Preventive Medicine Reports 21 (2021) 101303

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Race differences in predictors of weight gain among a community sample of smokers enrolled in a randomized controlled trial of a multiple behavior change intervention

Marcia M. Tan [a,*,1], Terry Bush [b], Jennifer C. Lovejoy [c], Harold Javitz [d], Alula Jimenez Torres [b], Ken Wassum [b], Bonnie Spring [a]

[a] Northwestern University Feinberg School of Medicine, 680 North Lake Shore Drive, Suite 1400, Chicago, IL 60611, USA
[b] Alere Wellbeing (a Wholly Owned Subsidiary of Optum), 999 Third Avenue, Suite 2000, Seattle, WA 98104, USA
[c] Institute for Systems Biology, 401 Terry Avenue North, Seattle, WA 98109, USA
[d] SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025, USA

ARTICLE INFO

Keywords:
Health disparities
Smoking cessation
Health behavior
Multiple behavior change
Weight gain

ABSTRACT

African Americans have disproportionate rates of post-cessation weight gain compared to non-Hispanic whites, but few studies have examined this weight gain in a multiracial sample of smokers receiving evidence-based treatment in a community setting. We examined race differences in short-term weight gain during an intervention to foster smoking cessation plus weight management.

Data were drawn from the Best Quit Study, a randomized controlled trial conducted via telephone quitlines across the U.S. from 2013 to 2017. The trial tested the effects on cessation and weight gain prevention of adding a weight control intervention either simultaneously with or sequentially after smoking cessation treatment. African Americans (n = 665) and whites (n = 1723) self-reported smoking status and weight during ten intervention calls. Random effects longitudinal modeling was used to examine predictors of weight change over the intervention period (average 16 weeks).

There was a significant race × treatment effect; in the simultaneous group, weight increased for African Americans at a faster rate compared to whites (b = 0.302, SE = 0.129, $p < 0.05$), independent of smoking status, age, baseline obesity, and education. After stratifying the sample, the effect of treatment group differed by race. Education level attenuated the rate of weight gain for African Americans in the simultaneous group, but not for whites.

African Americans receiving smoking and weight content simultaneously gained weight faster than whites in the same group; however, the weight gain was slower for African Americans with higher educational attainment. Future studies are needed to understand social factors associated with treatment receptivity that may influence weight among African American smokers.

1. Introduction

African Americans experience a disproportionate burden of chronic illnesses and modifiable risk factors, including tobacco use and obesity, in the U.S. Post-cessation weight gain, or weight gain after quitting smoking, may be a contributing factor to observed tobacco-related disparities in this group. Across all races, about 80% of smokers report post-cessation weight gain [i.e., an average of 4–10 pounds (lbs); 1.8–4.5 kilograms (kg)], which usually occurs within the first three months post cessation (Aubin et al., 2012; Perkins, 1993) and contributes to the development of obesity and chronic disease risk (Chinn et al., 2005; Mukhopadhyay and Wendel, 2011; Yeh et al., 2010). African Americans previously have been shown to gain excessively [>10 lbs (4.5 kg)] and at disproportionately higher rates after cessation (Klesges et al., 1998; Swan and Carmelli, 1995; Williamson et al., 1991) compared to non-Hispanic whites. However, few studies examining smoking and weight gain have examined smokers currently seeking treatment. In contrast to earlier research citing excessive weight gain, more recent research

* Corresponding author at: 5841 South Maryland Avenue, MC2000, Chicago, IL 60637, USA.
E-mail address: mmtan@uchicago.edu (M.M. Tan).
[1] Present institution: University of Chicago, 5841 South Maryland Avenue, MC2000, Chicago, IL 60637, USA.

https://doi.org/10.1016/j.pmedr.2020.101303
Received 26 November 2019; Received in revised form 24 November 2020; Accepted 1 December 2020
Available online 29 December 2020

demonstrated that African Americans seeking tobacco cessation treatment gained an average amount of weight after smoking cessation (Tan et al., 2018). In the current study, we sought to compare factors related to weight gain between African American and white smokers enrolled in treatment for smoking cessation and weight management.

