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Bidirectional relationships between nicotine vaping and maladaptive eating behaviors among young adults

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ABSTRACT

Background: Past research indicates that young adult cigarette smokers are at risk of engaging in maladaptive eating behaviors (MEBs); however, whether this relationship extends to nicotine vaping is unclear. The current study assessed bidirectional associations between four types of MEBs and nicotine vaping among young adults.
Methods: 1,303 young adults (20.5 ± 2.3 years; 63 % female) from a public, urban university were recruited and completed online surveys at six-month intervals from spring 2021 (W1) to spring 2023 (W5). Past 30-day nicotine vaping and four types of MEBs (susceptibility to external cues, emotional eating, routine restraint, and compensatory restraint) were evaluated.
Results: Longitudinal cross-lagged models examined the bidirectional relationships between past 30-day nicotine vaping and each type of MEB across five waves. Nicotine vaping predicted both susceptibility to external cues ($\beta = 0.10$, $p < .05$; Wave 2 to 3) and emotional eating ($\beta = 0.08$, $p < .05$; Wave 1 to 2). A significant cross-lag regression (Wave 4 to 5) showed nicotine vaping predicted to routine restraint ($\beta = 0.08$, $p < .05$), and routine restraint predicted to nicotine vaping ($\beta = 0.12$, $p < .05$).
Conclusions: Results indicated that nicotine vaping predicted MEBs; however, the type of MEB differed across waves, which may have been due to the COVID-19 pandemic context. Nicotine vaping predicted to MEBs reflecting vulnerability to the external environment and emotion regulation during a period of heightened restrictions, whereas later when pandemic restrictions had ceased nicotine vaping predicted only to routine restraint. Integrating research and practice on nicotine vaping and MEBs may inform public health efforts to decrease co-occurring health-risks in young adulthood.

1. Introduction

The period of young adulthood between 18 and 29 years, also known as emerging adulthood (Arnett, 2023), presents a critical developmental stage for examining co-occurring health-risks, as comorbid health conditions during this period set the foundation for life-long physical health impairments, mental health declines, and early mortality risk (Schulte & Hser, 2013; Stewart et al., 2009; Zheng et al., 2017). Given the high prevalence of both tobacco/nicotine use (17.2 % past 30-day nicotine vaping and 8.5 % past 30-day cigarette smoking in 2022 using nationally representative data; Patrick et al., 2023), and obesity (40 % based on 2017–2020 nationally representative estimates; body mass index ≥ 95th percentile; Stierman et al., 2021) in young adulthood, greater attention has recently been paid to understanding the relationship between tobacco/nicotine use and obesity in young adults (Huang et al., 2013; Lanza et al., 2017; Mason & Leventhal, 2021; Mason et al., 2022). Moreover, the eating disorder literature has focused on tobacco/nicotine use as a weight control strategy among younger populations (Hochgraf et al., 2023; Kechter et al., 2022; Morean et al., 2020). However, little empirical work has assessed the relationship between specific maladaptive eating behaviors and tobacco/nicotine use, particularly nicotine vaping, among young adults.

Maladaptive eating behaviors (henceforth referred to as MEBs) describe myriad eating behaviors (e.g., food restriction, environmental food triggers, emotional eating) that increase risk of eating disorders (including binge eating disorder and bulimia nervosa; Hay, 2020; Kober & Boswell, 2018; Leerhr et al., 2015). Adolescence and young adulthood present as critical periods for the development of eating disorder symptomology (Romano et al., 2022; Silén & Keski-Rahkonen, 2022; Ward et al., 2019). Though an abundant literature has shown a strong

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association between cigarette smoking and eating disorders or MEBs (Qeadan et al., 2023; Solmi et al., 2016), few empirical studies have assessed the association between nicotine vaping and eating disorder symptoms or MEBs. Morean and L'Insalate (2018) reported higher frequency of e-cigarette use and nicotine concentration among adults with a self-reported eating disorder. A study on adolescents in Korea showed that maladaptive weight control behaviors increased as e-cigarette/vaping use increased (Lee & Lee, 2019). Two recent studies using college student samples reported mixed findings; Ganson & Nagata (2021) indicated higher odds of eating disorders or eating disorder risk among past 30-day e-cigarette/vaping users, but Hennigan et al. (2022) reported no significant associations between eating disorder symptoms and nicotine vaping. Though past findings suggest a positive association between nicotine vaping and MEBs may exist, additional research is needed. Longitudinal studies are particularly warranted to assess the bidirectional relationships of nicotine vaping and MEBs, as it is yet unknown whether nicotine vaping predicts MEBS or MEBs predicts nicotine vaping. A greater understanding of co-occurring nicotine vaping and MEBs in young adulthood is likely to inform prevention/intervention efforts aimed to offset the high cost of tobacco/nicotine use and obesity/eating disorders on individual health outcomes and the health care system.

