Received: 22 March 2021 | Revised: 16 August 2021 | Accepted: 17 August 2021

DOI: 10.1002/osp4.557

ORIGINAL ARTICLE

Obesity Science and Practice WILEY

Environments and situations as correlates of eating and drinking among women living with obesity and urban poverty

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Funding information

National Heart, Lung, and Blood Institute (NHLBI), Grant/Award Number: R01 HL128494

Abstract

Objective: One path to improving weight management may be to lessen the self-control burden of physical activity and healthier food choices. Opportunities to lessen the self-control burden might be uncovered by assessing the spatiotemporal experiences of individuals in daily context. This report aims to describe the time, place, and social context of eating and drinking and 6-month weight change among 209 midlife women (n = 113 African–American) with obesity receiving safety-net primary care.

Methods: Participants completed baseline and 6-month weight measures, observations and interviews regarding obesogenic cues in the home environment, and up to 12 ecological momentary assessments (EMA) per day for 30 days inquiring about location, social context, and eating and drinking.

Results: Home was the most common location (62%) at times of EMA notifications. Participants reported "yes" to eating or drinking at the time of nearly one in three (31.1% ± 13.2%) EMA notifications. Regarding social situations, being alone was significantly associated with less frequent eating and drinking (OR = 0.75) unless at work in which case being alone was significantly associated with a greater frequency of eating or drinking (OR = 1.43). At work, eating was most common late at night, whereas at home eating was most frequent in the afternoon and evening hours. However, eating and drinking frequency was not associated with 6-month weight change.

Conclusions: Home and work locations, time of day, and whether alone may be important dimensions to consider in the pursuit of more effective weight loss interventions. Opportunities to personalize weight management interventions, whether digital or human, and lessen in-the-moment self-control burden might lie in identifying times and locations most associated with caloric consumption.

Clinical trial registration: NCT03083964 in clinicaltrials.gov

KEYWORDS

environmental factors, food, obesity, weight loss, women

1 | INTRODUCTION

Obesity (body mass index [BMI] ≥ 30) is associated with many conditions seen and treated in primary care, including cardiovascular diseases and diabetes.[1] In the U.S., there is now an alarming rise in the prevalence of severe obesity (BMI ≥ 40)[2] with prevalence greatest among those with annual household incomes of ≤$20,000, women, and non-Hispanic blacks (NHB) born in the U.S.[3] This may be related to an intersection of contextual and social or individual-level factors. Contextually, persons with minority status and/or household poverty often live in neighborhoods with limited access to affordable nutritious foods or appealing opportunities for physical activity, and instead experience more exposure to calorically dense food and advertisement of such foods as well as physical activity barriers.[4] In such a situation, weight management by an individual would require significant and continuous cognitive awareness, self-monitoring, and executive function.[5] It is perhaps not surprising then, that when included in weight loss trials, NHB adults and persons living in poverty have experienced less weight loss.[6] Underrepresentation in such trials has likely resulted in weight-loss strategies that are not well-adapted to these subpopulations.[6,7]

The most common interventions in weight loss trials are guided by social cognitive theories[8] and involve behavioral counseling to improve self-monitoring and goal-directed lifestyle behavior.[9,10] For those living in contexts where food and sedentary cues are ubiquitous, goal-directed weight loss requires near constant self-control.[11] Self-control involves self and situation awareness and cognitive control sufficient to act in a way consistent with long-term goals that are often contrary to immediate objectives for comfort, satiety, or pleasure.[12,13]

Low income urban communities have fewer resources and options for healthy foods and recreational physical activities,[7] and unhealthy options are more advertised and available.[14] Residents of these communities are more likely to suffer adverse social determinants of health (e.g. job, food, and housing insecurities) and acute and chronic stressors that may impair executive function skills, such as self-control.[15,16]

Unfortunately, interventions to improve executive function in adults have had limited effectiveness for enhancing skills like self-control.[17] An alternative is to lessen the self-control burden of physical activity and healthier food choices. A first step in this pursuit is to gather information that could guide intervention designs for healthier environments. In a 2019 report on the link between environment and obesity, Drewnowski and colleagues reviewed mixed to limited findings to date regarding links between environment and eating behavior or obesity. The authors underscored that ecological momentary assessments (EMA) connected with global positioning systems (GPS) is an "exciting and rapidly growing field of exposure and outcome assessment" due to its potential to achieve spatiotemporal assessments and potential for more tailored or precise interventions.[18]

This study surmised that opportunities to lessen the self-control burden might be uncovered by assessing spatiotemporal experiences of individuals in daily context. In an effort to explore such opportunities among women living with severe obesity in a context of urban poverty, this study investigated the internal home environments and momentary situations of a sample representing these women. Ultimately, such research might lead to more timely or precise strategies and support for contextual alterations that lessen the self-control burden of goal-directed weight loss. Here are described observed and self-reported household contexts and momentary situations of midlife women receiving primary care in 1 of 8 safety-net, primary care sites in Indianapolis, Indiana and living with severe obesity and often urban poverty. These data were used to explore the context and situations associated with eating and drinking and 6-month weight change. Preliminary hypotheses were that eating and drinking would be more frequent when alone, at home, and in the evening hours and for those living in a home where food, dishes, and televisions are commonly out and visible. It was further hypothesized that eating and drinking frequency would have a positive association with 6-month weight change.

