



Intention to lose weight and use of electronic cigarettes among adolescents

Ruth Sanchez^{a,*}, Nalini Ranjit^a, Steven H. Kelder^a, Montana Gill^b, Deanna M. Hoelscher^a

^a Michael & Susan Dell Center for Healthy Living, University of Texas School of Public Health, Austin Regional Campus, 1616 Guadalupe St., Suite 6.300, Austin TX 78701, USA

^b Texas Department of State Health Services, Division of Community Health Improvement, 110 West 49th St., Austin, TX 78756, USA

ARTICLE INFO

Keywords:

E-cigarettes
Weight intentions
Adolescents
Weight loss
Body Mass Index (BMI)

ABSTRACT

Electronic cigarette use among American adolescents is a major public health concern given the negative health consequences of nicotine in youth. Recent literature has shown that weight control may be one motivation for use in this population. This study examined associations between intention to lose weight and e-cigarette use among adolescents having overweight or obesity from an ethnically diverse sample of Texas youth by gender. We performed a cross-sectional analysis of a state representative sample of 9056 eighth and eleventh grade students from the 2015–2016 Texas School Physical Activity and Nutrition (Texas SPAN) study. Validated survey items assessed weight intentions and e-cigarette use. Staff collected anthropometric measures. Logistic regression analysis was conducted to assess the relationship between e-cigarette use and weight intentions with gender interaction, adjusting for grade, race/ethnicity, economic status, weight-behaviors and stratified by BMI class. More than half (50.9%) of the weighted sample were Hispanic and 12.5% were Non-Hispanic Black; 8.5% used e-cigarettes; and 50.0% intended to lose weight. Of the 40.2% of the sample having overweight or obesity, 82.9% intended to lose weight. Among respondents with obesity, use of e-cigarettes was significantly higher among males intending to lose weight than among females intending to lose weight (12% versus 6%, $p = 0.007$). These findings contrast with previous research suggesting that e-cigarette use in females is more likely to be motivated by an intent to lose weight. The ethnic diversity of the Texas SPAN population may explain this discrepancy.

1. Introduction

Electronic cigarettes (e-cigarettes) are battery-powered devices that heat and aerosolize nicotine in a liquid solution to be inhaled by users. Introduced to American markets in 2007 as an alternative to traditional cigarettes, e-cigarettes have become increasingly popular with adolescents and young adults, far exceeding use of traditional cigarettes in these populations (US Department of Health and Human Services, 2016). Among U.S. high school students for example, e-cigarette use increased by over 900% between 2011 and 2018, from 1.5% to nearly 21%, and increased by 78% from 2017 to 2018 (Cullen et al., 2018; US Department of Health and Human Services, 2016). These trends parallel those seen in other Western countries, according to survey data from Canada and 28 European countries (Cole et al., 2020; Kapan et al., 2020; Laverty et al., 2018). In 2016, the U.S. Surgeon General proclaimed e-cigarette use in American youth a major public health concern (US

Department of Health and Human Services, 2016). Given the astounding increase in e-cigarette use, it is important to understand the motivations behind the use of electronic cigarettes among adolescents in order to implement interventions that effectively curtail their use.

One major influence on adolescent behaviors is weight status and perception of weight (Harriger and Thompson, 2012). Adolescents that have overweight and those that perceive themselves as having overweight often adopt healthy and/or unhealthy behaviors in an attempt to achieve weight control (Haynes et al., 2018), including exercise, dietary choices, such as fasting or avoidance of high fat foods, purging, self-medication with laxatives or diet pills, and cigarette smoking (Alme-nara et al., 2014; Frank et al., 2018; Ursoniu et al., 2011; Zhang et al., 2011). Perversely, those with overweight or obesity have been shown to be more likely to engage in unhealthy eating behaviors such as eating in the absence of hunger, binge eating, and exercising less than those who have normal weight (Dressler and Smith, 2013a, 2013b; Opichka et al.,

Abbreviations: SPAN, School Physical Activity and Nutrition; BMI, Body Mass Index; E-cigarettes, Electronic cigarettes; YRBS, Youth Risk Behavior Survey; FRL, Free or reduced-price lunch; PATH, Population Assessment of Tobacco and Human Health.

* Corresponding author.

E-mail addresses: Ruth.Sanchez@utexas.edu (R. Sanchez), Nalini.Ranjit@uth.tmc.edu (N. Ranjit), Steven.H.Kelder@uth.tmc.edu (S.H. Kelder), Montana.Gill@dshs.texas.gov (M. Gill), Deanna.M.Hoelscher@uth.tmc.edu (D.M. Hoelscher).

<https://doi.org/10.1016/j.pmedr.2021.101406>

Received 31 August 2020; Received in revised form 5 May 2021; Accepted 9 May 2021

Available online 18 May 2021

2211-3355/© 2021 The Authors.

Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license

(<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2019). Individuals with normal weight, on the other hand, have been shown to be more knowledgeable about and more often utilize nutrition information to inform their eating habits than those with overweight or obesity (Dressler and Smith, 2013b). Internalized weight bias, internalized negative beliefs about being overweight by persons with overweight, has been shown to be positively correlated with unhealthy weight behaviors (Durso et al., 2012; Wu and Berry, 2018). Body image dissatisfaction in adolescents is more common both in those with overweight or obesity and among females (Jiménez et al., 2017). Furthermore, girls and boys utilize different weight loss methods to control weight. Girls have been found to be more likely to engage in calorie restriction through avoidance of sweets or fatty foods, while boys have greater odds of skipping meals and exercising to control weight (Brown et al., 2016; Frank, et al., 2018). These findings suggest that the motivations for weight loss behaviors may be distinct in those with overweight and obesity and gender differences may be present.