Beyond the need to examine longitudinal associations between nicotine vaping and MEBs in young adulthood, assessing whether associations differ across unique contexts can better inform how nicotine vaping and MEBs are interrelated. MEBs in young adulthood often emerge as a response to the multiple stressors occurring during the transition from adolescence to young adulthood (i.e., college academics and social life, transition into the workforce, increased autonomy and financial responsibility; Lipsky et al., 2017; Lyzwinski et al., 2018; Nelson et al., 2008). In addition, the unique context created by the COVID-19 pandemic for young adults - the physical and social environmental restrictions, transition from in-person to remote learning, employment/financial insecurity, and overall unpredictability - appear to have contributed to maladaptive eating behaviors (Flaudias et al., 2020; Freizinger et al., 2022; Mason et al., 2021). Prior to the COVID-19 pandemic, motivations for nicotine vaping among young adults revolved less around coping with stress and more around peer use, curiosity/experimentation, and desirability to be socially accepted (Kinouani et al., 2020; Leavens et al., 2019; Vu et al., 2019). Even with physical and social barriers (e.g., decreased access to tobacco/nicotine retailers, moving back home, restrictions on in-person gatherings) nicotine vaping increased among young adults during the COVID-19 pandemic. Just prior to the pandemic, in 2019, past 30-day nicotine vaping prevalence among young adults was 10.7 %. Through the pandemic years, prevalence increased almost 40 % (13.2 % in 2020, 16.9 % in 2021, and 17.2 % in 2022; Patrick et al., 2023), indicating that initial decreases in nicotine vaping at the onset of the pandemic (Kreslake et al., 2021) rebounded quickly during the pandemic (Kreslake et al., 2023). Furthermore, nicotine vaping did increase (Bennett et al., 2023; Parks et al., 2022) or quantity remained unchanged (Sokolovsky et al., 2021) among those with a past e-cigarette/vaping history and coping with pandemic-related stress. Given these links between pandemic-related stress and both MEBs and nicotine vaping, associations between nicotine vaping and MEBs during the pandemic may be qualitatively different compared to the post-pandemic context.

Limitations on our knowledge regarding nicotine vaping and MEBs in young adulthood are three-fold: 1) there is a dearth of research examining whether associations between tobacco/nicotine use and MEBs extend to nicotine vaping, and current research is mixed; 2) due to the lack of longitudinal studies on nicotine vaping and MEBs, bidirectional relationships are unknown; and 3) it is unclear whether the COVID-19 pandemic context influenced the relationship between nicotine vaping and MEBs. To address these limitations, the current study used data from a longitudinal cohort (five assessments across a two-year period; 2021–2023) to examine bidirectional associations between nicotine vaping and four types of MEBs (e.g., susceptibility to external cues, emotional eating, routine restraint, compensatory restraint) among young adults attending college. With close to two-thirds (62.0 %) of U.S. high school graduates attending college (U.S. Bureau of Labor Statistics, 2022), and evidence that undergraduates are at high risk for both nicotine vaping and MEBs (Lyzwinski et al., 2018; Patrick et al., 2023), college students are an increasingly valuable population for understanding development of co-occurring health-risk behaviors. Given previous studies linking cigarette smoking and MEBs (Qeadan et al., 2023; Solmi et al., 2016), and preliminary studies indicating positive associations between nicotine vaping and MEBs (Ganson & Nagata, 2021; Lee & Lee, 2019; Morean and L'Insalate (2018)), we expected positive associations to be identified between nicotine vaping and MEBs across time. We also speculated that changes in pandemic restrictions would result in differences in how nicotine vaping and types of MEBs were related across time, though further hypotheses on these differences were not specified. A better understanding of nicotine vaping and MEBs associations in young adulthood benefit public health efforts that aim to combat two of most concerning public health issues facing younger populations – substance use and obesity. Furthermore, research evaluating co-occurring health-risks during developmental and contextual periods that may heighten these risks can lead to more targeted and cost-effective public health campaigns and interventions that consider compounding health-risks under unique contexts.

2. Methods

2.1. Participants and procedure

Participants were 1303 young adults from a longitudinal cohort study (baseline, 6-, 12-, 18-, and 24-month assessments between 2021 and 2023) conducted at a large, urban public university in Southern California. During Spring 2021, 93 classes were randomly selected for participant recruitment from all non-asynchronous undergraduate classes. Of the 93 randomly selected classes, 67 (72.0 %) instructors agreed to a 10-minute class recruitment visit. Class visits (which took place online due to COVID-19 restrictions) were conducted by the PI from late January to late April 2021. Following the study presentation, eligible ($\geq$18 years, currently enrolled undergraduate) and interested participants were able to review the informed consent online. Once a student completed and submitted the informed consent form online, the PI individually emailed the participant an online survey link and unique verification code. Participants completed a 15-minute health behavior survey that included questions on eating habits, exercise, weight status, substance use, mood, personality, and social relationships; surveys were completed in spring 2021 and then at six-month intervals (fall 2021, spring 2022, fall 2022, and spring 2023). To avoid identifying information being collected within the survey, the unique verification code was used to link a participant's survey with their informed consent. Participants received a $15 Amazon e-giftcard for each survey. All study protocol was approved by the California State University, Long Beach Institutional Review Board.

