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Evaluation of socioecological factors on health behaviors and weight change during major life event: A cross-sectional study using data collected during the COVID-19 pandemic

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Abstract

Background: Socioecological factors are associated with key health behaviors that are critical for weight management, and major life events may disrupt engagement in these behaviors. However, the influence of socioecological factors on health behaviors in the midst of major life events is not clear and is difficult to study due to the random and sporadic nature of their occurrence. The COVID-19 pandemic provided a unique opportunity to study a major life event and its impacts on diet, physical activity, and body weight.

Objective: This cross-sectional study aimed to investigate associations between socioecological factors (environmental, interpersonal, and individual) and self-reported weight change during a major life event using data collected during the COVID-19 pandemic, and whether the associations were mediated through self-reported changes in eating and physical activity behaviors.

Methods: Participants self-reported socioecological factors, weight change, and changes in eating behaviors (EB) and physical activity (PA) via online questionnaires between December 2020 and October 2021. Changes in EB and PA were measured using scales with higher scores reflecting more positive changes during the COVID-19 pandemic.

Results: Participants (n = 1283) were mostly female (84.9%) with age 52.1 ± 14.1 years (mean ± SD) and BMI of 32.9 ± 8.2 kg/m^2. Stronger healthy eater and exercise identities (individual factors) were associated with higher EB scores (EBS) and PA scores (PAS), respectively (p's < 0.00001). Less discouragement for healthy eating by family/friends (interpersonal factor) was associated with higher EBS (p = 0.002). Higher EBS and PAS were associated with weight loss. The indirect effect of healthy eater identity (−0.72; 95% CI: −0.90, −0.55) and discouragement

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for diet (0.07; 95% CI: 0.03, 0.12) on weight change through EBS were significant, as was the indirect effect of exercise identity (−0.25; 95% CI: −0.35, −0.15) on weight change through PAS.

Conclusions: Stronger identities and less discouragement from family/friends may support health promoting behaviors and weight loss during a major life event, as well as identify additional behavioral targets for lifestyle interventions.

Clinical Trial Registration: IWCR was registered at ClinicalTrials.gov (NCT04907396).

KEYWORDS
behavioral science, diet, physical activity, weight change, weight management

1 | INTRODUCTION

It is well-known that gradual weight gain occurs over time in the majority of adults as they age. Observed changes in body weight are generally not continuous or linear but episodic. Often, perturbations to energy balance, both intentional and not, cause weight changes in either direction that are followed by periods of net energy balance and steady-state weight, which has been referred to as the "ratchet effect" pattern of weight change.[1]

Life events related to health (e.g., illness or death), occupation (e.g., retirement or loss of job), and interpersonal situations (e.g., divorce or relationship problems) can impact body weight change in either direction. In particular, life events associated with weight gain are less positive, controllable, and predictable compared to life events associated with weight loss.[2] Life events associated with weight gain can affect body weight by altering diet and physical activity patterns and are associated with decreased adherence to diet and physical activity recommendations.[2–4] It has been estimated that a single major life event can lead to 2.31 kg of weight gain.[3] Most major life events are either unexpected (e.g., illness and injury, etc.) or occur sporadically at the population level (e.g., loss of job and divorce, etc.), making it difficult to study their impacts on health-related behaviors and weight management.

The COVID-19 pandemic provided a unique opportunity to study a major life event experienced simultaneously by a large number of people and its impacts on diet, physical activity, and body weight. At the beginning of the pandemic, policies such as social restrictions and self-isolation were implemented, which significantly limited individuals' activities outside of their homes. This pandemic-induced environment coupled with the subsequent lockdown period impacted diet, physical activity, and sedentary time.[5] A meta-analysis revealed that a significant mean weight gain of 1.57 kg was observed during the lockdown period in Spring 2020.[6] The effects persisted even after the lockdowns were lifted.[7]

This study was informed by socioecological models, which propose that factors at the environmental, interpersonal, and individual levels influence dietary and physical activity behaviors and thus affect weight management.[8] At the environmental level, results from systematic reviews suggested that higher perceived accessibility and availability to healthy food are associated with healthy dietary habits.[9] Findings from meta-analyses suggested that higher perceived neighborhood walkability is associated with greater physical activity.[10] At the interpersonal level, encouraging social support from family and friends is positively associated with dietary behaviors[11] and physical activity.[12] Conversely, discouragement from family and friends for healthy eating is associated with negative eating behaviors.[13] At the individual level, the extent to which an individual personally identifies with health-related behaviors (e.g., healthy eater and exercise identities) is an emerging factor that may promote long-term behavior maintenance.[14–20]

It is evident that socioecological factors are associated with eating and physical activity behaviors, which are critical for weight management. However, it is currently unknown whether these socioecological factors impact eating and physical activity behaviors during major life events. Thus, the purpose of this cross-sectional study was to investigate whether selected socio-ecological factors were associated with self-reported weight change during a major life event using data collected during the COVID-19 pandemic and whether the associations were mediated through self-reported changes in eating and physical activity behaviors. It was hypothesized that supportive food and physical activity environments, encouraging social support for healthy eating and physical activity, and healthy eater and exercise identities would be associated with reductions or maintenance of self-reported body weight. Positive self-reported changes in eating and physical activity behaviors would mediate these associations. Conversely, it was hypothesized that discouragement from family and friends for eating a healthy diet would be negatively associated with healthy eating behavior, which would be associated with weight gain.