There is a long established association between cigarette use and weight status and weight control beliefs in adults (Bennett and Pokhrel, 2018; French and Jeffery, 1995; Klesges et al., 1989; Napolitano et al., 2018; Wee et al., 2001). The initiation of smoking is positively correlated with beliefs that smoking controls weight (French and Jeffery, 1995; Klesges et al., 1989). Substantial numbers of previous studies have shown that those that are overweight are more likely to be smokers, as compared to their counterparts with normal weight (French and Jeffery, 1995; Klesges et al., 1989; Lanza et al., 2017; Schindler-Ruwisch et al., 2015). Post-cessation weight concerns are not uncommon among cigarette smokers (French and Jeffery, 1995) and adult e-cigarette users (Strong et al., 2015). Recent research investigating both e-cigarette and cigarette behaviors has found a relation between smoking either product and weight concerns (Bennett and Pokhrel, 2018; Napolitano et al., 2018). Adult cigarette users, e-cigarette users, and dual users have been found to be more likely to have overweight or obesity (Lanza et al., 2017; Morean and Wedel, 2017; Strong et al., 2015) and more likely to smoke cigarettes or e-cigarettes for weight control or to report beliefs that e-cigarettes help with weight control (Bloom et al., 2019; Morean and L'insalata, 2018; Morean and Wedel, 2017; Napolitano et al., 2018). Furthermore, among adults, a positive relationship has been found between weight concerns and increased frequency of e-cigarette use (Bennett and Pokhrel, 2018; Morean and Wedel, 2017). In the only longitudinal study described, Strong et al. found that among current smokers, weight-related concerns at baseline were not associated with experimentation with e-cigarettes at one year follow up, despite significantly greater increases in rates of experimentation with e-cigarettes over time in smokers with overweight/obesity as compared to normal weight counterparts (2015). Compared to men, women are more likely to hold beliefs that e-cigarettes aid in weight control (Piñeiro et al., 2016), which is consistent with gender differences noted with cigarettes and weight beliefs (Klesges et al., 1989). It is noteworthy that while several studies have measured smoking intentionally as a tool for weight control (Bloom et al., 2019; Morean and L'insalata, 2018; Morean and Wedel, 2017), many studies merely correlate e-cigarette use to beliefs that e-cigarettes aid in weight control (Napolitano et al., 2018; Piñeiro et al., 2016).

There is an association between conventional cigarette use and BMI-status, as well as perceived weight among adolescents (Caria et al., 2009; Cawley et al., 2004; Potter et al., 2004; Plotnikoff et al., 2006; Seo et al., 2009; Tomeo et al., 1999); however, research examining associations between e-cigarette use and weight status in adolescents is limited (Cho et al., 2018; Mantey et al., 2018). Current understanding of the appeal of e-cigarettes in youth include availability of appealing flavors (e.g., fruit flavors), ability to use e-cigarettes covertly, decreased tobacco use/addiction potential, decreased harm potential, cost savings, and social acceptability (Camenga et al., 2017; Gorukanti et al., 2017; Harrell et al., 2016; McKelvey et al., 2018; Temple et al., 2017). Several recent studies have examined associations among adolescent BMI-based weight status and e-cigarette use (Delk et al., 2018; Green et al., 2018;

Cho et al., 2018). Cho et al. found that e-cigarette use was more prevalent in adolescents with perceived overweight and obesity, with female adolescents who perceived themselves as overweight more likely to use e-cigarettes than normal weight counterparts (2018). Delk et al. found that males with obesity had higher odds of past 30-day e-cigarette use, as compared to normal weight counterparts (2018). Mantey et al., the only study to date to examine weight intentions and e-cigarette use, analyzed data from the 2015 Youth Risk Behavior Survey (YRBS), a nationally representative survey of American high school students, and found an association between intention to lose weight and 30-day e-cigarette use (2018). Furthermore, gender differences were noted with e-cigarette use associated with greater odds of intention to lose weight among females, but among males, e-cigarette use was associated with greater odds of intentions to gain weight (2018). To date, no studies have examined this relationship in a diverse, middle school population.

In order to address current gaps about weight intentions, weight status, and e-cigarette use in adolescents, the current study will assess for associations between e-cigarette use and weight intentions among adolescents from a representative sample of Texas youth, after controlling for BMI, among other confounders. Our study builds upon previous research through evaluation of an ethnically diverse population of middle and high school students. We hypothesized that e-cigarette use is positively associated with intention to lose weight among adolescents with overweight or obesity, and that the relation is stronger among girls than boys, after adjustment for confounders.

2. Methods

2.1. Study design

A cross-sectional analysis was performed using data drawn from the Texas School Physical Activity and Nutrition (Texas SPAN) project, a Texas state-wide surveillance system developed to assess nutrition and physical activity attitudes, knowledge, and behaviors among school-aged children. SPAN utilizes a stratified, multistage probability sampling scheme in order to collect representative data from eight health service regions, with stratification of school district by urban center, other urban/suburban and rural, and Texas border and non-border areas. This design produces representative samples of 8th and 11th grade public school students in Texas. At the 8th grade level, 126 middle schools were targeted for sampling, representing 347,620 students, and 152 high schools representing 311,688 students targeted for participation at the 11th grade level. Participation rates were 62% for 8th grade students and 34% for 11th grade students. Data were collected during the 2015–2016 school years.

This study was reviewed and approved by the Institutional Review Board at the University of Texas Science Center at Houston, the Texas Department of State Health Services Institutional Review Board, as well as local school district review committees. Written active or passive informed consent was attained from all study participants.

2.2. Survey administration

Trained and certified project staff and state and county personnel administered the SPAN questionnaire and collected anthropometric measures. The survey was a pencil and paper questionnaire administered using a standard protocol and completed by the student in 30–45 min of provided time in a classroom setting.

Staff measured height with a portable stadiometer (PE-AIM-101 Stadiometer) to the nearest 0.1 cm and measured weight with a portable digital scale with remote display to the nearest 0.1 kg (Tanita DC-430U Dual Frequency Full Body Composition Monitor).

2.3. Study measures

Selection of confounders was guided by the literature on known

associations with e-cigarette use, weight intentions, and BMI-status (Gentzke et al., 2019; Mantey et al., 2018; Pérez et al., 2011; Peters, et al., 2018; Simon et al., 2018). Participants self-reported their grade level, sex, and ethnicity. Ethnicity was recoded as Black, Hispanic, or White/Other. Because none of the other ethnic groups exceeded 2% of the population, they were grouped together and included with the White ethnic group. Economic status was defined as the percentage of all students enrolled at each school eligible for free or reduced-price lunch (FRL). Eligibility for FRL is based upon federal poverty guidelines and a student's family income. This metric has frequently been used as a proxy for individual economic status with SPAN and other data (Pérez et al., 2011; Peters et al., 2018; Springer et al., 2010) given that student reports of individual economic status are frequently unreliable. One-third of the students, categorized as being in the lowest tertile of economic status, were from schools where >83.5% of their student population was eligible for FRL. Another third of students, categorized as being in the highest tertile of economic status were from schools that had 0 to <57.9% eligible for FRL, while students were characterized as being in the middle tertile of economic status if they were from schools with 57.9% to 83.5% eligible.