Of 2,651 students targeted in 67 randomly selected classes, 1,361 students (51.3 %) participated in the study. Participants between 18 and 29 years at baseline (spring 2021) were selected for current study analyses (N = 1,303; 95.7 % of total sample); participants ranged from undergraduate freshman to seniors. Retention rates among the analytic sample were: 1085 (83.3 %) at six-month follow-up; 982 (75.4 %) at one-year follow-up; 890 (68.3 %) at 18-month follow-up; and 888 (68.2 %) at two-year follow-up. The average age of participants was M = 20.52 (SD = 2.29) years. The sample closely aligned with the gender and race/ethnicity composition of the institution's undergraduate population. Participants in the sample included: 62.5 % female, 34.8 % male; 2.5 % transgender or gender variant/non-binary/non-conforming; 41.2 % Hispanic/Latino/a/x, 30.3 % Asian-American/Asian, 18.0 % Caucasian/White, 1.8 % African-American/Black, 7.5 % Multiracial; 0.8 %

Pacific Islander/Native Hawaiian, and 0.1 % Native American/Alaskan Native. About two-thirds (62.8 %) reported their parents attended some college or a higher level of education.

3. Measures

3.1. Tobacco/Nicotine use

Past 30-day use of nicotine vaping at baseline (spring 2021) and six-month (fall 2021), one-year (spring 2022), 18-month (fall 2022), and two-year (spring 2023) follow-ups were assessed with participant self-report. Participants were first asked: "Have you ever used a vaporizer to vape nicotine (e.g., Puff Bar, JUUL, Box mod)?". If participants reported lifetime use for nicotine vaping, they were then asked a corresponding question on past 30-day use: "In the past 30 days have you vaped nicotine?". Responses for past 30-day use were coded as 0 = *no past 30-day use,* 1 = *past 30-day use*.

3.2. Eating behaviors

Four types of maladaptive eating behaviors (MEBs): 1) susceptibility to external cues, 2) emotional eating, 3) compensatory restraint, and 4) routine restraint, were assessed from Waves 1 to 5 (baseline to two-year follow-up) with the validated Weight-Related Eating Questionnaire (WREQ; Schembre & Geller, 2011; Schembre et al., 2009). The WREQ is comprised of 16 items; participants responded to each item with a five-point likert scale (1 = *Not at all* to 5 = *Completely*). A mean score for each type of eating behavior is derived from specific items. Sample items for each type of MEB include: "If I see others eating, I have a strong desire to eat too" (susceptibility to external cues); "I tend to eat when I am disappointed or feel let down" (emotional eating); "I purposely hold back at meals in order not to gain weight" (routine restraint); and "If I eat more than usual during a meal, I try to make up for it at another meal" (compensatory restraint). Reliability estimates for the sample across waves were: α = 0.77-0.82 susceptibility to external cues; α = 0.88.90 emotional eating; α = 0.77-0.79 routine restraint; and α = 0.77-0.86 compensatory restraint.

3.3. Covariates

Age, gender, ethnicity/race, and parent highest education were self-reported at baseline. Participants reported their age (in years), gender (female, male, transgender female, transgender male, gender variant/non-binary/non-conforming), race/ethnicity (African-American/Black, Asian-American/Asian, Caucasian/White, Hispanic/Latino/a/x, Native American/Alaskan Native, Pacific Islander/Native Hawaiian, Multiracial, and other), and highest parent education (less than some high school, some high school, graduated from high school, some college, graduated from college, earned graduate degree). Gender was recoded into two dummy variables: *female* vs. *non-female and male* vs. *non-male* (including two dummy variables vs. one allowed females and males to be compared to the rest of the sample, including transgender and non-binary participants). Race/ethnicity was recoded into dummy variables (*Asian American/Asian* vs. *non-Asian American/Asian*) for racial/ethnic groups representing ≥ 10 % of the sample (89.2 % of the total sample was comprised of Hispanic/Latino/a/x: 41.4 %, Asian American/Asian: 29.6 %; and Caucasian/White: 18.2 %). Highest parent education was recoded into a binary variable (≥*some college* vs. < *some college*). Past 30-day cigarette smoking at baseline (0 = *no past 30-day use,* 1 = *past 30-day use*) was also included as a covariate.