2 | METHODS

The data reported here were obtained from context and behavior assessments that precede randomization in the ongoing Addressing People and Place Microenvironments (APP-Me) weight loss randomized trial described elsewhere.[19] Briefly, following a 1-month period of data collection, participants were randomized to receive enhanced usual care (EUC) or EUC plus APP-Me messaging. EUC included usual primary care appointments as well as primary care provider referral to a federally qualified health center (FQHC)-operated goal-directed weight loss counseling and support program called HealthyMe.[20] APP-Me messages were personalized health reminders scheduled for up to five delivery times per day with the message content and delivery schedule partially determined by each participant's context and behavior patterns.[21] Sample sizes reported here were determined based on the power analysis for the APP-Me trial. The study was approved by the Indiana University Institutional Review Board.

Participants for this study all resided in Indianapolis, Indiana, among the largest 20 cities in the U.S. with a population of slightly less than 1 million—66% non-Hispanic white (NHW) and 28% black (NHB)—and a median household income of $42,168.[22] The study enrolled NHB and NHW women nonsmokers who were not currently nor had been pregnant within 6 months with a BMI ≥ 30 aged 35–64 years who received primary care in 1 of 10 FQHCs.

Recruitment involved several steps: (1) Health system data managers with access to electronic medical records identified patients who met study BMI and demographic criteria and received a HealthyMe referral. (2) Study research assistants (RAs) sought permission from FQHC providers to contact potentially eligible participants. (3) Potentially eligible participants received a telephone call from an RA who described the project and completed a brief telephone screener. (4) Those who were eligible were invited to schedule a home visit for informed consent, baseline assessment, and onboarding for 4 weeks of EMA. Those who wished not to have the RA come into the home were able to schedule a visit at research offices on the Indiana University School of Medicine campus.

Data for this report include weight-related aspects of home contexts as reported by participants or observed by RAs, worksite context as reported by participants, and survey assessments and weight measurements. Weight measures were obtained in duplicate by RAs using the Tanita BWB-800A scale, or WB-800S if participant exceeded 200 kg. With the exception of a 6-month weight measurement, the above data were captured just prior to a 4-week ecological momentary sampling and assessment period. Weight change was calculated as weight at 6 months follow-up minus weight at baseline.

Age, race, ethnicity, and gender eligibility and absence of substance abuse, pregnancy, smoking, and cognitive impairment were confirmed at the telephone screening. Survey questions included mental health screeners for depression (Patient Health Questionnaire [PHQ-2])[23] and anxiety (Generalized Anxiety Disorder [GAD-2]).[24] Social determinants measures included the Newest Vital Sign (NVS) for health literacy assessment[25] and questions regarding food insecurity, year of completed schooling, household size and income (recoded to poverty level), and work status and work shift.

Assessments of the home environment included individual items from a novel home environment composite (HEC) score assigning the values indicated in the parentheses after each variable below to create a score ranging from 0 to 6. The variables in the HEC included number of televisions (1 if 3 or more, 0 otherwise), television in or viewable from kitchen (1, 0 otherwise), presence of a body weight scale in the home (0, 1 otherwise), presence of fitness equipment in the home (0, 1 otherwise), how often fast food was brought into the home (1 if daily or weekly, and 0 otherwise), and whether food or dishes were out and visible (1 if so, 0 otherwise). For those who completed the assessment at home, RAs suggested sitting at a kitchen table and recorded what was observable and asked participants about the remaining items. For participants who completed the assessment at research offices, these variables were all self-reported.

EMA assessments that occur in the moment reduce recall bias[26] and are considered the gold standard of experiential sampling.[27] In the creation of the EMA tool, a user-centered design process was used to create an EMA application "app."[28–32] EMA question formats were co-designed and evaluated by users, and included eating or drinking, social interaction, and location questions.[21] To minimize participant burden, users were able to set approximate times of wake, eat, sleep, and not to be disturbed from within the EMA app. This information guided the timing of EMA questions for each participant, which came in the form of push notifications. Response options appeared with the question and required a single tap response. Participants' information and responses are stored on a secure server.