2 | METHODS

2.1 | Study participants

This study included participants enrolled in the International Weight Control Registry (IWCR) and resided in the United States (U.S.). The

IWCR is an ongoing observational study aiming to understand factors contributing to long-term weight loss success. The inclusion criteria for the IWCR were adults aged 18 years and above who had attempted weight loss or expressed interest in losing weight. Details regarding recruitment and data collection can be found elsewhere.[21] Briefly, U.S. participants were recruited from clinical trials relevant to obesity, recruitment databases, affiliated healthcare networks, weight management centers, and community partners. Potential participants received recruitment materials through email, flyers, and social media posts. Participants also entered the IWCR directly from the public IWCR website (https://internationalweightcontrolregistry.org/). The IWCR was approved by the institutional review board at Tufts University (MODCR-04-13075) and registered at ClinicalTrials.gov (NCT04907396). Prior to participation, all participants signed the electronic consent via REDCap. All data were collected and managed using REDCap electronic data capture tools hosted at the University of Alabama at Birmingham.[22,23]

An overview of the sample size determination, data selection and cleaning, and measures are depicted in Figure 1. For the present study, only U.S. participants who enrolled between December 2020 and October 2021 and completed the selected questionnaires were included in the analyses. U.S. participants were excluded from the present study if they did not meet the inclusion criteria for the IWCR, reported age below 18 years, reported implausible height (<121.9 cm or >218.4 cm) and implausible weight (<13.6 kg or >453.6 kg),[24] did not respond to the COVID-19 questionnaire, reported extreme values of weight loss during the COVID-19 pandemic, and did not report any independent variables, mediators, and weight change.

2.2 | Structural models

Two mediation models (Eating Behavior Model (M1) and Physical Activity Model (M2)) were constructed. In the Eating Behavior Model

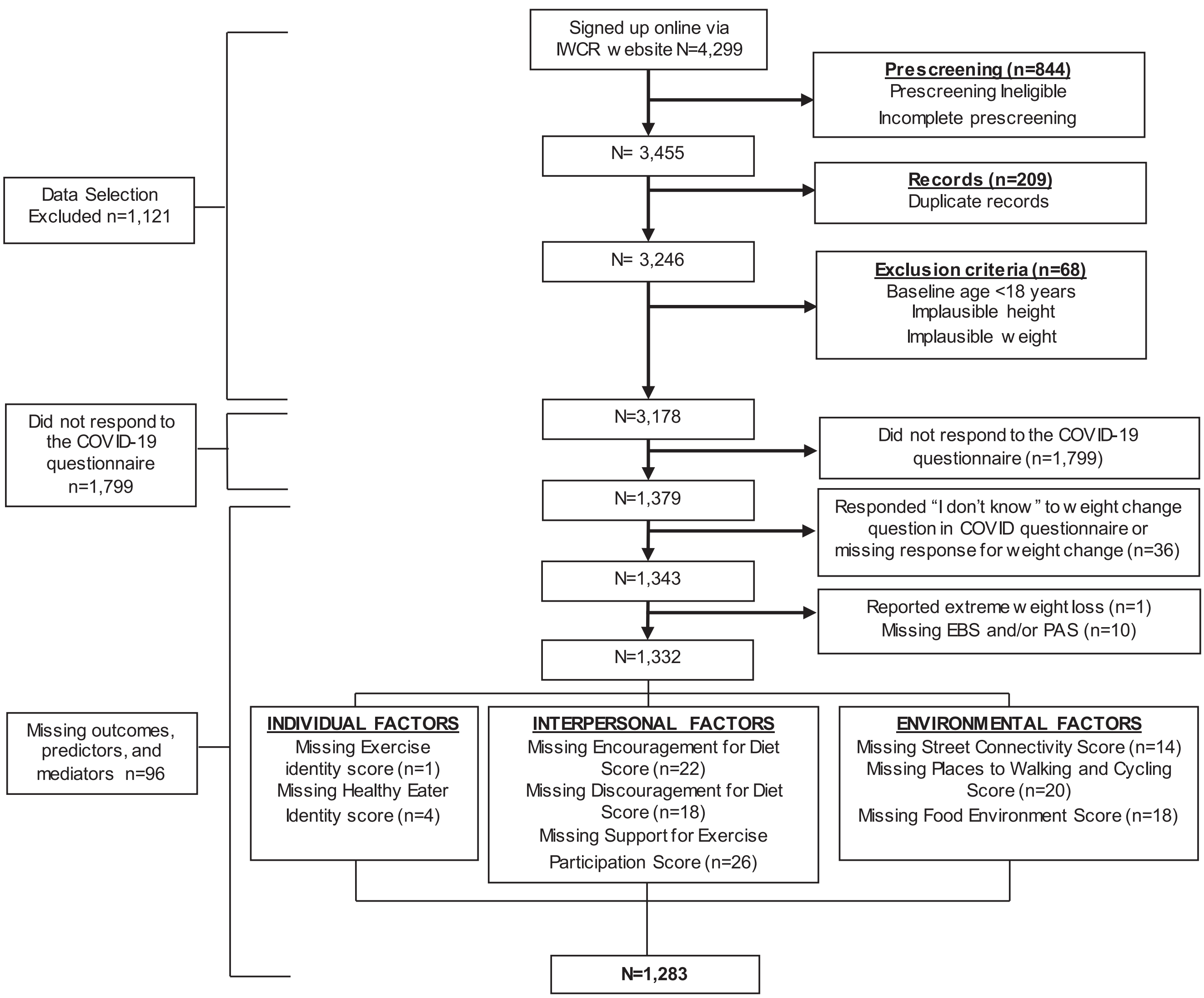

FIGURE 1 Depicts participant enrollment, retention, and inclusion in the statistical analysis. EBS, Eating Behavior Score; PAS, Physical Activity Score.