3.4. Analysis plan

Following descriptive analyses, a series of five-timepoint cross-lagged regression models were conducted to examine the bidirectional associations between each type of MEB (susceptibility to external cues, emotional eating, routine restraint, compensatory restraint) and past 30-day nicotine vaping. Analyses were conducted in Mplus 8.9 using the Weighted Least Squares with Mean and Variance adjustment estimation procedure, which presents as an ideal option for modeling both categorical and continuous data, as well as accommodating missingness in longitudinal models (Muthén & Muthén, 2017). Of the 1303 participants, four were excluded from cross-lag analyses due to missingness on a covariate, resulting in a final analytical sample of 1299 young adults.

For each of the four cross-lagged regression models conducted, we estimated 12 paths from each covariate to baseline (W1) nicotine vaping and type of MEB. Eight cross-lagged associations were assessed with direct paths from baseline (W1) nicotine vaping to MEB at six-month follow-up (W2) and baseline MEB to nicotine vaping at six-month follow-up, through 18-month follow-up (W4) nicotine vaping to MEB at two-year follow-up (W5) and 18-month follow-up MEB to nicotine vaping at two-year follow-up. Eight stability paths between consecutive waves (e.g., W1 to W2) were also estimated for nicotine vaping and MEB, as well as five covariances between nicotine vaping and MEB at each wave.

4. Results

4.1. Descriptive characteristics

Table 1 presents descriptive characteristics for sociodemographics and key study variables. As detailed above, participants were 62.5 % female; 41.2 % Hispanic/Latino/a/x; and the mean (SD) age at baseline was 20.52 (2.29) years. Past 30-day nicotine vaping ranged from 8.8 % to 10.6 % across assessment waves. The means for each type of MEB (possible range 1.00–5.00) across waves were: 2.69–2.72 for susceptibility to external cues, 2.15–2.18 for emotional eating, 1.94–2.01 for routine restraint, and 2.55–2.64 for compensatory restraint.

4.2. Cross-lagged regression analyses

Of the four cross-lagged regression models estimated, three resulted in significant associations between nicotine vaping and MEBs (nicotine vaping x susceptibility of external cues, nicotine vaping x emotional eating, nicotine vaping x routine restraint). Figs. 1-3 present results of these three significant models.

Fig. 1 presents the cross-lagged path model between nicotine vaping and susceptibility to external cues. One of the eight cross-lagged paths was significant; the path from six-month (W2) nicotine vaping to one-year (W3) susceptibility to external cues (β = 0.10, p <.05). All stability paths were positive and significant; past 30-day nicotine vaping and susceptibility of external cues predicted to their respective variable between W1 and W2 (β = 0.91, p <.001 vaping; β = 0.77, p <.001 external cues), W2 and W3 (β = 0.93, p <.001 vaping; β = 0.85, p <.001 external cues), W3 and W4 (β = 0.92, p <.001 vaping; β = 0.91, p <.001 external cues), and W4 and W5 (β = 0.93, p <.001 vaping; β = 0.85, p <.001 external cues). Within wave covariances were not significant. Significant covariate associations are presented in Fig. 1.

The cross-lag model assessing associations between nicotine vaping and emotional eating (Fig. 2) revealed one significant cross-lag path from baseline (W1) nicotine vaping to six-month (W2) emotional eating (β = 0.08, p <.05). All stability paths were positive and significant; past 30-day nicotine vaping and emotional eating predicted to their respective variable between W1 and W2 (β = 0.92, p <.001 vaping; β = 0.86, p <.001 emotional eating), W2 and W3 (β = 0.93, p <.001 vaping; β = 0.88, p <.001 emotional eating), W3 and W4 (β = 0.92, p <.001 vaping; β = 0.90, p <.001 emotional eating), and W4 and W5 (β = 0.93, p <.001 vaping; β = 0.85, p <.001 emotional eating). Within wave covariances were not significant. Significant covariate associations are presented in Fig. 2.

Fig. 3 presents the cross-lagged path model between nicotine vaping and routine restraint. The cross-lag paths from nicotine vaping to

Table 1
Sociodemographic characteristics and key study variables (N = 1303).