EMA questions were sent at semi-random times and roughly hourly within the times which a participant designated as open to receiving notifications. Questions sent might have included "where are you?," "eating now or in the past 15 min?," "drinking now or in the past 15 min anything other than water?," and "with anyone?" The particular set of questions sent was a function of the participant's location. If the participant was at work, home, the store or the mall, then all questions were sent. If the participant was at a restaurant or the gym, then only the "with anyone" question was sent. If the participant was at a friend's or family member's home then the eating and drinking questions were sent. If a participant was at the Doctor's office or the HealthyMe clinic then the questions about eating, drinking, or "with anyone" were sent. Lastly, if a participant was at a Place of Worship, then only the eating and drinking questions were sent. An APP-Me EMA logic map is available in Srinivas et al.[21]

The location was detected in one of two ways: by the app itself using GPS or by the participant responding to the question "where are you." The app used latitude and longitude coordinates to identify participant-specific locations such as home, work, and friends/family home. These were set up early in the study and used by the app in a lookup table to identify the location in subsequent notification sets. This reduced the burden of questioning the participant about location. In the instance that the participant had changed location farther than 50 m from the prior location, the app sent the question "where are you." When "where are you" was sent, it was the first question sent among the hourly set of questions. When "where are you" was not sent, the eating question was the first question sent to the participant among the hourly set of questions.

2.1 | Analyses

EMA data were analyzed at the subject level, as average daily proportions of responses to the EMA questions. Because EMA questions were time, location, and situation-specific, the relative frequencies of responses are reported for all time windows (morning, afternoon, evening, and night), location categories (home, work, friend's home), and social situations (alone, with family/friends, with others). The average proportions of eating and drinking behaviors for these times, locations, and situations are then reported. In the initial versions of the EMA app, eating and drinking were combined into one question and thus, for analysis, eating and drinking were combined into one eating/drinking variable.

The composite home environment score was calculated as the sum of the six home environment questions. In situations of missing responses of individual questions, the composite score was rescaled using the non-missing responses if fewer than three items were missing. Composite scores were not calculated for those with more than three items missing.

A mixed-effect logistic regression analysis was conducted to examine the associations between eating/drinking and the home environment variables as well as demographic, mental health, and social determinants. A random subject effect was included in the model to account for the potential correlations among the repeatedly measured outcomes within the subject. Associations were quantified by estimated odds ratios (OR) and related 95% confidence intervals (CI).

TABLE 1 Demographic, social determinant, mental health, and home environment characteristics (N = 209)

Variable	Statistic
Age, years (Mean ± SD)	52.1 ± 8.0
African–American, *n* (%)	113 (54.1)
Education level	
Primary school	1 (0.5)
High school	90 (43.1)
Some college	87 (41.6)
Four year college degree	21 (10.0)
Graduate school	10 (4.8)
Low health literacy (sum of new vital sign items ≤3), *n* (%)	77 (36.8)
Currently working, *n* (%)	98 (46.9)
Shift work	
Not working	111 (53.1)
1st shift (start time 6–8 AM)	67 (32.1)
2nd shift (start time 2–5 PM)	10 (4.8)
3rd shift (start time 10 PM-midnight)	2 (1.0)
Varies	19 (9.1)
Household income below federal poverty level	85 (43.1)
Food security score, mean ± SD	2.0 ± 2.2
Food security class	
High/marginal food security	105 (50.2)
Low food security	60 (28.7)
Very low food security	44 (21.1)
PHQ9: Score ≥3 depression	38 (18.4)
GAD: Score ≥3 anxiety	53 (25.5)
Number in household	
1	59 (28.2)
2	60 (28.7)
3	38 (18.2)
4	26 (12.4)
5+	26 (12.4)
Home environment (HEC) score (0–6), Mean ± SD	3.3 ± 1.2
HEC item 1: Number of televisions 3 or more, *n* (%)	116 (56.6)
HEC item 2: TV in the kitchen, *n* (%)	27 (13.0)
HEC item 3: No scale in home, *n* (%)	91 (43.5)
HEC item 4: No fitness equipment in home, *n* (%)	130 (65.3)
HEC item 5: Fast food brought in home daily or weekly, *n* (%)	132 (63.5)
HEC item 6: Plates, cups or other dishes visible	154 (74.8)
BMI at baseline, Mean ± SD	45.0 ± 10.3
36_or_less	39 (18.7)
36.1–41	52 (24.9)
41.1–46	38 (18.2)
46.1–52	33 (15.8)
52.1+	47 (22.5)
Weight (kg) at baseline, Mean	115.39 ± 28.39
Weight (kg) at 6 months, Mean ± SD	114.89 ± 28.53
Weight change (kg) at 6 months, Mean ± SD	−0.54 ± 5.94

Abbreviations: BMI, body mass index; GAD, Generalized Anxiety Disorder; HEC, home environment composite; PHQ, Patient Health Questionnaire.