Dietary behavior was measured utilizing a previously created variable, the SPAN Healthy Eating Index, which assesses previous day consumption of both healthy (e.g. fruits, brown rice, vegetables) and unhealthy (e.g. dessert items, salty fried snacks) marker foods, as reported by the student (Ranjit, et al., 2015). Items were summed and scaled to a range of 0–100; higher values represent healthier diets. Physical activity behavior was measured through student reported participation in any organized sports team. This item was dichotomized, with all responses greater than 0 recoded as “Participates in organized physical activity.”

Questions relating to weight loss behavior were adapted and validated previously by Hoelscher et al. (2003). Intention to lose weight was assessed through a single item asking: “What are you trying to do about your weight?: Lose weight, Gain weight, Stay the same weight, Nothing.” This item was dichotomized, with all responses other than “lose weight,” recoded as a single category: “not intending to lose weight.”

Body Mass Index (BMI) was calculated based on the participant's measured height and weight. Based on the U.S. Centers for Disease Control and Prevention (CDC) age- and sex-adjusted percentiles, students were categorized as having normal weight, overweight, or obesity status if BMI was less than the 85th percentile, between the 85th and 95th percentile, or greater than the 95th respectively (CDC, 2018). Underweight students, which represented a small percentage of participants (2% of 8th grade and 2.5% of 11th grade students) were categorized as normal weight.

Prevalence of electronic cigarette use was assessed using two items taken from the Population Assessment of Tobacco and Human Health (PATH) Study [United States]. Students were asked if they had ever used an e-cigarette, and how many of the previous 30 days they had used e-cigarettes, with responses ranging from 1 through 30. For this analysis, responses to these items were combined into one dichotomized variable, recoded as: never/past e-cigarette user or current e-cigarette user, following the CDC's definition of a current smoker as any use in the past 30 days (CDC, n.d; Wang et al., 2019).

2.4. Data analysis

Unweighted counts and weighted frequency statistics for each demographic characteristic were calculated and reported among the full sample (n = 9056) and by e-cigarette use status. Description of intention to lose weight was further described with calculation and report of unweighted counts and weighted frequency statistics of weight intention by BMI class (n = 8589).

We performed a series of logistic regressions to evaluate our hypotheses. First, bivariate analysis between e-cigarette use and each

dependent variable was performed to test for association among the full sample. Next, we evaluated our hypothesis that e-cigarette use is a function of intention to lose weight through multivariable logistic regression among the BMI-class subpopulations with overweight (n = 1632) or obesity (n = 2142) with gender interaction, adjusted for several potential confounding variables: grade, gender, ethnicity, and economic status. Two additional multivariable logistic regressions were performed among the BMI-class subpopulation with overweight (n = 1564) or obesity (n = 2048), adjusted for all covariables including diet and physical activity to assess if our findings could be accounted for by these additional weight-related behaviors. To evaluate for gender interaction, marginal estimated probabilities for electronic cigarette use by gender categories were derived from each of the multiple logistic regression models by BMI-class, with tests for significance of difference in the strength of association ($p < 0.05$) across gender categories. Models for the normal weight subpopulation were omitted from analysis because their motivations may be distinct from those in the overweight and obese groups (Dressler and Smith, 2013a, 2013b; Durso et al., 2012; Opichka et al., 2019; Wu and Berry, 2018) and a substantially smaller proportion of normal weight students were intending to lose weight (about one quarter as compared to 75% or more in the overweight and obese groups). All statistical analyses were performed with Stata 16.0, using appropriate sampling weights to produce representative data for the entire state by grade, strata (the six urban/rural regions), race/ethnicity, and gender.

3. Results

3.1. Descriptive statistics

Overall, 9.4% of the weighted sample used e-cigarettes in the past 30 days. The sample was composed of 59.8% students with normal weight/underweight, 17.9% with overweight, and 22.3% with obesity. Among all students, nearly half (49.4%) intended to lose weight. Of the 40.2% of the sample with overweight or obesity, four in five (82.9%) intended to lose weight. More than half (50.9%) of the sample were Hispanic, 12.5% Non-Hispanic Black and 36.6% were Non-Hispanic White/Other. Participants were evenly distributed by gender and by grade level. The mean age of participants by grade was 13.6 years and 16.5 years in the eighth and eleventh grades, respectively. Across the entire weighted sample, 65.6% of students were classified as economically disadvantaged at the school level on average. Further descriptive statistics can be found in Tables 1 and 2.

3.2. Correlates of E-cigarette use

In bivariate analyses, weight intentions and BMI-class (unadjusted) were not found to predict e-cigarette use (Table 3). Females were found to be less likely to use e-cigarettes as compared to males (OR = 0.60, 95% CI: 0.42–0.86). Eleventh grade students were found to be 2.19 (95% CI: 1.39–3.46) times more likely to use e-cigarettes as compared to 8th grade students. No associations between e-cigarettes and race/ethnicity or economic status were noted in bivariate analysis. Dietary and physical activity behaviors were not found to predict e-cigarette use.

3.3. E-cigarette use and weight-related intentions

In multivariable analyses, among the subpopulation with obesity, we found a gender difference predicated upon weight intention. Use of e-cigarettes was significantly higher among males intending to lose weight than among females intending to lose weight (11% versus 6%, $p = 0.009$), among students with obesity. Among the overweight subpopulation, no association was found between e-cigarette use and weight-related intentions. These findings were consistent after controlling for weight-related behaviors (Fig. 1), physical activity and diet; among students with obesity, use of e-cigarettes was significantly higher among

Table 1
Descriptive statistics by e-cigarette use (Texas School Physical Activity and Nutrition, 2015–2016 Texas SPAN): unweighted sample size and weighted percentages,^a n = 9056.