(M1), socioecological factors (food environment, encouragement for diet, discouragement for diet, and healthy eater identity) were the independent variables (x), self-reported weight change during the COVID-19 pandemic was the dependent variable (y), and Eating Behavior Score (EBS) (i.e., a score created to assess self-reported change in eating behavior during the COVID-19 pandemic) was the putative mediator. In the Physical Activity Model (M2), the socio-ecological factors (street connectivity, places for walking and cycling, support for exercise participation, and exercise identity) were the independent variables, self-reported weight change during the COVID-19 pandemic was the dependent variable, and Physical Activity Score (PAS) (i.e., a score created to assess self-reported change in physical activity behavior during the COVID-19 pandemic) was the putative mediator.

2.3 | Independent socioecological variables

All survey items used in this study are shown in Supporting Information S1.

2.3.1 | Food environment

Perceived neighborhood's availability of healthy food was assessed using the questions from the Multiethnic Study of Atherosclerosis (MESA).[25] Three questions were included: (1) A large selection of fruits and vegetables is available in my neighborhood, (2) The fresh fruits and vegetables in my neighborhood are of high quality, and (3) A large selection of low-fat products is available in my neighborhood. Participants were asked to consider their neighborhood as the area within a 20-min walk or approximately a mile from their home. Responses to these questions were recorded on a 5-point Likert scale ranging from 0 (strongly disagree) to 4 (strongly agree). A total score was calculated by summing all the items, resulting in a summed score of 0 (low availability) to 12 (high availability).[25]

2.3.2 | Physical activity environment

Perceived walkability was measured using the street connectivity subscale of the abbreviated Neighborhood Environment Walkability Scale (NEWS-A)[26] and the places for walking and cycling subscale of the Neighborhood Environment Walkability Scale (NEWS).[27] The street connectivity subscale consisted of two questions: (1) The distance between intersections in my neighborhood is usually short, and (2) There are many alternative routes for getting from place to place in my neighborhood. The places for walking and cycling subscale consisted of five questions: (1) There are sidewalks on most of the streets in my neighborhood, (2) The sidewalks in my neighborhood are well maintained (paved, even, and not a lot of cracks), (3) There are bicycle or pedestrian trails in or near my neighborhood that are easy to get to, (4) Sidewalks are separated from the road/traffic in my neighborhood by parked cars, and (5) There is a grass/dirt strip that separates the streets from the sidewalks in my neighborhood. Participants provided responses on a scale ranging from 1 (strongly disagree) to 4 (strongly agree). Average scores were calculated for each subscale with higher scores representing higher walkability.

2.3.3 | Interpersonal factors

Social Support for Diet and Social Support for Exercise developed by Sallis et al. were used to measure perceived social support.[28] The surveys used in this study combined perceived social support from family and friends, whereas the original survey measured support from family and friends separately. Survey items and scoring instructions are shown in Supporting Information S1. Due to the published factor structure of the Social Support for Exercise survey,[28] the punishment and reward subscale was not calculated in the current study. The Social Support for Diet survey included 10 items and two subscales: a five-item "encouragement" subscale and a five-item "discouragement" subscale. The Social Support for Exercise survey included 10 items and a single score for "exercise participation." Both Social Support for Diet and Social Support for Exercise surveys use a response scale ranging from 1 (none) to 5 (very often). Subscale scores were calculated by summing items within each subscale. For diet encouragement and exercise participation subscales, higher scores indicated greater support from family and friends. For the diet discouragement subscale, a higher score reflected more discouragement from family and friends.

2.3.4 | Individual factors

Exercise identity was assessed using the four-item exercise identity scale developed by de Bruijin and van den Putte.[29] Healthy eater identity was assessed using a four-item scale adapted from the four-item exercise identity scale. The four questions included: (1) Engaging in (sufficient exercise/healthy eating) is something that fits the way I want to live, (2) Engaging in (sufficient exercise/healthy eating) is something that fits who I am, (3) I see myself as someone who engages in (sufficient exercise/healthy eating), and (4) I am a typical person who engages in (sufficient exercise/healthy eating). For both identity scales, the scores were averaged and ranged from −3 (strongly disagree) to +3 (strongly agree) with a higher score indicating stronger identities. Caldwell et al. validated both four-item exercise identity and healthy eater identity scales among IWCR participants.[30] The results indicated a high correlation between exercise identity and exercise behaviors as well as healthy eater identity and eating behaviors. These findings were further supported by the convergent and discriminate validity.