Finally, linear regression analysis was performed to examine the effects of eating/drinking on 6-month weight changes in the study participants. The analysis was performed at the subject level. The models included the average daily eating/drinking frequencies, as well as the demographic, clinical, social, and environmental variables. The average daily percent of positive responses to eating/drinking questions, to location, to being alone, with friends or family, or with others were calculated. Covariates in the model included Black race, baseline BMI, highest level of education, work shift (1st, 2nd, 3rd, varied shift, or no work), food insecurity level, income below poverty, depression, anxiety, low health literacy, and home score. Additionally, separate models were fitted for NHB and NHW women to explore the race-specific effects. From this, an interaction of race and anxiety was identified and included in the presented models. All analyses were performed using R software. p values less than 0.05 were considered statistically significant.

3 | RESULTS

In Table 1, descriptive data for demographic, social determinants of health, and household level measures are shown (N = 209). The mean age of the sample was 52.1 (±8.0) years, all were women, and 46% were NHW and 54% were NHB. Regarding social determinants, 95% completed high school and/or some college, 15% had a college degree, and 37% scored 3 or less on the NVS, indicating low health literacy. 32% worked a day shift, 15% another or variable shift, and 53% did not work outside of the home. 43% lived in households with an income below the federal poverty level, and one-half had low or very low food security. With regard to mental health, 18% screened positive for depression, and 26% for GAD. 28% lived alone, and the HEC score had a mean of 3.3 (SD 1.2).

Mean BMI was 45.0 (±10.3) at baseline. Mean weight was 115.4 kg (±28.8 kg). Mean weight change at 6-month follow-up was −0.5 kg (±5.9 kg).

As a reminder, participants received up to 12 EMA question sets per day at semi-random intervals for 28 days, or up to a maximum of 336 question sets. The mean response rate was 56.8% (±20.3%). 63% of participants had response rates higher than 50%. The EMA data are shown in Table 2. Participants reported being alone for 34.3% (±23.0%) of EMA notifications and with family or friends for 28.7% (±18.1%) of notifications. The mean daily combined eating/drinking frequency was 31.1% (±13.2%). In other words, participants reported "yes" to eating or drinking at the time of nearly one in three EMA notifications. Positive responses to eating/drinking occurred in every time period of a day and were similarly likely in the morning and evening hours, slightly more likely in the afternoon, and less likely in the nighttime hours. Home was the most common location of eating or drinking by far (82.3%), but home was also where participants were most likely to be (62.2%) over the course of a day. Work was the second most commonly specified location for eating or drinking and friend or family home was the third most common. Elsewhere (doctor's office, gym, HealthyMe, mall, place of worship, restaurant, store, other) made up 21.6% of locations. Figure 1 shows eating/drinking probability by location and time of day.

TABLE 2 Ecological momentary assessment (EMA) data

Variable	Statistic (N = 209)
Mean daily eat or drink percent	31.1 ± 13.2
Mean daily eat or drink proportion by time of day	
Morning	16.5 ± 10.6
Afternoon	19.1 ± 7.6
Evening	16.8 ± 5.9
Night	3.7 ± 8.2
Most likely eat/Drink location	
Friend/Family home	3 (1.4)
Home	172 (82.3)
Other	7 (3.3)
Place of worship	1 (0.5)
Store	1 (0.5)
Work	25 (12.0)
Location frequency (Mean daily percent)	
Home	62.2 ± 20.9
Work	17.6 ± 20.3
Friend or family home	13.3 ± 15.5
Elsewhere	21.6 ± 12.4
With others (Mean daily percent)	
Alone	34.3 ± 23.0
Friend/Family	28.7 ± 18.1
Other	16.9 ± 13.1

Table 3 shows demographic, social determinant, and environment variable associations with eating and drinking frequency. Race, years of age or education, poverty or food security status, or scores on health literacy, mental health, and HEC were not associated with eating and drinking frequency. Not working relative to working 1st shift, however, was associated with more frequent eating and drinking (odds ratio [OR] = 1.50, 95% confidence interval [CI] = (1.11, 2.04)). Relative to morning hours, afternoon (OR = 1.26, 95% CI: 1.18–1.35; $p < 0.0001$) and evening hours (OR = 1.27, 95% CI: 1.18–1.37; $p < 0.0001$) were associated with more frequent eating and drinking, while night hours were associated with less frequent eating and drinking (OR = 0.59, 95% CI: 0.47–0.75; $p < 0.0001$). Location and social situations were found to significantly interact with each other. Being at home and alone was significantly associated with a lower likelihood of eating and drinking than being at home but not alone (OR = 0.75, 95% CI: 0.69–0.82; p-value = <0.0001). Being at work and alone was significantly associated with greater frequency