Demographics	n(%) or *Mean* ± *SD*
Age (years)	20.52 ± 2.29
Gender	
Female	815 (62.5 %)
Male	454 (34.8 %)
Non-Binary	26 (2.0 %)
Transgender	6 (0.5 %)
Ethnicity/Race	
African-American/Black	24 (1.8 %)
Asian-American/Asian	395 (30.3 %)
Caucasian/White	235 (18.0 %)
Hispanic/Latino/a/x	537 (41.2 %)
Native American/Alaska	1 (0.1 %)
Native	11 (0.8 %)
Pacific Islander/Native	98 (7.5 %)
American	
Multiracial	
Parent Highest Education Level	
≥ some college	831 (63.8 %)
< some college	469 (36.0 %)
Past 30-day Nicotine Vaping	Reported nicotine vaping / respondents at specific wave
Baseline (W1)	113/1277 (8.8 %)
Six-month follow-up (W2)	109/1082 (10.1 %)
One-year follow-up (W3)	100/981 (10.2 %)
18-month follow-up (W4)	94/890 (10.6 %)
Two-year follow-up (W5)	85/889 (9.6 %)
Maladaptive Eating Behaviors: Susceptibility to External Cues	
Baseline (W1)	2.71 ± 0.95
Six-month follow-up (W2)	2.70 ± 0.95
One-year follow-up (W3)	2.69 ± 0.95
18-month follow-up (W4)	2.69 ± 0.95
Two-year follow-up (W5)	2.74 ± 0.97
Maladaptive Eating Behaviors: Emotional Eating	
Baseline (W1)	2.18 ± 0.1.04
Six-month follow-up (W2)	2.15 ± 0.1.04
One-year follow-up (W3)	2.15 ± 1.01
18-month follow-up (W4)	2.15 ± 1.01
Two-year follow-up (W5)	2.16 ± 1.05
Maladaptive Eating Behaviors: Routine Restriction	
Baseline (W1)	1.94 ± 0.97
Six-month follow-up (W2)	1.99 ± 0.99
One-year follow-up (W3)	1.96 ± 0.95
18-month follow-up (W4)	1.96 ± 0.95
Two-year follow-up (W5)	2.01 ± 0.98
Maladaptive Eating Behaviors: Compensatory Restriction	
Baseline (W1)	2.62 ± 1.12
Six-month follow-up (W2)	2.60 ± 1.16
One-year follow-up (W3)	2.55 ± 1.14
18-month follow-up (W4)	2.55 ± 1.14
Two-year follow-up (W5)	2.64 ± 1.16

routine restraint (β = 0.08, p <.05) and routine restraint to nicotine vaping (β = 0.12, p <.05) from eighteen-month follow-up (W4) to two-year follow-up (W5) were significant. All stability paths were positive and significant; past 30-day nicotine vaping and routine restraint predicted their respective variable between W1 and W2 (β = 0.91, p <.001 vaping; β = 0.82, p <.001 routine restraint), W2 and W3 (β = 0.93, p <.001 vaping; β = 0.89, p <.001 routine restraint), W3 and W4 (β = 0.92, p <.001 vaping; β = 0.89, p <.001 routine restraint), and W4 and W5 (β = 0.92, p <.001 vaping; β = 0.84, p <.001 routine restraint). Within wave covariances were not significant. Significant covariate associations are presented in Fig. 3.

5. Discussion

The current study expanded on past research highlighting significant associations between tobacco/nicotine use and maladaptive eating behaviors (MEBs) among young adults by assessing bidirectional relationships between nicotine vaping and MEBs. Key findings indicate that the strong association reported between cigarette smoking and MEBs (Qeadan et al., 2023; Solmi et al., 2016) does extend to nicotine vaping, as most earlier studies reported (Ganson & Nagata, 2021; Lee & Lee, 2019; Morean and L'Insalate (2018)). Furthermore, nicotine vaping predicted to multiple types of MEBs – susceptibility to external cues, emotional eating, routine restraint – while only routine restraint predicted to nicotine vaping; consequently, the pathway from nicotine vaping to MEBs appears to be more predominant. The physical and social environment also may play a role in how nicotine vaping and MEBs are related. During pandemic restrictions, nicotine vaping predicted to MEBs underlying environmental cues and emotional regulation, but post-pandemic restrictions the relationship between nicotine vaping and MEBs was specific to those characterized by routine restraint.

In addition to the already stressful challenges young adults transitioning from adolescence endure (e.g., increased financial responsibilities, college, entering the workforce, etc.), the COVID-19 pandemic increased difficulties in navigating social contexts (Grim et al., 2023; Hagedorn et al., 2022). At the outset of the pandemic, the vast majority of U.S. universities/colleges moved from in-person courses and on-campus activities to virtual modes of instruction and interaction. The college students in this study experienced significant physical and social restrictions between baseline (spring 2021) and one-year follow up (spring 2022). The 'lockdown' COVID-19 restrictions in California that restricted capacity for most businesses were officially lifted in June 2021, but a full unrestricted re-opening of state public universities/college campuses did not occur until fall 2022. During this period of greater restrictions, nicotine vaping predicted to greater susceptibility to external cues and emotional eating. Though the underlying risk processes explaining the pathway from nicotine vaping and these specific types of MEBs are presently unknown, we speculate that young adults engaging in nicotine vaping during this period were more vulnerable to restrictions due to greater emotional dysregulation (Brockenberry et al., 2022; Reff&Baschnagel, 2021). Greater emotion dysregulation may have also increased MEBs specifically linked to emotion reactivity and environmental triggers. Thus, the physical and social restrictions placed on young adult nicotine vapers may not just have contributed to increased use (Bennett et al., 2023; Parks et al., 2022), but also to developing MEBs reflecting a dysregulated response to the stressful pandemic environment (Flaudias et al., 2020; Freizinger et al., 2022; Mason et al., 2021; Parks et al., 2022).