2.4 | Putative mediators: EBS and PAS

The COVID-19 questionnaire, developed by the IWCR team, was used to assess changes in eating and physical activity behaviors as well as weight change during the COVID-19 pandemic. For changes in eating during the pandemic, five items were used: (1) Consumption of high-calorie foods, (2) Consumption of low-calorie foods (e.g., fruit, vegetables), (3) Frequency of cooking at home, (4) Frequency of ordering from restaurants and fast-food places, and (5) Stress-related or emotional eating. Changes in physical activity behaviors were assessed using six items reflective of the domains of physical activity in the International Physical Activity Questionnaire (IPAQ)[31]: (1) Physical activity as part of the job (excluding commuting), (2) Physical activity for transportation, (3) Physical activity for housework, house maintenance, and caring for family, (4) Physical activity for recreation, sport, and leisure, (5) Amount of time spent sitting, and (6) Amount of daily screen time. Responses ranged from −2 (decreased a lot) to +2 (increased a lot) with an additional option of N/A (which was considered as no change in behavior or did not engage in behavior prior to the COVID-19 pandemic). Consumption of high-calorie foods, frequency of ordering from restaurants and fast-food places, stress-related or emotional eating, screen time, and sitting time were reversely scored.

To assess changes in eating behavior during the COVID-19 pandemic, an Eating Behavior Score (EBS) was created by summing the responses from the five diet-related items, resulting in a total score ranging from −10 to +10. Likewise, changes in physical activity behavior were captured through a Physical Activity Score (PAS) obtained by summing the responses from the six physical activity behavior items, yielding a total score ranging from −12 to +12. Higher scores indicated positive changes in eating or physical activity behaviors.

2.5 | Dependent variable: Self-reported weight change

Participants were asked "How has your weight changed since COVID-19 was first reported in the region where you live?" Responses included "increased," "decreased," "no change," and "I don't know." Participants reporting either "increased" or "decreased" weight were prompted to report the amount of weight gained or lost. Those who reported "no change" were coded as having 0 kg of weight change. Participants who selected "I don't know" were excluded from analyses.

2.6 | Covariates

Consistent with previous research, self-reported demographic characteristics including age, biological sex, race, and income were included as covariates in the statistical models as factors that could influence body weight. The U.S. census region was also included as a covariate because restriction policies varied across different areas of the U.S. during the COVID-19 pandemic. Age was calculated from the date of birth and treated as a continuous variable. Biological sex, race, income, and U.S. census region were treated as categorical variables. Biological sex was classified into two categories (male and female). Questions about race were adapted from the U.S. Census[32] and included seven categories for race (American Indian/Alaska Native, Asian, Native Hawaiian/other Pacific Islander, Black/African American, White/Caucasian, more than one race/other). Participants were asked to report their household income relative to quintiles of 2018 national household income[33] and collapsed into two categories (<\$25,000 and ≥\$25,000, which represents the 1st quintile). The U.S. census region was classified using four categories (Northeast, West, South, and Midwest).

Responses including "decline to answer," "prefer not to specify," or "unknown" to any of the covariates were considered as missing values. Race and U.S. census regions were dummy coded to binary variables. All covariates were tested in each model. To avoid over-adjusting the models, ethnicity was not included as a covariate since the majority of the study samples were White and non-Hispanic. Testing of hypotheses was based on the identification of the most parsimonious statistical models that considered statistical, racial, regional, and physiological differences. Thus, only covariates demonstrating significant contributions to the models were included in the analyses. Hence, both models included different covariates, which are described later.

2.7 | Statistical analyses

All analyses were conducted using SAS statistical software version 9.4 for Windows (SAS Institute Inc., Cary, NC). Descriptive statistics (mean, standard deviation (SD), and frequencies) were used to summarize age, body mass index (BMI), biological sex, race, ethnicity, education, income, U.S. census region, independent variables, mediators, and dependent variables. Participants who had missing data for any of the independent variables, mediators, or dependent variables were excluded before analyses. Independent sample *t* tests for interval/ratio data and chi-squared tests for nominal/ordinal data were conducted to examine differences in demographics between the current study sample and the excluded sample.

Mediation analyses using ordinary least squares path analysis were conducted to examine the mediating effect of EBS and PAS on socioecological factors (independent variables) and self-reported weight change (dependent variable). The bootstrapped confidence intervals for both direct and indirect effects were based on 5000 samples. Next, the same models were tested with covariates that had significant contributions to each model. The Eating Behavior Model (M1) was adjusted for age, biological sex (female vs. male), race (White vs. other races), income (<\$25,000 vs. ≥\$25,000), and U.S.

census regions (Midwest vs. other regions). The Physical Activity Model (M2) was adjusted for age, biological sex, race (White vs. other races and Black vs. other races), and U.S. census regions (Northeast vs. other regions, Midwest vs. other regions, and South vs. other regions). The results reported below were for the adjusted models.

All assumptions for mediation analyses were met for all models, including multicollinearity, independence of all independent variables, normality, and homoscedasticity. Residuals were then tested for normality after visual evaluation of residuals from the models. Outliners were considered as residuals +/− 3 SD and were excluded for the Eating Behavior Model ($n = 25$) and the Physical Activity Model ($n = 23$). The PROCESS macro version 4.1 developed by Hayes[34] was used to perform the mediation analysis. Statistical significance was considered at $p < 0.05$.