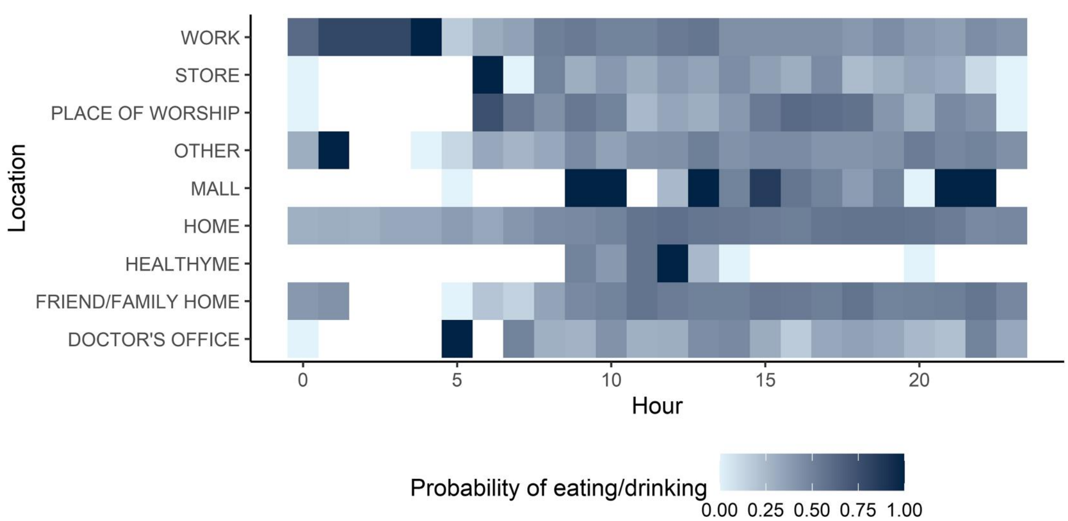

FIGURE 1 Reported eating or drinking by location and hours of the day

TABLE 3 Factors associated with reported eating or drinking

Term	Level	Estimate	Std error	95% confidence interval		Odds ratio	Odds ratio 95% confidence interval		*p*-value
Intercept		−0.024	0.639	-	-	-	-	-	0.9701
Age		−0.003	0.008	−0.019	0.013	0.997	0.981	1.013	0.7075
Race	Black	0.003	0.163	−0.317	0.323	1.003	0.728	1.381	0.9859
	White	0.000	-	-	-	Reference	-	-	-
BMI at baseline		0.005	0.007	−0.007	0.018	1.005	0.993	1.018	0.4034
Education level	Primary school	−1.170	0.889	−2.911	0.572	0.310	0.054	1.772	0.1881
	High school	0.047	0.249	−0.441	0.535	1.048	0.643	1.708	0.8504
	Some college	−0.103	0.235	−0.564	0.358	0.902	0.569	1.430	0.6611
	Four year college degree	0.000	-	-	-	Reference	-	-	-
	Graduate school	0.132	0.340	−0.534	0.798	1.141	0.587	2.220	0.6972
Shift work	Not working	0.405	0.156	0.100	0.711	1.500	1.105	2.035	0.0092
	1st shift (start time 6–8 AM)	0.000	-	-	-	Reference	-	-	-
	2nd shift (start time 2–5 AM)	0.295	0.303	−0.299	0.889	1.343	0.742	2.433	0.3300
	3rd shift (start time 10 AM-midnight)	0.748	0.949	−1.113	2.609	2.113	0.329	13.579	0.4308
	Varies	0.056	0.225	−0.386	0.498	1.058	0.680	1.645	0.8038
Household income	Below federal poverty level	0.060	0.144	−0.221	0.342	1.062	0.802	1.407	0.6750
Food security class	High/marginal food security	0.000	-	-	-	Reference	-	-	-
	Low food security	−0.113	0.158	−0.423	0.198	0.894	0.655	1.219	0.4769
	Very low food security	−0.061	0.178	−0.411	0.289	0.941	0.663	1.335	0.7321
PHQ-9: Score ≥3 depression	Yes	−0.319	0.195	−0.701	0.062	0.727	0.496	1.064	0.1008
GAD: Score ≥3 anxiety	Yes	0.119	0.227	−0.326	0.563	1.126	0.722	1.756	0.6003
Low health literacy	Yes	0.152	0.160	−0.161	0.466	1.165	0.851	1.593	0.3406
Home environment (HEC) score		−0.052	0.056	−0.163	0.058	0.949	0.850	1.060	0.3526