Although this sample did not allow us to evaluate whether bidirectional relationships between nicotine vaping and MEBs post-pandemic restrictions were similar to pre-pandemic relationships or relationships earlier in the pandemic, the bidirectional relationships between nicotine vaping and routine restraint post-pandemic restrictions suggests pre-pandemic findings linking nicotine vaping to weight control/management continue. Studies using pre-pandemic data have shown significant associations between e-cigarette use (or more frequent e-cigarette use) and attempts to lose weight or control weight (Hochgraf et al., 2023; Morean & Wedel, 2017). Additionally, two longitudinal studies, one analyzing pre-pandemic data (Mason et al., 2022) and one analyzing data collected during the pandemic (Kechter et al., 2022) reported tobacco-related weight control beliefs predicted to e-cigarette initiation and maintenance.

Given that routine restraint was the only MEB that predicted nicotine vaping in this study, future studies should address this specific link. Noting this prediction occurred at the end of the study when all pandemic restrictions had recently lifted, we hypothesize that young adults felt heightened stress related to a changing food context (e.g., more opportunities to eat outside the home), and thus enacted a restraint routine as a weight management/maintenance strategy. The increased stress is likely to have influenced the development of maladaptive coping strategies, such as nicotine vaping, in efforts to control/manage weight.

The findings of this study, while promising in their ability to identify bidirectional relationships between nicotine vaping and specific MEBs, need to be interpreted with limitations in mind. The use of a sample

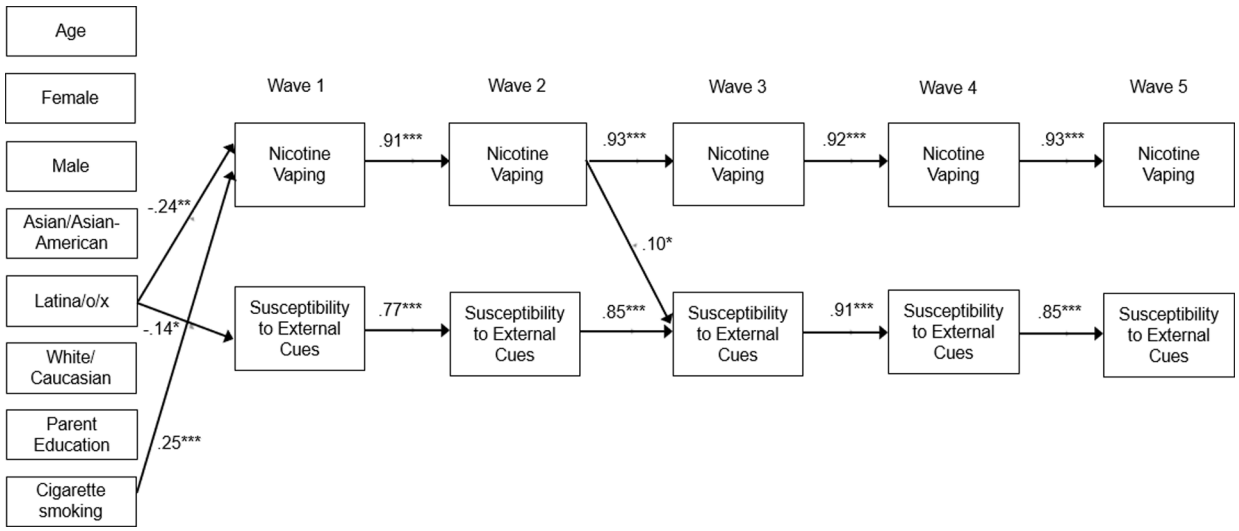

Fig. 1. Cross-lagged path model examining bidirectional associations between nicotine vaping and susceptibility to external cues for eating The cross-lagged path model examined bidirectional associations across five waves (Wave 1: baseline; Wave 2: six-month follow-up; Wave 3: one-year follow-up; Wave 4: 18-month follow-up; Wave 5: two-year follow-up). $X^2(8) = 9.92$, $p > .05$; CFI = 0.98; TLI = 0.98; RMSEA = 0.03. Estimates are from standardized solution (STDYX). Only significant paths are shown. [a]gender was coded separately as female vs. non-female and male vs. non-male to include non-binary and transgender participants in analysis; [b]Highest parent education coded as ≥ some college vs. < some college.