COVID-19 related distress was tested as a moderator for path a in both mediation models. A single-item "worry about being infected by COVID-19" with five possible responses (extremely worried to not worried, and also included the answer "I have wanted to get infected") was tested for path moderation. The variable was then collapsed into two categories: High (extremely worried and very worried) and Low (somewhat worried, not worried, and I have wanted to get infected) distress. However, COVID-19 related distress did not moderate path a in either the Eating Behavior Model (coefficient = −0.46, SE = 0.44, $p = 0.29$) or Physical Activity Model (coefficient = 0.33, SE = 1.35, $p = 0.81$). Thus, COVID-19 related distress was not included in the final models.

3 | RESULTS

3.1 | Participants

Participant characteristics are shown in Table 1. In the present study, 1283 participants were included in the analyses. Participants reported mean age of 52.1 ± 14.1 years (SD) with BMI of 32.9 ± 8.2 kg/m^2 (mean ± SD). The majority of participants identified as females (84.9%) and had a high level of education with over 70% holding a college degree or higher. The sample was predominantly white (78.1%) and non-Hispanic (95.5%). Additionally, more than half of the participants resided in the South. Significant differences between excluded samples and those included in the analysis were observed for BMI, race, education, and US census regions (Table S1).

3.2 | Mediation models

The Eating Behavior Model (M1) that evaluated the mediating effect of EBS between proposed socioecological factors related to eating behaviors and weight change and the Physical Activity Model (M2) that evaluated the mediating effect of PAS between proposed socioecological factors related to physical activity behaviors and weight change showed significant results ($p < 0.00001$).

TABLE 1 Participants' characteristics.

	***n* (%)**
N	1283
Age, mean (SD)[a]	52.1 (14.1)
Age, range	19.0–91.0
BMI, mean (SD) kg/m^2[b]	32.9 (8.2)
BMI, range[b]	18.3–74.3
BMI categories[b]	
Underweight	4 (0.3)
Healthy weight	188 (14.9)
Overweight	338 (26.8)
Obese I	287 (22.7)
Obese II	217 (17.2)
Obese III	229 (18.1)
Sex (female)	1087 (84.9)
Race	
White	987 (78.1)
Black	198 (15.7)
American Indian or Alaska Native	6 (0.5)
Asian	26 (2.1)
Native Hawaiian or other Pacific Islander	5 (0.4)
Other races	42 (3.3)
Ethnicity	
Not Hispanic or Latino	1191 (95.5)
Education	
High school & some college	380 (29.7)
College & Graduate degree	900 (70.3)
Income	
Less than $25,000	113 (8.9)
$25,000–$49,999	233 (18.4)
$50,000–$79,999	317 (25.1)
$80,000–$130,000	324 (25.6)
Greater than $130,000	278 (22.0)
US census region	
Northeast	230 (18.0)
Midwest	197 (15.4)
South	682 (53.4)
West	168 (13.2)
Worry about becoming infected with COVID-19	
Extremely worried	198 (15.4)
Very worried	266 (20.8)

TABLE 1 (Continued)

	n (%)
Somewhat worried	546 (42.6)
Not worried	266 (20.8)
I have wanted to get infected	6 (0.47)
	mean (SD)
Self-reported weight change (kg) during COVID-19 pandemic	2.3 (8.9)
Socioecological factors	
Food environment	
0 *(low availability)* to 12 *(high availability)*	8.2 (3.8)
Street connectivity	
1 *(strongly disagree)* to 4 *(strongly agree)*	2.8 (0.9)
Places for walking and cycling	
1 *(strongly disagree)* to 4 *(strongly agree)*	2.4 (1.0)
Encouragement for diet	
5 *(less support)* to 25 *(greater support)*	11.8 (5.1)
Discouragement for diet	
5 *(less discouragement)* to 25 *(greater discouragement)*	12.3 (5.1)
Support for exercise participation	
10 *(less support)* to 50 *(greater support)*	21.8 (9.9)
Healthy-eater identity	
−3 *(weak identity)* to +3 *(strong identity)*	0.8 (1.5)
Exercise identity	
−3 *(weak identity)* to +3 *(strong identity)*	0.2 (1.7)
Mediators	
EBS	
−10 *(negative change)* to +10 *(positive change)*	−0.2 (3.2)
PAS	
−12 *(negative change)* to +12 *(positive change)*	−3.0 (3.8)

Abbreviations: BMI, Body mass index; EBS, Eating Behavior Score; kg, kilogram; PAS, Physical Activity Score; SD, Standard deviation.
[a] $n = 1200$, 83 participants did not report age.
[b] $n = 1281$, 2 participants had missing BMI values.

3.3 | Eating Behavior Model

Results from mediation analysis for the Eating Behavior Model (M1) are presented in Figure 2 and Table 2. Mediation analysis indicated that there were significant indirect and direct effects of discouragement for diet and healthy eater identity on weight change. Specifically, for path *a*, less discouragement for diet from family and friends ($a_3 = -0.06$, SE = 0.02, $p = 0.002$) and stronger healthy eater identity ($a_4 = 0.57$, SE = 0.06, $p < 0.0001$) were associated with higher EBS. For path *b*, higher EBS was associated with approximately 1.26 kg of weight loss ($b = -1.26$, SE = 0.06, $p < 0.0001$). Results from the bootstrapped confidence interval of 5000 samples for indirect effects revealed that zero was not included in the lower and upper 95% confidence intervals of discouragement for diet and healthy eater identity, indicating that EBS mediated the relationships between discouragement for diet and weight change as well as healthy eater identity and weight change. For direct effects (path *c*′), discouragement for diet ($c'_3 = 0.08$, SE = 0.04, $p = 0.044$) was positively associated with weight change, whereas healthy eater identity ($c'_4 = -0.31$, SE = 0.13, $p = 0.016$) was negatively associated with weight change independent of their association with EBS. Measures of the food environment and encouraging social support for diet were not associated with EBS or weight change.