TABLE 3 (Continued)

Term	Level	Estimate	Std error	95% confidence interval		Odds ratio	Odds ratio 95% confidence interval		*p*-value
Period of the day	Morning	0.000	-	-	-	Reference	-	-	-
	Afternoon	0.234	0.034	0.168	0.300	1.264	1.183	1.350	<0.0001
	Evening	0.239	0.037	0.167	0.311	1.270	1.182	1.365	<0.0001
	Midnight	−0.527	0.121	−0.764	−0.289	0.591	0.466	0.749	<0.0001
Location	Elsewhere	−0.214	0.049	−0.310	−0.119	-	-	-	<0.0001
	Friend/Family home	−0.139	0.072	−0.279	0.001	-	-	-	0.0523
	Home	0.000	-	-	-	Reference	-	-	-
	Work	−0.096	0.056	−0.205	0.014	-	-	-	0.0867
With someone	Alone	−0.282	0.042	−0.365	−0.199	-	-	-	<0.0001
	Not alone	0.000	-	-	-	Reference	-	-	-
Race * anxiety	Black * Anxiety	0.055	0.291	−0.516	0.626	-	-	-	0.8506
	Black * No anxiety	0.000	-	-	-	-	-	-	-
	White * Anxiety	0.000	-	-	-	-	-	-	-
	White * No anxiety	0.000	-	-	-	-	-	-	-
Location * Alone	Elsewhere * Alone	−0.135	0.089	−0.310	0.039	-	-	-	0.1279
	Elsewhere * Not alone	0.000	-	-	-	-	-	-	-
	Work * alone	0.456	0.095	0.271	0.642	-	-	-	<0.0001
	Work * Not alone	0.000	-	-	-	-	-	-	-

Abbreviations: BMI, body mass index; GAD, Generalized Anxiety Disorder; HEC, home environment composite; PHQ, Patient Health Questionnaire.

of eating or drinking than being at work but not alone (OR = 1.19, 95% CI = 0.91–1.56).

In Table 4 it can be seen that average daily eating and drinking frequency was not associated with weight change. Six-month weight change was not significantly associated with eating/drinking, location, or social situation or for race, years of age or education, work status or shift work, poverty or food security status, or scores on health literacy, HEC, or depression. However, a significant interaction was evident between race and anxiety in that NHW women who screened positive for anxiety (32%) had a mean weight gain of 3.11 kg (95% CI = −9.18, 15.40) while NHB women with anxiety (20%) had a mean weight loss of −1.52 kg (95% CI = −13.72, 10.67).

TABLE 4 Correlates of 6 months weight change

Term	Level	Estimate	Std error	95% confidence interval		*p*-value
Intercept		0.747	11.321	-	-	0.9475
Age		0.046	0.126	−0.201	0.292	0.7165
Race	Black	−0.352	2.660	−5.566	4.861	0.8948
	White	-	-	-	-	-
BMI at baseline		−0.059	0.098	−0.252	0.134	0.5500
Education level	Primary school	−6.112	13.602	−32.771	20.548	0.6538
	High school	−0.888	3.821	−8.377	6.601	0.8165
	Some college	−0.503	3.592	−7.543	6.537	0.8888
	Four year college degree	0.000	-	-	-	-
	Graduate school	−3.938	5.180	−14.090	6.214	0.4481
Shift work	Not working	0.368	3.405	−6.305	7.041	0.9141
	1st shift (start time 6–8 AM)	0.000	-	-	-	-
	2nd shift (start time 2–5 PM)	0.888	4.560	−8.050	9.827	0.8458
	3rd shift (start time 10 PM-Midnight)	11.857	13.709	−15.012	38.726	0.3883
	Varies	1.931	3.459	−4.848	8.710	0.5774
Household income	Below federal poverty level	1.253	2.172	−3.005	5.511	0.5649
Food security class	High/Marginal food security	0.000	-	-	-	-
	Low food security	0.979	2.409	−3.743	5.701	0.6850
	Very low food security	−3.409	2.674	−8.650	1.832	0.2041
PHQ-9: Score ≥3 depression		1.251	2.981	−4.591	7.093	0.6753
GAD: Score ≥3 anxiety		11.076	3.453	4.308	17.844	0.0016
Low health literacy		−1.653	2.416	−6.388	3.083	0.4949
Home environment (HEC) score		0.148	0.868	−1.553	1.849	0.8645
Mean daily percent home		−0.004	0.071	−0.143	0.134	0.9500
Mean daily percent work		0.079	0.080	−0.078	0.235	0.3258
Mean daily percent friend or family home		−0.104	0.065	−0.231	0.024	0.1135
Mean daily percent elsewhere		−0.015	0.082	−0.175	0.145	0.8578
Mean daily percent alone		0.041	0.051	−0.059	0.142	0.4218
Mean daily eat or drink percent = yes		−0.112	0.082	−0.272	0.048	0.1733
Race * anxiety	Black * Anxiety	−11.800	4.449	−20.520	−3.080	0.0088
	Black * No anxiety	0.000	-	-	-	-
	White * Anxiety	0.000	-	-	-	-
	White * No anxiety	0.000	-	-	-	-