	Full Sample n (weighted %)	Uses e-cigarettes n (weighted %)	Does not use e-cigarettes n (weighted %)
Percent of sample	100	9.4	90.6
Gender			
Male	4555 (51.1)	476 (62.4)	3733 (49.8)
Female	4501 (48.9)	315 (37.6)	3913 (50.2)
Grade			
8th grade	5421 (52.7)	395 (34.5)	4558 (53.7)
11th grade	3635 (47.3)	396 (65.5)	3088 (46.4)
Age by Grade (years) (mean (SD))			
Age, 8th grade	13.6 (0.6)	13.8 (0)	13.6 (0.6)
Age, 11th grade	16.5 (0.6)	16.7 (0.7)	16.5 (0.6)
Race/ethnicity			
Non-Hispanic White/Other	1810 (36.6)	147 (40.4)	1557 (36.5)
Hispanic/Latino	6630 (50.9)	593 (46.1)	5590 (51.9)
Non-Hispanic Black	616 (12.5)	51 (13.6)	499 (11.6)
Economic Status (mean (SD))			
Lowest tertile	92.5 (4.7)	92.7 (5.6)	92.5 (4.6)
Middle tertile	73.4 (6.9)	73.0 (6.9)	73.3 (6.9)
Highest tertile	31.2 (10.3)	26.7 (10.4)	31.8 (10.2)
Body Mass Index Class			
Normal Weight/Underweight	5002 (59.8)	430 (62.2)	4252 (60.2)
Overweight	1695 (17.9)	127 (13.3)	1464 (18.0)
Obese	2226 (22.3)	216 (24.5)	1855 (21.7)
Weight Intentions			
Not intending to change weight	744 (9.8)	78 (12.4)	639 (9.7)
Intending to lose weight	4628 (49.4)	414 (45.5)	4051 (49.8)
Intending to stay the same weight	1702 (20.2)	130 (15.5)	1511 (21.0)
Intending to gain weight	1617 (20.6)	161 (26.6)	1390 (19.5)
Sports Participation			
No sports team participation	2625 (34.1)	218 (35.3)	2307 (34.4)
Participates on sports teams	6192 (65.9)	569 (64.7)	5285 (65.6)
SPAN Healthy Eating Index	43.6 (7.0)	42.6 (7.0)	43.7 (6.9)

Abbreviations: SD, standard deviation.

^a Data drawn from the 2015–2016 Texas School Physical Activity and Nutrition Survey.

Table 2
Descriptive statistics of BMI-class by weight intention^a, n = 8589.

	Normal & Underweight Weight n (weighted %)	Students with Overweight n (weighted %)	Students with Obesity n (weighted %)
Weight Intentions			
Intending to lose weight	1511 (26.6)	1213 (75.6)	1856 (88.7)
Not intending to lose weight	3304 (73.4)	419 (24.4)	286 (11.3)

^a Data drawn from the 2015–2016 Texas School Physical Activity and Nutrition Survey.

males intending to lose weight as compared to females intending to lose weight (12% versus 6%, $p = 0.007$). As in bivariate analysis, neither sports participation nor dietary behavior significantly predicted e-cigarette use in the multivariable models. Furthermore, a sensitivity analysis conducted to examine the impact of utilizing different definitions of the

Table 3
Weighted univariate logistic regression evaluating the relationship between e-cigarette use and each covariate.^a

Independent Variable	E-cigarette Use	
	OR (95% CI)	p-value
Gender, n = 8437		
Male	Ref	
Female	0.60 (0.42–0.86) **	0.005
Grade, n = 8437		
8th grade	Ref	
11th grade	2.19 (1.39–3.46) ***	0.001
Race/ethnicity, n = 8437		
Non-Hispanic White/Other	Ref	
Hispanic/Latino	0.80 (0.50–1.28)	0.343
Non-Hispanic Black	1.06 (0.50–2.24)	0.880
Economic Status, n = 8437		
Lowest tertile	Ref	
Middle tertile	1.22 (0.79–1.88)	0.368
Highest tertile	1.21 (0.58–2.50)	0.612
Body Mass Index Class, n = 8344		
Normal Weight & Underweight	Ref	
Overweight	0.71 (0.47–1.08)	0.108
Obese	1.09 (0.58–2.06)	0.782
Weight Intentions, n = 8374		
Not intending to change weight	Ref	
Intending to lose weight	0.71 (0.40–1.25)	0.237
Intending to stay the same weight	0.57 (0.31–1.09)	0.089
Intending to gain weight	1.06 (0.53–2.11)	0.864
Sports Participation, n = 8379		
No sports team participation	Ref	
Participates on sports teams	0.96 (0.66–1.40)	0.839
SPAN Healthy Eating Index, n = 8432	0.98 (0.95–1.01)	0.138

Abbreviations: OR, odds ratio; CI, confidence interval; Ref, reference value.

Bold indicates statistical significance: * $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

^a Data drawn from the 2015–2016 Texas School Physical Activity and Nutrition Survey.

e-cigarette use variable (current smoker vs. never smoker, with past smokers excluded from analysis) revealed in all cases that results were comparable.

In multivariable analyses, when adjusting for all covariables including weight-related intentions and a gender interaction, we found e-cigarette use was not associated with grade, race/ethnicity, sports participation, nor the SPAN Healthy Eating Index in either weight-based subpopulation. Among adolescents with overweight we found, the highest tertile of economic status to be 2.90 (95% CI 1.09–7.67) times more likely to use e-cigarettes compared to the lowest tertile after adjusting for all covariables. In contrast, among adolescents with obesity, the middle tertile of economic status was found to be 1.96 (95% CI: 1.09–3.53) times more likely to use e-cigarettes compared to the lowest tertile after adjusting for all covariables, while the highest tertile was not associated with e-cigarette use.

4. Discussion

Our findings indicate that among adolescents with obesity, males intending to lose weight were twice as likely to use e-cigarettes as females intending to lose weight. This is in contrast to previous research which has shown that females are more likely to be motivated to use e-cigarettes by an intent to lose weight as compared to males (Mantey et al., 2018). Key differences between our study and Mantey et al. may explain differences in our findings. Our study population was composed of a more ethnically diverse population, with both younger students (middle school students) and a larger percentage of students with overweight and obesity. After controlling for other weight-related behaviors that may impact or cluster with e-cigarette use or weight intentions, we still found that e-cigarette use among those intending to