3.4 | Physical Activity Model

Results from mediation analysis for the Physical Activity Model (M2) are presented in Figure 3 and Table 3. Mediation analysis indicated that there were significant direct and indirect effects of exercise identity on weight change. Specifically, for path *a*, stronger exercise identity was associated with higher PAS ($a_4 = 0.37$, SE = 0.07, $p < 0.0001$). For path *b*, higher PAS was associated with 0.66 kg weight loss ($b = -0.66$, SE = 0.06, $p < 0.0001$). Results from the bootstrapped confidence interval of 5000 samples for indirect effect revealed that zero was not included in the lower and upper 95% confidence intervals of exercise identity, indicating that PAS mediated the relationship between exercise identity and weight change. For direct effects (path *c*′), exercise identity was negatively associated with weight change independent of its association with PAS ($c'_3 = -0.33$, SE = 0.13, $p = 0.01$). Support for exercise participation was negatively associated with weight change independent of its association with PAS ($c'_3 = -0.05$, SE = 0.02, $p = 0.034$). No significant associations of street connectivity or places for walking and cycling were observed for PAS or weight change.

4 | DISCUSSION

This study investigated the association of socioecological factors (environmental, interpersonal, and individual) with self-reported weight change via their associations with self-reported eating and physical activity behaviors during a major life event using data collected during the COVID-19 pandemic. As hypothesized, stronger healthy eater identity and less discouragement for healthy eating from family and friends were associated with a positive change in eating behavior, which was in turn associated with greater weight loss. Stronger exercise identity was associated with a positive change in physical activity, which was also associated with weight loss. However, measures of the food and physical activity environments were not associated with their respective health behaviors or weight change during the COVID-19 pandemic.

Consistent with previous studies that found positive associations between identities and health promoting behaviors,[14–20] the present study found that having strong healthy eater and exercise identities

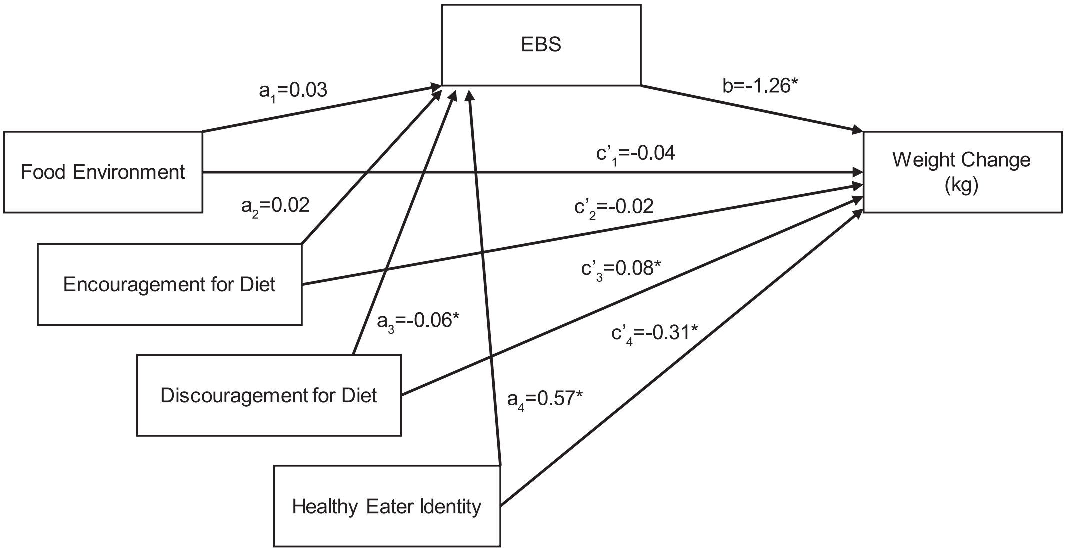

FIGURE 2 Eating Behavior Model (M1): results from mediation analysis ($n = 1258$). The model included age, sex, race, income, and US census regions as covariates. EBS, Eating Behavior Score.

TABLE 2 Regression coefficients, standard errors, and model summary information for the path analysis model predicting self-reported weight change in the Eating Behavior Model (M1) are depicted in Figure 2 ($n = 1258$).