Abbreviations: BMI, body mass index; GAD, Generalized Anxiety Disorder; HEC, home environment composite; PHQ, Patient Health Questionnaire.

4 | DISCUSSION

The majority of weight loss interventions have relied strongly on prolonged self-monitoring and self-control.[8] One possibility to improve outcomes is to highlight spatiotemporal opportunities to lessen the self-control burden of goal-directed weight management, particularly among vulnerable subpopulations. Thus, this study investigated the characteristics of situations and eating and drinking patterns, including time and place, women with obesity experienced. It was anticipated that eating and drinking would be more frequent when alone, at home, in the evening hours, and for those with a higher HEC score. Somewhat consistent with expectations, eating and drinking were more frequent when at home than at friend's or family members' homes or elsewhere and more frequent in the afternoon and evening hours than in the morning. Contrary to expectations, eating and drinking were less frequent when alone, but, if at work and alone, more frequent. Also contrary to expectations, a score representing obesogenic cues that may be present in the home (i.e. the HEC score) was not associated with eating and drinking frequency. Large variability and reduced power could contribute to the non-significant finding.

At least one other study has applied EMA methodology to explore situations associated with eating and drinking frequency. That study also included urban NHB women with obesity and many living in poverty.[33] That study found that watching television or talking was associated with greater snack food intake but not beverage intake. Greater intake while talking is somewhat consistent with the finding that being alone was associated with less frequent eating and drinking; however, in the present study, this association was reversed when the location was the workplace; being alone at work was associated with a higher frequency of eating and drinking.

Somewhat unexpectedly, the EMA-derived variables—mean percent of the day at home, work, others' home, or elsewhere, or mean percent of the day spent alone—were not associated with weight change. Interestingly, the mean percent of the day spent in a location within the 30-days observation window is a combination of objective (GPS) and subjective (EMA) reports, yet it too showed no association with weight change. As stated, eating and drinking frequency were expected to positively affect weight change but it was found that mean percent of the day eating and drinking was not associated with 6-month weight change in either direction. There are many possible reasons why eating and drinking frequency was not associated with weight change, not the least of which was the large variation observed in mean daily eating and drinking frequency (mean = 31.1, standard deviation = 13.2). Validation of EMA reports is challenging, and there are no data for such validation. There is also the potential for time and location influences on EMA validity and completion.

The nature of the eating and drinking question is also likely a factor in the lack of association with weight change as the question did not ask about food type or quantity; it only inquired whether one has eaten or drank anything other than water in the last 15 min. Frequency of eating may facilitate weight management depending on what one is frequently eating and how much but research generally shows three primary meals and infrequent snacking the most effective for weight management.[34] Initially EMA questions were tested regarding food type and quantity but participants had great difficulty reporting this information in any low burden format imagined by this team. Other investigators have had similar challenges. Weight Watchers has recently adopted an EMA program called OnTrack that assesses potential triggers of dietary lapses.[35] In a recent randomized trial, two OnTrack EMA survey versions—a 9 question and 18 question version—were evaluated for data completeness, predictive modeling of lapse, and behavioral and weight outcomes from timely, digital interventions.[36] The study found the short EMA version had a significantly higher rate of completion, but the long EMA version resulted in better prediction, presumably due to more questions per EMA survey. There were no differences in intervention effectiveness between the two versions. Clearly, participant burden, prediction, and intervention effectiveness need further study.

The intention of the present study was to identify opportunities to reduce the burden of self-control associated with obesity and weight management among vulnerable populations. While this report is important in that the subpopulation studied is at high risk of severe obesity and its consequences, the study's focus on time, place, and situation of eating and drinking revealed few obvious opportunities to reduce the burden of self-control. Potential opportunities may exist by considering time of day and location for digital or human supported behavioral interventions around time and place of frequent eating and drinking (late work shifts, when alone, and afternoon/evening times at home). A 2018 review found that such just-in-time interventions for weight loss have mainly focused on timely reminders or behavioral support.[37] Four of nine studies reviewed found improvements in diet or physical activity behavior.