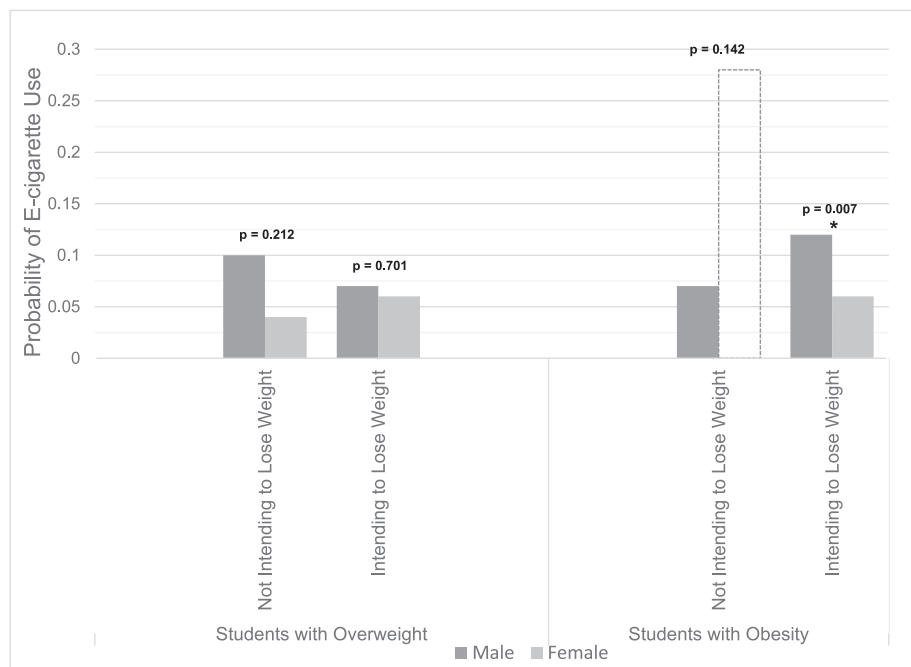


Fig. 1. Estimated Probability of Electronic Cigarette Use by Weight Intentions and Gender, Stratified by BMI-status. Gender difference estimates are derived from the weight-behavior adjusted logistic regression models for e-cigarette use with weight intention as a primary predictor, a gender interaction and adjusted for grade, race/ethnicity, economic status, sports participation and the SPAN Healthy Eating Index. A separate logistic regression model was performed for students with overweight ($n = 1564$) and students with obesity ($n = 2048$). Dashed lines indicate that the model estimate was unreliable for the indicated category due to small sample size ($n = 67$) among females with obesity not intending to lose weight. ^aData drawn from the 2015–2016 Texas School Physical Activity and Nutrition Survey. * indicates statistical significance $p \leq 0.05$.

lose weight was twice as likely among male students with obesity than among females with obesity.

Interestingly, no association was found between e-cigarette use and weight-related intentions among the subpopulation with overweight. This may represent that further deviance from normal weight carries a greater risk of e-cigarette use. It is possible that this reflects greater internalized weight stigma in the subpopulation with obesity as compared to those with overweight, leading to a higher risk of engaging in unhealthy weight behaviors, such as e-cigarette use.

Evaluation of e-cigarette use in middle school aged students is critical because in 2019, one in ten middle school students reported e-cigarette use in the past 30 days. Findings indicated there was an increased likelihood to use e-cigarettes among 11th graders as compared to 8th graders in bivariate analysis, but no differences between grades eight and eleven were found in multivariable models. This suggests that differences between these two age groups may be accounted for by the covariables.

Given the diversity of this sample, it was surprising to find no racial/ethnic group nor socioeconomic differences. Research by the CDC has shown that in 2018, e-cigarette use in high school students was highest among Non-Hispanic White students (26.8%) (Gentzke et al., 2019). In our sample, 8.9% of Hispanic students were e-cigarette users as compared to 8.1% of Non-Hispanic White students. Furthermore, data have shown e-cigarette use is more common in adolescents with higher socioeconomic status (Simon et al., 2018). In 2015, when our data was collected, the e-cigarette youth epidemic was in its infancy and prior to the introduction of the highly popular youth e-cigarette product, the JUUL, and explosion in advertising which may account for the lack of noted racial/ethnic and socioeconomic associations.

4.1. Study limitations and strengths

This paper has several limitations. Principally, we conducted cross-sectional analyses, so causal inferences cannot be made, nor can inferences of directionality be made; it cannot be determined if weight intention and/or BMI-status preceded and influenced e-cigarette use or if the associations were merely correlational. While our findings held after controlling for diet and physical activity, a longitudinal study is needed to further investigate these relationships and to determine if the

relationships suggested in this study reflect a clustering of unhealthy behaviors this study did not measure (e.g., drug use), rather than a possible motivation for e-cigarette use. This is particularly important for interpretation of our findings for use in guiding e-cigarette prevention and cessation interventions in youth.

As previously mentioned, the data for this analysis were collected prior to the sharp increase in e-cigarette use in youth. Small sample sizes in certain sub-categories may have affected our models. Since the number of female students with obesity not intending to lose weight was quite small, model estimates for this sub-category are unreliable in our adjusted multivariable models. Furthermore, our characterizations made may not adequately reflect the current state of affairs. The survey instrument in this study did not collect information on other important motivators or modifiers of e-cigarette use in youth, such as e-cigarette flavors or exposure to e-cigarette advertising (Harrell et al., 2016; Simon et al., 2018). Even so, it is possible that these motivators did not yet play a significant role in e-cigarette use because these marketing tactics were not as widespread. In addition, smoking behaviors were self-reported. Several studies have found adequately valid self-reported smoking rates measured by confidential surveys delivered in schools, as was the procedure for SPAN; however, these studies did not specifically evaluate e-cigarette smoking behaviors (Komro et al., 1993, 2004).

Defining economic status at the school level may limit our ability to draw conclusions based on this variable and may have resulted in the inconsistent findings among the subpopulation with obesity as compared to the subpopulation with overweight related to economic status. However, this metric is frequently used in SPAN and other analyses as a proxy for individual economic status (Pérez et al., 2011; Peters et al., 2018; Springer et al., 2010). It is considered appropriate as public school attendance is determined by zoning that often overlaps with current or historical residential zoning that results in homogeneity of economic status among students at any one school (Pérez et al., 2011; Peters et al., 2018; Springer et al., 2010; US Congress Joint Economic Committee, 2019).

Despite these limitations, this study has several strengths, including a multiethnic state representative sample at two grade levels, and the use of validated instruments.

5. Conclusion

With the relatively new public health concern of e-cigarette use in youth, it is important to understand the associations with use in this population. Building upon previous research indicating gender and BMI-based differences in patterns of use, the present study suggests that males with obesity who are intending to lose weight may be an important group to target for intervention given their higher use of e-cigarettes as compared to females intending to lose weight. Future research should evaluate the role of weight control motivations for e-cigarette use in adolescents with measures of temporality to allow for interpretations of causality, especially given the evolving nature of youth vaping and body image. Elucidating the relations between body size and e-cigarette use can help to disentangle the motivations for vaping among youth, as well as offer strategies for addressing both behaviors in intervention programs.