Although observational research has shown racial disparities in excessive weight gain, studies conducted with smokers receiving treatment have not shown these disparities. For example, longitudinal survey data indicated that African American smokers gain more weight after quitting and were more likely to gain excessively compared to white smokers (Klesges et al., 1998; Williamson et al., 1991). However, no race differences in weight gain were observed in smokers enrolled in a longitudinal smoking cessation trial (O'Hara et al., 1998). These studies, conducted in the 1990s and early 2000s, primarily examined long-term weight change (follow up 5 and 10 years), and only a few reported information on whether smokers were receiving treatment for smoking and/or weight management. A recent study in 2018 examined weight change among African Americans enrolled in a cognitive behavioral therapy smoking cessation trial, and did not observe excessive weight gain in the sample. Abstainers gained within the average 4–10 lbs (1.8–4.5 kg) during a one-year follow up (Tan et al., 2018). Because a majority of post-cessation weight gain occurs within three months of quitting, studies are needed to examine short-term weight gain in multiracial samples of treatment-seeking smokers to identify potential disparities in weight outcomes.

We aimed to study weight in smokers receiving treatment for both smoking and weight. In an effort to reduce/prevent post-cessation weight gain, weight management interventions have been administered either simultaneously with smoking cessation or immediately following (Farley et al., 2012). Particularly, behavioral interventions (e.g., exercise, diet) have proven to be beneficial for controlling weight without diminishing cessation rates (Spring et al., 2009). Despite the concern of treatment fatigue (i.e., increased burden of changing two behaviors at once), adding a weight component to a standard behavioral smoking treatment limits weight gain in the short-term (Farley et al., 2012). However, few interventions to date have reported efficacy among African Americans (Marcus et al., 2005; Spring et al., 2009), as many trials enrolled a small sample or did not report race. A recent effectiveness trial with a larger sample of African Americans (i.e., 33%) found that adding weight management counseling to a tobacco quitline intervention did not improve weight outcomes at one year (Bush et al., 2018). Because multiple behavior interventions have shown some evidence in mitigating post-cessation weight gain, smokers in treatment should be compared to understand factors that may contribute to disparities in weight gain.

Understanding the distinctive factors related to weight gain in smokers is critical to address the disproportionate burden of tobacco- and obesity-related illnesses that African Americans experience. Few studies have compared weight in multiracial samples of smokers receiving evidence-based treatment in a community setting. The current study examined race differences between African American and white smokers in factors related to short-term weight gain during an intervention to foster smoking cessation plus weight management.

2. Methods

Data were drawn from the Best Quit Study, a randomized controlled trial that tested the effects on cessation and weight gain prevention of adding a weight control intervention either simultaneously with or sequentially after smoking cessation treatment; study protocol, measures, methods (Bush et al., 2016), and results have been published elsewhere (Bush et al., 2018).

2.1. Participants

Participants were adults who called into one of three state quitlines (Indiana, Maryland and North Carolina) or ten commercial (employer-provided) quitlines. Inclusion criteria included: age of at least 18 years, body mass index (BMI) greater than or equal to 18.5, smoked at least ten cigarettes per day, motivated to quit smoking within 30 days, and could read and speak English. Exclusion criteria were: current pregnancy, current substance abuse or psychosis, current diabetes, history of an eating disorder, recent or planned obesity surgery, no access to internet, being unavailable for any 2-week time period over the following six months, and/or not interested in receiving ten coaching calls. Eligible participants gave verbal informed consent to participate in the study, and the study was approved by the Western Institutional Review Board.