	Consequents							
		M (EBS)				Y (weight change kg)		
Antecedent	Path	Coeff.	SE	p	Path	Coeff.	SE	p
X (food environment)	a_1	0.03	0.02	0.203	c'_1	−0.04	0.05	0.443
		Indirect effect ($a_1 \times b$) = −0.04, 95% CI [−0.04, 0.03]						
X (encouragement for diet)	a_2	0.02	0.02	0.233	c'_2	−0.02	0.04	0.579
		Indirect effect ($a_2 \times b$) = −0.03, 95% CI [−0.08, 0.02]						
X (discouragement for diet)	a_3	−0.06	0.02	0.002	c'_3	0.08	0.04	0.044
		Indirect effect ($a_3 \times b$) = 0.07, 95% CI [0.03, 0.12]						
X (healthy-eater identity)	a_4	0.57	0.06	<0.00001	c'_4	−0.31	0.13	0.016
		Indirect effect ($a_4 \times$ b) = −0.72, 95% CI [−0.90, −0.55]						
M (EBS)	-	-	-	-	b[a]	−1.26	0.06	<0.00001
Constant	i_M[a]	−0.22	0.60	0.720	i_y[a]	0.21	1.22	0.865
	$R^2 = 0.10$; $F(9, 1134) = 14.77$ $p < 0.00001$				$R^2 = 0.33$; $F(10, 1133) = 56.67$ $p < 0.00001$			

Note: Model included age, sex, race, income, and US census regions as covariates.

Abbreviations: CI, confident interval; EBS, Eating Behavior Score; M, mediator; SE, standard errors; X, independent variables; Y, dependent variable.

[a]The effect of EBS (M) on weight change (Y) (path b) and model constants were reported only once, as these estimates were the same across each of the four predictors for weight change (Y).

can protect individuals from disengaging in health promoting behaviors. Rhodes et al.[35] found that change in exercise identity predicts moderate-to-vigorous intensity physical activity across 2 years of the COVID-19 pandemic. Results from this study further supported the central premise of the Maintain IT (Identity Transformation) Model of Health Behavior Change and Maintenance[36] (Maintain IT). Maintain IT proposes that aligning core aspects of one's centered identity with behaviors is more behaviorally sustainable than relying on cognitive control to maintain health promoting behaviors and weight loss in the long term, especially in challenging situations or unsupportive environments.[36] Healthy eater and exercise identities are examples of centered identity within Maintain IT. Results from this study showed that having strong healthy eater and exercise identities can promote maintenance of healthy eating and exercise behaviors, respectively, even during challenging situations such as the COVID-19 pandemic.

Social support from family and friends, which is generally an important predictor for health promoting behaviors,[11–13] may

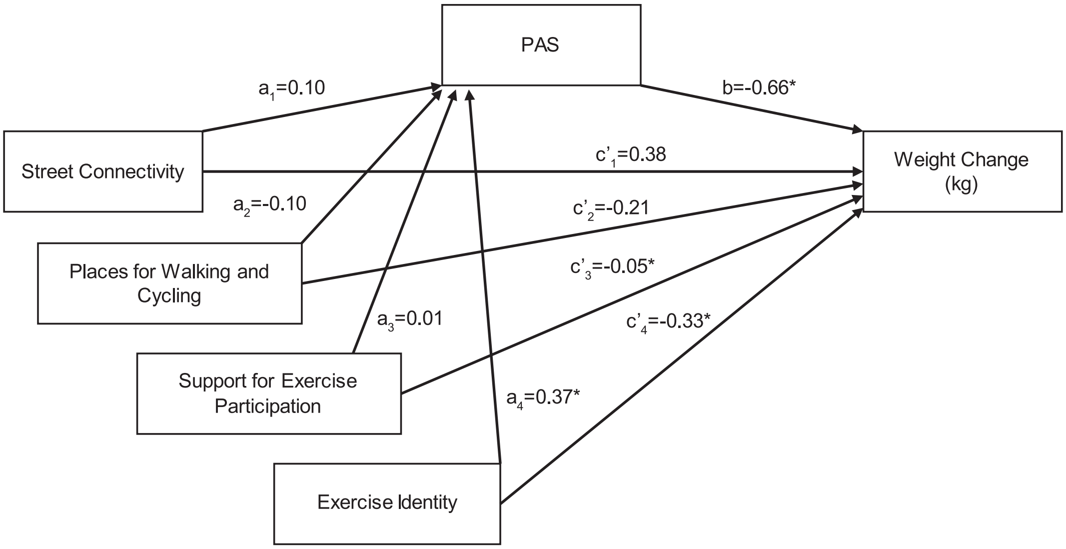

FIGURE 3 Physical Activity Model (M2): results from mediation analysis. The model included age, sex, race, and US census regions as covariates. PAS, Physical Activity Score.

TABLE 3 Regression coefficients, standard errors, and model summary information for the path analysis model predicting self-reported weight change in the Physical Activity Model (M2) are depicted in Figure 3 (n = 1260).

	Consequents							
		M (PAS)				Y (weight change kg)		
Antecedent	**Path**	**Coeff.**	**SE**	***p***	**Path**	**Coeff.**	**SE**	***p***
X (street connectivity)	a_1	0.10	0.13	0.459	c'_1	0.38	0.25	0.126
		Indirect effect ($a_1 \times b$) = −0.07, 95% CI [−0.24, 0.11]						
X (places for walking and cycling)	a_2	−0.10	0.13	0.464	c'_2	−0.21	0.25	0.404
		Indirect effect ($a_2 \times b$) = 0.07, 95% CI [−0.11, 0.24]						
X (support for exercise participation)	a_3	0.01	0.01	0.254	c'_3	−0.05	0.02	0.034
		Indirect effect ($a_3 \times b$) = −0.009, 95% CI [−0.02, 0.01]						
X (exercise identity)	a_4	0.37	0.07	<0.00001	c'_4	−0.33	0.13	0.01
		Indirect effect ($a_4 \times b$) = −0.25, 95% CI [−0.35, −0.15]						
M (PAS)	-	-	-	-	b[a]	−0.66	0.06	<0.00001
Constant	i_M[a]	−3.38	0.87	<0.0001	i_Y[a]	0.11	1.65	0.945
	$R^2 = 0.064$; $F(11, 1146) = 7.09$ $p < 0.00001$				$R^2 = 0.15$; $F(12, 1145) = 17.29$ $p < 0.00001$			

Note: Model included age, sex, race, and US census regions as covariates.