Funding

This work was supported by Texas Department of State Health Services with funds from the Title V Maternal and Child Health Block Grant to Texas (B04MC2937), and by the Michael & Susan Dell Foundation through the Michael & Susan Dell Center for Healthy Living.

CRedit authorship contribution statement

Ruth Sanchez: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Nalini Ranjit:** Software, Validation, Writing - review & editing, Supervision. **Steven H. Kelder:** Conceptualization. **Montana Gill:** Supervision. **Deanna M. Hoelscher:** Conceptualization, Writing - review & editing, Supervision.

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.

Acknowledgments

The authors would like to acknowledge all the participating school districts, schools, families, research staff, and state-wide partners who contributed to the success of SPAN. This study was funded by the Michael and Susan Dell Foundation through the Michael and Susan Dell Center for Healthy Living and the Texas Department of State Health Services (DSHS) with funds from the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) as part of an award totaling \$34,479,260 with 0.15% financed with non-governmental sources. The contents are those of the author(s) and do not necessarily represent the official views of, nor an endorsement, by Texas DSHS, HRSA, HHS, or the U.S. Government.

References

- Almenara, C.A., Fauquet, J., López-Guimerà, G., Massana, M.P., Sánchez-Carracedo, D., 2014. Self-perceived weight status, dieting and unhealthy weight-control behaviors among Spanish male adolescents. *Nutr. Hosp.* 30 (2), 301–305. <https://doi.org/10.3305/nh.2014.30.2.7596>.
- Bennett, B., Pokhrel, P., 2018. Weight concerns and use of cigarettes and e-cigarettes among young adults. *Int. J. Environ. Res. Publ. Health* 15 (6), 1084. <https://doi.org/10.3390/ijerph15061084>.
- Bloom, E.L., Farris, S.G., DiBello, A.M., Abrantes, A.M., 2019. Smoking-related weight and appetite concerns and use of electronic cigarettes among daily cigarette smokers. *Psychol. Health Med.* 24 (2), 221–228. <https://doi.org/10.1080/13548506.2018.1537495>.
- Brown, C.L., Skelton, J.A., Perrin, E.M., Skinner, A.C., 2016. Behaviors and motivations for weight loss in children and adolescents. *Obesity (Silver Spring)* 24 (2), 446–452. <https://doi.org/10.1002/oby.21370>.

- Camenga, D.R., Kong, G., Cavallo, D.A., Krishnan-Sarin, S., 2017. Current and former smokers' use of electronic cigarettes for quitting smoking: an exploratory study of adolescents and young adults. *Nicotine Tob. Res.* 19 (12), 1531–1535. <https://doi.org/10.1093/ntr/ntw248>.
- Caria, M.P., Bellocco, R., Zambon, A., Horton, N.J., Galanti, M.R., 2009. Overweight and perception of overweight as predictors of smokeless tobacco use and of cigarette smoking in a cohort of Swedish adolescents. *Addiction* 104 (4), 661–668. <https://doi.org/10.1111/j.1360-0443.2009.02506.x>.
- Cawley, J., Markowitz, S., Tauras, J., 2004. Lighting up and slimming down: the effects of body weight and cigarette prices on adolescent smoking initiation. *J. Health Econ.* 23 (2), 293–311. <https://doi.org/10.1016/j.jhealeco.2003.12.003>.
- Centers for Disease Control and Prevention, 2018. Defining Childhood Obesity. Last accessed July 8, 2020. Retrieved from <<https://www.cdc.gov/obesity/childhood/defining.html>>.
- Centers for Disease Control and Prevention, n.d. 1991–2019 High School Youth Risk Behavior Survey Data. Last accessed on Dec 29, 2020. Available at <<http://yrbs-explorer.services.cdc.gov/>>.
- Cho, B.Y., Seo, D.C., Lin, H.C., Lohrmann, D.K., Chomistek, A.K., Hendricks, P.S., Timsina, L., 2018. Adolescent weight and electronic vapor product use: comparing BMI-based with perceived weight status. *Am. J. Prev. Med.* 55 (4), 541–550. <https://doi.org/10.1016/j.amepre.2018.05.010>.
- Cole, A.G., Aleyan, S., Battista, K., Leatherdale, S.T., 2020. Trends in youth e-cigarette and cigarette use between 2013 and 2019: insights from repeat cross-sectional data from the COMPASS study. *Can. J. Publ. Health* 112 (1), 60–69. <https://doi.org/10.17269/s41997-020-00389-0>.
- Cullen, K.A., Ambrose, B.K., Gentzke, A.S., Apelberg, B.J., Jamal, A., King, B.A., 2018. Notes from the field: use of electronic cigarettes and any tobacco product among middle and high school students—United States, 2011–2018. *MMWR Morb. Mortal Wkly. Rep.* 67 (45), 1276–1277. <https://doi.org/10.15585/mmwr.mm6745a5>.