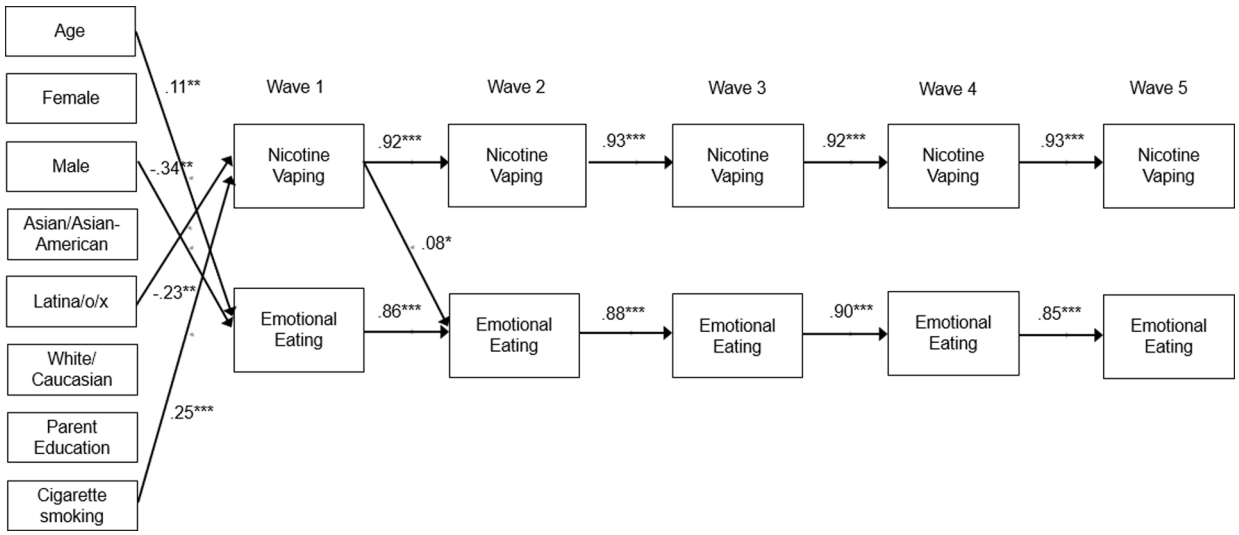

Fig. 2. Cross-lagged path model examining bidirectional associations between nicotine vaping and emotional eating. The cross-lagged path model examined bidirectional associations across five waves (Wave 1: baseline; Wave 2: six-month follow-up; Wave 3: one-year follow-up; Wave 4: 18-month follow-up; Wave 5: two-year follow-up). $X^2(8) = 4.60$, $p > .05$; CFI = 0.99; TLI = 0.99; RMSEA = 0.02. Estimates are from standardized solution (STDYX). Only significant paths are shown. [a]gender was coded separately as female vs. non-female and male vs. non-male to include non-binary and transgender participants in analysis; [b]Highest parent education coded as ≥ some college vs. < some college.

specific to the Southern California region limits generalizability of findings but does increase the likelihood young adults in this study were exposed to similar COVID-19 physical/social restrictions (including those implemented by their university) and tobacco/nicotine policies and trends during the period of assessment. The focus on college students also precludes generalizability to all young adults; however, the high rate (62.0 %) of graduating U.S high school students enrolling directly into college suggests that college students are becoming increasingly representative of the U.S. young adult population (U.S. Bureau of Labor Statistics, 2022). It is important to note that participants in the study ranged from college freshman to seniors at baseline; consequently, the social context likely changed for those graduating before the study ended. The study also relied on self-report of nicotine vaping and MEBs, though this is the most common method of measuring substance use behaviors and underlying motivations for eating behavior. Due to low cell counts for high-frequency nicotine vaping use, a dichotomous variable was used to measure past 30-day nicotine vaping at each wave. Though notable large epidemiological studies have also relied on dichotomous past 30-day nicotine vaping measures (e.g., Cohn et al., 2019; Nguyen et al., 2019; Pierce et al., 2023), we recognize that the use of a dichotomous variable limits the variability in the sample, and thus a comprehensive understanding of how nicotine vaping and MEBs are interrelated. Finally, albeit the study was able to examine longitudinal, bidirectional relationships from a period of greater to lesser pandemic restrictions, the assessment period did not begin until Spring 2021; thus, bidirectional relationships between nicotine vaping and MEBs either before or during the onset of pandemic restrictions is unknown.