Future advancement of this work might be through testing interventions that assist with removing triggers or adjusting situations in a way that lessens a present self-control challenge. Others have recently noted a need to consider the intersection of Social Determinants of Health and behavior change interventions.[38] Adjusting the self-control burden may require attention to this intersection by acknowledging the need to address housing, safety, food security and other social challenges affecting many of those most vulnerable to obesity and severe obesity, and to design interventions with these social challenges squarely in mind.[4] For example, there is growing work evaluating interventions for food insecurity as a means to improve health and health behavior.[38]

Living and working in contexts that lack appealing nutritious food or physical activity options increases the already high self-control burden of weight-related behavior change. Thus, weight loss interventions may benefit from knowledge of and adaptation to individual situations. If an individual's usual situations involve limited access to health-enhancing options, then addressing those deficits may be a needed component of an effective intervention. In fact, a meta-analysis showed that diet interventions most effective in improving cardiovascular risk factors have been those that include environmental changes.[39] Delivering self-control support in the form of digital or human interventions in situations and moments one is most likely to engage in obesogenic behavior may also prove valuable. Intensive behavioral interventions, whether in-person or by telephone, are effective for weight loss in some individuals[4] but these interventions have rarely been delivered or tested as just-in-time interventions to alleviate self-control burden. Such an approach is imaginable but an effective and scalable tool for detecting momentary self-control burden has yet to be designed.

In an effort to reduce participant burden and not repeat years of prior work, this study did not include traditional behavior change measures such as stages of change or domains of self-efficacy. This may be a missed opportunity in that the value of the novel measures cannot be weighed against the more traditional measures in this sample. The novel measures themselves have methodological limitations; the home environment variables that make up the HEC are a mix of observation and self-report. About two-thirds of the way through enrollment, participants were offered the option to meet at research offices rather than in participant's home for the baseline assessment, and the home environment variables were self-reported in these cases. This change was made to improve and accelerate enrollment as some participants indicated discomfort having an unknown RA in the home.

In summary, in this lower SES sample of both NHB and NHW women with a high prevalence of severe obesity and food insecurity, frequent EMA data capture was achieved each day for 28 days. Time and place and being alone or not were influential in eating and drinking frequency, but eating and drinking frequency was not associated with weight change. In fact, no subject level characteristic was associated with weight change other than anxiety for NHW women; neither food insecurity nor a nutrition literacy test, nor a home environment score (created from measures of dishes or food out and visible, no fitness equipment visible in the home, more televisions in the home or on, and more fast food brought into the home) have an association with eating frequency or weight change.

Regarding race differences in the influence of anxiety on weight change, cultural differences in social and emotional factors related to eating and weight may play a role. In an investigation of 27 urban poor NHB and NHW women with obesity in which home interviews were conducted by race-matched research assistants, white women consistently reported excess weight as negatively impacting health and quality of life. NHB women were less consistent regarding the effect of weight on well-being. Perhaps most relevant to the role of anxiety, NHW consistently reported repeat failures to lose weight and attributed negative emotions as motive for eating whereas NHB women reported eating as a positive and pleasurable activity.[40] Coping behaviors in response to anxiety (e.g. emotional eating) may lead to weight gain among NHW and less so among NHB women. It is important to note that NHB and NHW women in the sample were all quite poor, had similar levels of education, and lived in the same city with similar access to health care. Yet, anxiety had opposing influences on weight change. This may indicate that weight loss interventions need to be tailored to better address social contextual influences on obesogenic behaviors and weight management.

In summary, there are increasing calls for novel investigations into behavior and behavior change. For example, one author highlights the potential for neuroscience to shed light on affective and cognitive components of behavior change, or what the author referred to as the "will" and the "way"[41] and another highlights the need to better address cognition such as executive function, which is directly related to self-control.[5] There is a need for continued work in novel explorations and highlight the need for this is particularly great in subpopulations most likely to experience significant self-control burden owing to social and physical environments that make the will and the way particularly complex.[4]

ACKNOWLEDGEMENT

This study was funded by National Heart, Lung, and Blood Institute (NHLBI) R01 HL128494.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR CONTRIBUTIONS

Drs. Clark, Keith, and Agarwal contributed to study conceptualization and writing, Mr. Hackett to data management and writing, Ms. Ofner and Drs. Li and Tu contributed to data analyses and writing.

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How to cite this article: Clark DO, Keith NR, Ofner S, et al. Environments and situations as correlates of eating and drinking among women living with obesity and urban poverty. *Obes Sci Pract*. 2022;8(2):153-163. https://doi.org/10.1002/osp4.557