- Delk, J., Creamer, M.R., Perry, C.L., Harrell, M.B., 2018. Weight status and cigarette and electronic cigarette use in adolescents. *Am. J. Prev. Med.* 54 (1), e31–e35. <https://doi.org/10.1016/j.amepre.2017.09.007>.
- Dressler, H., Smith, C., 2013a. Environmental, personal, and behavioral factors are related to body mass index in a group of multi-ethnic, low-income women. *J. Acad. Nutr. Diet.* 13 (12), 1662–1668. <https://doi.org/10.1016/j.jand.2013.07.009>.
- Dressler, H., Smith, C., 2013b. Health and eating behavior differs between lean/normal and overweight/obese low-income women living in food-insecure environments. *Am J Health Promot.* 27 (6), 358–365. <https://doi.org/10.4278/ajhp.120119-QUAL-55>.
- Durso, L.E., Latner, J.D., Hayashi, K., 2012. Perceived discrimination is associated with binge eating in a community sample of non-overweight, overweight, and obese adults. *Obes Facts* 5 (6), 869–880. <https://doi.org/10.1159/000345931>.
- Frank, R., Claumann, G.S., Felden, É.P., Silva, D.A., Pelegrini, A., 2018. Body weight perception and body weight control behaviors in adolescents. *J. Pediatr. (Rio J.)* 94 (1), 40–47. <https://doi.org/10.1016/j.jped.2017.03.008>.
- French, S.A., Jeffery, R.W., 1995. Weight concerns and smoking: a literature review. *Ann. Behav. Med.* 17 (3), 234–244. <https://doi.org/10.1007/BF02903918>.
- Gentzke, A.S., Creamer, M., Cullen, K.A., Ambrose, B.K., Willis, G., Jamal, A., King, B.A., 2019. Vital Signs: Tobacco Product Use Among Middle and High School Students - United States, 2011–2018. *MMWR Morb. Mortal Wkly. Rep.* 68 (6), 157–164. <https://doi.org/10.15585/mmwr.mm6806e1>.
- Green, V.R., Silveira, M.L., Kimmel, H.L., Conway, K.P., 2018. Body mass index and tobacco-product use among US youth: Findings from wave 1 (2013–2014) of the Population Assessment of Tobacco and Health (PATH) Study. *Addict. Behav.* 81, 91–95. <https://doi.org/10.1016/j.addbeh.2018.02.005>.
- Gorukanti, A., Delucchi, K., Ling, P., Fisher-Travis, R., Halpern-Felsher, B., 2017. Adolescents' attitudes towards e-cigarette ingredients, safety, addictive properties, social norms, and regulation. *Prev. Med.* 94 (65) <https://doi.org/10.1016/j.ypmed.2016.10.019>.
- Harrell, M.B., Weaver, S.R., Loukas, A., Creamer, M., Marti, C.N., Jackson, C.D., Heath, J. W., Nayak, P., Perry, C.L., Pechacek, T.F., Eriksen, M.P., 2016. Flavored e-cigarette use: Characterizing youth, young adult, and adult users. *Prev. Med. Rep.* 5, 33–40. <https://doi.org/10.1016/j.pmedr.2016.11.001>.
- Harriger, J.A., Thompson, J.K., 2012. Psychological consequences of obesity: weight bias and body image in overweight and obese youth. *Int. Rev. Psychiatry* 24 (3), 247–253. <https://doi.org/10.3109/09540261.2012.678817>.
- Haynes, A., Kersbergen, I., Sutin, A., Daly, M., Robinson, E., 2018. A systematic review of the relationship between weight status perceptions and weight loss attempts, strategies, behaviours and outcomes. *Obesity Rev.* 19 (3), 347–363. <https://doi.org/10.1111/obr.v19.310.1111/obr.12634>.
- Hoelscher, D.M., Day, R.S., Kelder, S.H., Ward, J.L., 2003. Reproducibility and validity of the secondary level School-Based Nutrition Monitoring student questionnaire. *J. Am. Diet. Assoc.* 103 (2), 186–194. <https://doi.org/10.1053/jada.2003.50031>.
- Jiménez, P.F., Jiménez, A.C., Bacardi, M.G., 2017. Body-image dissatisfaction in children and adolescents: a systematic review. *Nutr. Hosp.* 34 (2), 479–489. <https://doi.org/10.20960/nh.455>.
- Kapan, A., Stefanac, S., Sandner, I., Haider, S., Grabovac, I., Dorner, T.E., 2020. Use of electronic cigarettes in European populations: a narrative review. *Int. J. Environ. Res. Publ. Health* 17 (6), 1971. <https://doi.org/10.3390/ijerph17061971>.
- Klesges, R.C., Meyers, A.W., Klesges, L.M., LaVasque, M.E., 1989. Smoking, body weight, and their effects on smoking behavior: a comprehensive review of the literature. *Psychol. Bull.* 106 (2), 204. <https://doi.org/10.1037/0033-2909.106.2.204>.
- Komro, K.A., Kelder, S.H., Perry, C.L., Klepp, K.I., 1993. Effects of a saliva pipeline procedure on adolescent self-reported smoking behavior and youth smoking prevention outcomes. *Prev. Med.* 22 (6), 857–865. <https://doi.org/10.1006/pmed.1993.1077>.