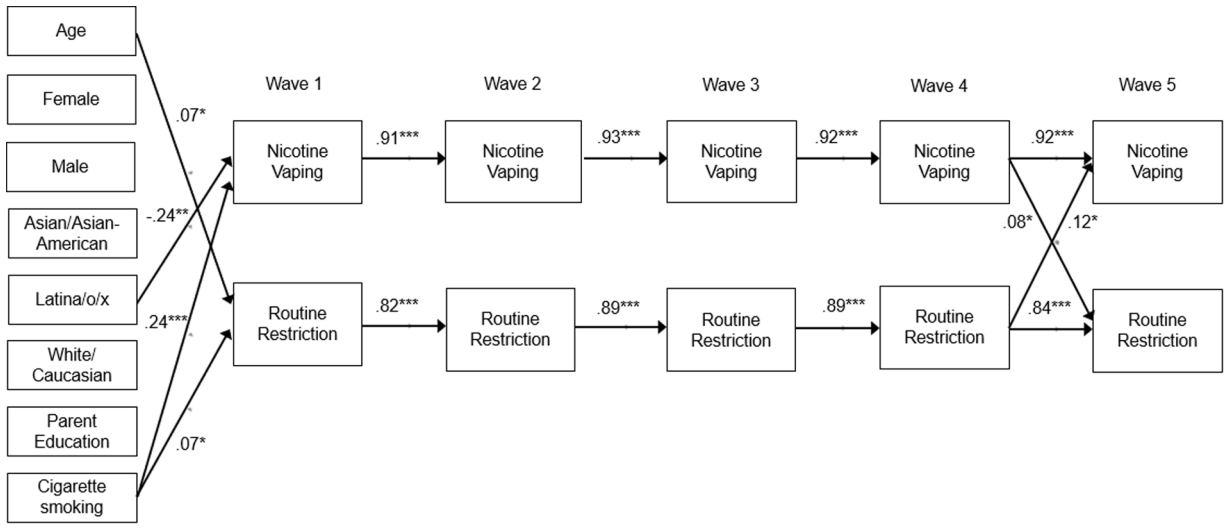

Fig. 3. Cross-lagged path model examining bidirectional associations between nicotine vaping and routine restrictive eating. The cross-lagged path model examined bidirectional associations across five waves (Wave 1: baseline; Wave 2: six-month follow-up; Wave 3: one-year follow-up; Wave 4: 18-month follow-up; Wave 5: two-year follow-up). $X^2(8) = 15.29$, $p > .05$; CFI = 0.99; TLI = 0.99; RMSEA = 0.02. Estimates are from standardized solution (STDYX). Only significant paths are shown. [a]gender was coded separately as female vs. non-female and male vs. non-male to include non-binary and transgender participants in analysis; [b]Highest parent education coded as ≥ some college vs. < some college.

Nevertheless, acknowledging the significant associations between nicotine vaping and MEBs is likely to benefit prevention/ intervention efforts aimed at decreasing co-occurring health-risks in young adults. Past research shows that nicotine vaping is associated with future tobacco/nicotine dependence (Parks et al., 2022; Vogel et al., 2020) and injurious health outcomes, such as respiratory disease symptoms (Braymiller et al., 2020; Tackett et al., 2023). The current study showed that nicotine vaping also appears to pose a risk for future MEBs; consequently, when screening for nicotine vaping during routine health visits, probing for MEBs may also be of benefit. Screening, brief intervention, and referral to treatment (SBIRT) interventions have been found to be successful for myriad substance use, including nicotine vaping (Kurdak et al., 2023; Sterling et al., 2022), and recent studies show promise for eating disorder symptomology as well (Holden & Simerson, 2023; Peat & Felter, 2022). Though the MEBs examined in this study are not clinical eating disorder diagnoses, they do underlie eating disorder symptomology, which suggests SBIRT interventions screening for MEBs, particularly routine restraint, may be useful for identifying early indicators of maladaptive coping strategies to manage weight, such as nicotine vaping.

Greater empirical work assessing the underlying processes explaining pathways between nicotine vaping and MEBs (e.g., emotional dysregulation, weight management), is warranted. Young adults have endured the challenges of navigating their education, employment, and socialization through a restrictive pandemic lens, and are now facing the stressors of a post-pandemic context. Though there is consensus that tobacco/nicotine use and MEBs are common responses to these stressors in young adults (Brytek-Matera (2021) Brytek-Matera (2021); Donaldson et al., 2022), recognizing these two health-risk behaviors are inextricably linked is vital for improving public health efforts to decrease co-occurring health-risks. Moreover, evaluating whether qualitative differences exist across nicotine/tobacco products (cigarette smoking vs. nicotine vaping) and MEBs may further refine and improve public health initiatives.

Though empirical work on nicotine vaping and MEBs is in its infancy, previous findings and this study indicate that limited healthcare resources may be used more effectively by simultaneously tackling multiple health-risks in young adults vs. a more siloed approach to harm reduction efforts. For example, web-based interventions targeting different health-risks, like substance use and binge eating, are using similar behavior change techniques (Humphreys et al., 2021; Thomas Craig et al., 2021). Consequently, a future direction for harm reduction strategies in young adulthood, including SBIRT and ehealth prevention/ intervention treatments, is to shift focus from one health-risk to address multiple interrelated health risks, such nicotine vaping and MEBs.

CRediT authorship contribution statement

H. Isabella Lanza: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Kailey Waller:** Writing – review & editing, Investigation, Conceptualization. **Lalaine Sevillano:** 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

The data that has been used is confidential.

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