavior (Champion and Skinner, 2008; Strecher and Rosenstock, 1997). Individuals who perceive that they are susceptible to experiencing a poor health outcome due to behaviors related to such poor outcomes will be less likely to engage in such behaviors. Consistent with previous literature (Adzrago et al., 2022; Champion and Skinner, 2008; Strecher and Rosenstock, 1997), we found the perceived harmfulness of e-cigarette use compared to smoking cigarettes was negatively associated with e-cigarette use behaviors. Black/African American adults who perceived e-cigarette use as less harmful compared to smoking cigarettes were more likely to be former and current e-cigarette users. In other words, our findings revealed that individuals who perceived e-cigarette use as being just as harmful, more harmful, or were uncertain were less likely to be former or current daily e-cigarette users. This e-cigarette harm perception could be due to multinational tobacco companies and marketers portraying e-cigarettes as safer than and substitutes for cigarette smoking and other tobacco products (Grana et al., 2014; Huang et al., 2019; Luo et al., 2014; Paek et al., 2014). Particularly, tobacco industries often target Black/African American adults with tobacco products, including e-cigarettes, by portraying positive images of these products (CDC, 2020a). However, e-cigarettes contain nicotine and other chemicals, which are extremely addictive and harmful to the cardiovascular and pulmonary systems (CDC, 2020b; c; Singh et al., 2020; US Department of Health and Human Services, 2016; Williams et al., 2013). Public health behavioral change communications may need to focus interventions on e-cigarette harm perceptions by presenting the health consequences of e-cigarette use among this population.

We found that anxiety/depression symptoms moderated the association between the perceived harmfulness of e-cigarette use and e-cigarette use behaviors among our study population. The association between e-cigarette use behaviors and their perceived harmfulness varied based on anxiety/depression symptoms. Higher probabilities of not using e-cigarettes were revealed among individuals who had no
anxiety/depression symptoms but perceived e-cigarette use as more harmful or were uncertain; experienced mild anxiety/depression but were uncertain about the perceived harmfulness of e-cigarette use; and experienced severe anxiety/depression and perceived e-cigarette use as less harmful. Former e-cigarette users experienced no anxiety/depression and perceived e-cigarette use as less harmful; they also experienced moderate anxiety/depression and perceived e-cigarette use as more harmful; those who experienced no anxiety/depression and perceived e-cigarette use as more harmful had the lowest probabilities. Current e-cigarette users experienced moderate or severe anxiety/depression symptoms and perceived e-cigarettes as less harmful to use, while the lowest probabilities were detected for those who experienced severe anxiety/depression symptoms and perceived e-cigarette use as more harmful.

The moderation analysis results are consistent with the previous publications that barriers such as anxiety/depression may influence the perception about a health-related behavior and performing that behavior (Champion and Skinner, 2008; Streecher and Rosenstock, 1997). Individuals may not have accurate beliefs or perceptions about the harmfulness of e-cigarette use due to interference in their thoughts based on their anxiety/depression symptoms. These findings underscore the need to consider the impact of anxiety/depression symptoms when addressing e-cigarette use harm perceptions and e-cigarette use, especially among this population with the highest burdens of mental health disorder symptoms (Obisesan et al., 2019; Vahratian et al., 2021).

Despite the strengths of our study, some potential limitations need to be considered when interpreting the findings. First, this is a cross-sectional study; therefore, we were not able to establish causal relationships or make causal inferences between the e-cigarette use behaviors and the perceived harmfulness of e-cigarette use, anxiety/depression symptoms, or sociodemographic characteristics. However, we were able to establish associations for variables that had not been looked at for Black/African American adult populations. Second, HINTS data are based on participants’ self-reported responses, which often lead to response and social desirability biases that may result in underreporting and underestimating findings. Nonetheless, such biases might not have significantly affected the findings because the measures used to assess the self-reported responses have been validated and widely used. Additionally, we were unable to assess the e-cigarette brands used because the HINTS does not contain this measure, although understanding the use of different brands may help in intervention development.

5. Conclusions

The results of this study suggest that some sociodemographic differences exist in e-cigarette use behaviors among Black/African American adults. Young adults and males were more likely to use e-cigarettes than their counterparts, which provides an opportunity to offer tobacco cessation and prevention interventions to subgroups in this population. Anxiety/depression symptoms and perceived harmfulness of e-cigarette use and their interactions were significantly associated with former and daily e-cigarette use. Individuals with moderate to severe anxiety/depression symptoms presented with greater risks of engaging in daily or someday e-cigarette use, while perceiving e-cigarette use as less harmful compared to smoking cigarettes was associated with former and daily/somday e-cigarette use. The moderation analysis results imply that the severity of anxiety/depression symptoms and inaccurate perception about e-cigarette use harmfulness are associated, which influences former and daily/somday e-cigarette use behaviors. Future studies may perform mediation analysis to evaluate the mechanisms or pathways of anxiety/depression symptoms and perceived harmfulness of e-cigarette use and their effect on actual e-cigarette use behavior among this population.

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Data availability

The data and materials are publicly available at https://hints.cancer.gov/data/Default.aspx.

CRediT authorship contribution statement

David Adzrago: Conceptualization, Methodology, Validation, Formal analysis, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization. Kayo Fujimoto: Writing – review & editing. Melissa B. Harrell: Writing – review & editing. Antwan Jones: Writing – review & editing. J. Michael Wilkerson: Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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