- Komro, K.A., Perry, C.L., Munson, K.A., Stigler, M.H., Farbaksh, K., 2004. Reliability and Validity of Self-Report Measures to Evaluate Drug and Violence Prevention Programs. *J. Child Adolesc. Subst. Abuse*. 13 (3), 17–51. https://doi.org/10.1300/J029v13n03_02.
- Lanza, H.I., Pittman, P., Batshoun, J., 2017. Obesity and cigarette smoking: extending the link to e-cigarette/vaping use. *Am. J. Health Behav.* 41 (3), 338–347. <https://doi.org/10.5993/AJHB.41.3.13>.
- Laverty, A.A., Filippidis, F.T., Vardavas, C.I., 2018. Patterns, trends and determinants of e-cigarette use in 28 European Union Member States 2014–2017. *Prev. Med.* 116, 13–18. <https://doi.org/10.1016/j.ypmed.2018.08.028>.
- Mantey, D.S., Omega-Njemnobi, O., Kelder, S.H., 2018. E-cigarette use is associated with intentions to lose weight among high school students. *Nicotine Tob. Res.* 22 (5), 838–842. <https://doi.org/10.1093/ntr/nty245>.
- McKelvey, K., Baiocchi, M., Halpern-Felsher, B., 2018. Adolescents' and young adults' use and perceptions of pod-based electronic cigarettes. *JAMA Netw. Open* 1 (6). <https://doi.org/10.1001/jamanetworkopen.2018.3535> e183535-e183535.
- Morean, M.E., L'insalata, A., 2018. Electronic cigarette use among individuals with a self-reported eating disorder diagnosis. *Int. J. Eat. Disord.* 51 (1), 77–81. <https://doi.org/10.1002/eat.22793>.
- Morean, M.E., Wedel, A.V., 2017. Vaping to lose weight: predictors of adult e-cigarette use for weight loss or control. *Addict. Behav.* 66, 55–59. <https://doi.org/10.1016/j.addbeh.2016.10.022>.
- Napolitano, M.A., Lynch, S.B., Stanton, C.A., 2018. Young adult e-cigarette users: perceptions of stress, body image, and weight control. *Eat. Weight Disord* 25 (2), 487–495. <https://doi.org/10.1007/s40519-018-0627-6>.
- Opichka, K., Smith, C., Levine, A.S., 2019. Problematic eating behaviors are more prevalent in african american women who are overweight or obese than African American women who are lean or normal weight. *Fam. Commun. Health* 42 (2), 81–89. <https://doi.org/10.1097/FCH.0000000000000222>.
- Pérez, A., Hoelscher, D.M., Springer, A.E., Brown, H.S., Barroso, C.S., Kelder, S.H., Castrucci, B.C., 2011. Physical activity, watching television, and the risk of obesity in students, Texas, 2004–2005. *Prev. Chronic* 8 (3), A61.
- Peters, E.N., Bae, D., Barrington-Trimis, J.L., Jarvis, B.P., Leventhal, A.M., 2018. Prevalence and sociodemographic correlates of adolescent use and polyuse of combustible, vaporized, and edible cannabis products. *JAMA Netw. Open* 1 (5), e182765. <https://doi.org/10.1001/jamanetworkopen.2018.2765>.
- Piñeiro, B., Correa, J.B., Simmons, V.N., Harrell, P.T., Menzie, N.S., Unrod, M., Meltzer, L.R., Brandon, T.H., 2016. Gender differences in use and expectancies of e-cigarettes: online survey results. *Addict. Behav.* 52, 91–97. <https://doi.org/10.1016/j.addbeh.2015.09.006>.
- Plotnikoff, R.C., Bercovitz, K., Rhodes, R.E., Loucaides, C.A., Karunamuni, N., 2006. Testing a conceptual model related to weight perceptions, physical activity and smoking in adolescents. *Health Educ. Res.* 22 (2), 192–202. <https://doi.org/10.1093/her/cyl065>.
- Potter, B.K., Pederson, L.L., Chan, S.S., Aubut, J.A.L., Koval, J.J., 2004. Does a relationship exist between body weight, concerns about weight, and smoking among adolescents? An integration of the literature with an emphasis on gender. *Nicotine Tob. Res.* 6 (3), 397–425. <https://doi.org/10.1080/14622200410001696529>.
- Ranjit, N., Wilkinson, A.V., Lytle, L.M., Evans, A.E., Saxton, D., Hoelscher, D.M., 2015. Socioeconomic inequalities in children's diet: the role of the home food environment. *Int. J. Behav. Nutr. Phys. Act.* 12 (Suppl 1), S4. <https://doi.org/10.1186/1479-5868-12-S1-S4>.
- Schindler-Ruwisch, J., Augustson, E., Lynch, K., Patrick, H., 2015. BMI and smoking: interrelated factors among cessation website users. *Am. J. Health Behav.* 39 (3), 330–337. <https://doi.org/10.5993/AJHB.39.3.5>.
- Seo, D.C., Jiang, N., Kolbe, L.J., 2009. Association of smoking with body weight in US high school students, 1999–2005. *Am. J. Health Behav.* 33 (2), 202–212. <https://doi.org/10.5993/ajhb.33.2.9>.
- Simon, P., Camenga, D.R., Morean, M.E., Kong, G., Bold, K.W., Cavallo, D.A., Krishnan-Sarin, S., 2018. Socioeconomic status and adolescent e-cigarette use: the mediating role of e-cigarette advertisement exposure. *Prev. Med.* 112, 193–198. <https://doi.org/10.1016/j.ypmed.2018.04.019>.
- Springer, A.E., Kelder, S.H., Barroso, C.S., Drenner, K.L., Shegog, R., Ranjit, N., Hoelscher, D.M., 2010. Parental influences on television watching among children living on the Texas-Mexico border. *Prev. Med.* 51 (2), 112–117. <https://doi.org/10.1016/j.ypmed.2010.05.013>.
- Strong, D.R., Myers, M., Linke, S., Leas, E., Hofstetter, R., Edland, S., Al-Delaimy, W.K., 2015. Gender differences influence overweight smokers' experimentation with electronic nicotine delivery systems. *Addict. Behav.* 49, 20–25. <https://doi.org/10.1016/j.addbeh.2015.05.003>.
- Temple, J.R., Shorey, R.C., Lu, Y., Torres, E., Stuart, G.L., Le, V.D., 2017. E-cigarette use of young adults motivations and associations with combustible cigarette alcohol, marijuana, and other illicit drugs. *Am J. Addict.* 26 (4), 343–348. <https://doi.org/10.1111/ajad.12530>.
- Tomeo, C.A., Field, A.E., Berkey, C.S., Colditz, G.A., Frazier, A.L., 1999. Weight concerns, weight control behaviors, and smoking initiation. *Pediatrics* 104 (4), 918–924. <https://doi.org/10.1542/peds.104.4.918>.
- Ursoniu, S., Putnoky, S., Vlaicu, B., 2011. Body weight perception among high school students and its influence on weight management behaviors in normal weight students: a cross-sectional study. *Wien. Klin. Wochenschr.* 123 (11–12), 327–333. <https://doi.org/10.1007/s00508-011-1578-3>.
- United States Congress Joint Economic Committee, 2019. Zoned Out: How School and Residential Zoning Limit Educational Opportunity. Last accessed on Dec 31 2020. Available at <<https://www.jec.senate.gov/public/index.cfm/republicans/2019/11/zoned-out-how-school-and-residential-zoning-limit-educational-opportunity>>.
- US Department of Health and Human Services, 2016. E-cigarette use among youth and young adults. A report of the Surgeon General. Atlanta, GA.
- Wang, T.W., Gentzke, A.S., Creamer, M.R., Cullen, K.A., Holder-Hayes, E., Sawdey, M.D., Anic, G.M., Portnoy, D.B., Hu, S., Homa, D.M., Jamal, A., Neff, L.J., 2019. Tobacco product use and associated factors among middle and high school students—United States, 2019. *MMWR Morb. Mortal Wkly. Rep.* 68 (12), 1–22. <https://doi.org/10.15585/mmwr.ss6812a1>.
- Wee, C.C., Rigotti, N.A., Davis, R.B., Phillips, R.S., 2001. Relationship between smoking and weight control efforts among adults in the United States. *Arch. Intern. Med.* 161 (4), 546–550. <https://doi.org/10.1001/archinte.161.4.546>.
- Wu, Y.K., Berry, D.C., 2018. Impact of weight stigma on physiological and psychological health outcomes for overweight and obese adults: a systematic review. *J. Adv. Nurs.* 74 (5), 1030–1042. <https://doi.org/10.1111/jan.13511>.
- Zhang, J., Seo, D.C., Kolbe, L., Lee, A., Middlestadt, S., Zhao, W., Huang, S., 2011. Comparison of overweight, weight perception, and weight-related practices among high school students in three large Chinese cities and two large US cities. *J. Adolesc. Health* 48 (4), 366–372. <https://doi.org/10.1016/j.jadohealth.2010.07.015>.