Abbreviations: CI, confident interval; M, mediator; PAS, Physical Activity Score; SE, standard error; X, independent variables; Y, dependent variable.

[a]The effect of EBS (M) on weight change (Y) (path b) and model constants were reported only once, as these estimates were the same across each of the four predictors for weight change (Y).

have uniquely and disparately affected eating and physical activity behaviors during the pandemic. When the COVID-19 lockdown mandates were in place, individuals were forced to practice social distancing and self-isolation. Thus, many individuals were physically separated from their social networks, whereas others may have spent more time than usual with household members during the pandemic. According to findings from this study, receiving less discouragement from family and friends was a more important factor for eating healthy than receiving more encouragement from family and friends. Similar to findings from this study, Rieger et al. found that greater discouragement from family and friends for healthy eating is associated with greater problem eating, higher perceived negatives of weight loss, and greater negative impact of obesity on quality of life.[13] In addition, findings from this study suggested that support for exercise participation was a factor that directly related to body weight change rather than physical activity behavior. It is possible that there are mediating factors in this relationship that were not examined in the present study.

Outdoor recreation was one of the few promoted or allowable activities during the COVID-19 lockdown, and sustained increases in the rates of outdoor recreation have been observed since the pandemic.[37] Thus, the hypothesis was that the IWCR participants living in favorable food and physical activity environments would report engaging in healthier eating and physical activity behaviors, respectively, which would mediate reported weight loss or weight maintenance during the pandemic. Results from this study showed that neither the food nor physical activity environment were associated with weight change nor eating or physical activity behaviors during the pandemic. While large-scale studies such as the Moving to Opportunity study demonstrated high-level impacts of residing in high versus low poverty neighborhoods on obesity and diabetes risks,[38] studies investigating narrower definitions or features of the neighborhood environment and their relationships with health behaviors and weight status have produced mixed results. Cross-sectional observational studies commonly demonstrate a positive association between favorable food and physical activity environments with their associated health behaviors and obesity prevalence.[9,10] However, these relationships are less-consistently observed with longitudinal designs[39] and retrospective moderation analyses of randomized weight loss trials.[40–42] Besides, it is important to note that the majority of the IWCR participants in this study reported high household income, which might potentially affect the predictive values of the environmental factors because they have the resources necessary to travel outside of their immediate home neighborhood to access healthy foods and exercise facilities. It is possible that these environmental factors could be important mediators of health behavior in samples with a greater range of socioeconomic status.

There are several limitations to the present study. First, this study is a cross-sectional study that assessed changes in eating and physical activity behaviors at a single time point, which was about a year after the start of COVID-19 pandemic. This might limit how the results can be interpretated due to the subjective response of changes in behaviors. Second, all variables in this study were self-reported, which introduced recall and social-desirability bias. However, it was challenging to implement objective measurements in such a large sample, especially during the COVID-19 pandemic. Third, the recruitment and data collection for the IWCR were conducted exclusively online, which limited participation to individuals proficient in digital literacy. Lastly, there were significant demographic differences between the current study and the excluded samples. Additionally, over 85% of the IWCR samples were female. These could also limit the generalizability of the findings. However, gender imbalance is a common issue in weight management studies.[43] To address gender imbalance, the IWCR is an ongoing study actively implementing strategies to recruit a more diverse sample into the registry.

5 | CONCLUSION

This study found that individuals who have strong healthy eater and exercise identities and receive less discouragement from family and friends are able to adhere to health promoting behaviors during the COVID-19 pandemic, and hence continue to lose or maintain weight. The findings broadly support the importance of interpersonal and individual factors in health behavior maintenance and weight management during major life events and support the development of innovative strategies to improve weight management in the long term.

AUTHOR CONTRIBUTIONS

Tsz Kiu Chui, R. Drew Sayer, Assil El Zein, Ann E. Caldwell, John C. Peters, James E. Friedman, and Sai Krupa Das conceptualized the study. Tsz Kiu Chui and R. Drew Sayer prepared the original draft of the manuscript. Tsz Kiu Chui curated the data and performed the formal analysis. Swati DebRoy provided advice for data curation. Yenni E. Cedillo and Gregory Pavela provided advice for analysis and interpretation of the results. Tsz Kiu Chui prepared tables and figures. All authors reviewed and edited the submitted manuscript.

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CONFLICT OF INTEREST STATEMENT

Dr. Roberts founded the iDiet, a web-based behavioral weight loss program (www.theidiet.com) and is a Board member of Danone. Dr. Peters received grants/contracts from the American Pecan Council and McCormick Science Institute, and also received consulting fees from the University of Alabama Birmingham. The remaining authors have no relevant conflicts of interest to disclose.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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