2.2. Intervention and procedures

Details of the intervention are published in (Bush et al., 2016) and are summarized here. In the Best Quit Study, eligible participants (N = 2528) were randomized to one of three treatment groups: a) simultaneous tobacco cessation and weight management (n = 839), b) sequential cessation then weight management (n = 849), or c) tobacco cessation only (control; n = 840). Data from callers who identified as either non-Hispanic "Black or African American" (n = 665) or "White" (n = 1723) were used in the current study. During the verbal informed consent, participants were told that they will be assigned by chance to receive the standard of care cessation treatment, or a combined intervention that includes weight management, and provided details of each intervention arm and expected treatment. The intervention consisted of ten coaching calls administered by a trained quitline coach. All groups received five tobacco cessation coaching calls, and the intervention groups received an additional five weight management calls either during the tobacco call (simultaneous) or after all five tobacco calls were completed (sequential). To match on contact time, the simultaneous and control groups received five healthy living calls following the tobacco plus weight or the tobacco calls, respectively. The healthy living calls did not discuss tobacco or weight content, but addressed topics such as sun protection, flu prevention, and pedestrian safety (see Appendix A for timeline of calls). The tobacco treatment included counseling sessions (e.g., developing a quit plan, problem solving, relapse prevention, etc.), a web intervention and mailed print materials. The weight management treatment included coaching calls (e.g., setting goals for diet, physical activity, and weight, self-monitoring, and calorie reduction), mailed print materials, and an optional web-based program that included online tracking forms. Calls lasted approximately 13 min for tobacco content (control and sequential), 16–22 min for tobacco plus weight content (simultaneous), 15–20 min for weight content only (sequential), and 7 min for the healthy living calls (control and simultaneous). In addition, participants randomized to the control condition were offered free access to a web-based weight management program after their 12-month assessment.

Coaches made several attempts over five different days to reach participants for each of their ten planned calls (see call completion rates in Results section). Coaches were trained to discuss only the content that was scheduled for the current call using a structured pattern of counseling. If a participant wanted to discuss tobacco or weight content in addition to content scheduled for the call, the scheduled content was delivered first, then the portion of those calls discussing unscheduled content was recorded separately as "adhoc." Adhoc calls were included in the definition of "Total calls" for the respective intervention (i.e., "Total tobacco" or "Total weight")." All calls were recorded, and research staff reviewed and coded a select number of calls to ensure intervention fidelity. Participants were also offered up to eight weeks of nicotine replacement therapy (NRT; gum, patch, and/or lozenge). All participants were administered surveys either over the phone or by mail (if unreachable by phone) at 6- and 12-months post coaching call intervention; they were compensated up to $110 for completing both surveys.

2.3. Measures

2.3.1. Outcome variable

Weight. Participants reported weight at each call, including tobacco only and healthy living calls, and the weight recorded from all calls, including adhoc calls, were used in the analysis.

2.3.2. Predictor variables

Smoking status. Participants reported the total number of cigarettes smoked the previous day (cpd; i.e., 24-hour point prevalence abstinence) at each call. Data were only available for calls that were completed. We calculated both a) quit status (0 = reporting > 0 cpd, 1 = reporting no cpd) and b) abstinence trajectory (how often the participant reported abstinence over the intervention period; 0–100%; missing values were coded as smoking).

Demographics. Race, age, sex, and education level were self-reported at baseline. Education level (0 = < 9th grade, 1 = 9th-11th grade/no degree, 2 = GED, 3 = high school degree, 4 = some technical/trade school, 5 = technical/trade school degree, 6 = some college or university, 7 = college or university degree) was included as a continuous variable in the model. Body mass index was calculated using height and baseline weight, and included as a dichotomous variable (obesity; 0 = BMI < 30, 1 = BMI ≥ 30) (Centers for Disease Control and Prevention, 2014).

2.3.3. Covariates

At baseline, participants answered questions regarding weight concern, depression and anxiety symptoms, and exercise frequency. Participants answered a single question on a 10-point scale: "How concerned are you about gaining weight after quitting?" (≥ 6 = moderate weight concern). Patient Health Questionnaire-2 (PHQ-2) (Kroenke et al., 2003), a 2-item depressive symptom screening, was used to assess frequency of depressed mood and anhedonia (cutoff score of 3 indicated an increased likelihood of major depressive disorder). Generalized Anxiety Disorder 2-item (GAD-2) (Kroenke et al., 2007), a 2-item screening for anxiety disorders, was used to assess anxiety symptoms (cutoff score of 3 used to identify potential cases of generalized anxiety disorder). Participants answered a single question on exercise frequency: "How many days of moderate to strenuous exercise did you do in the last 7 days?"

2.4. Statistical analysis

Chi-square and t-tests were performed to illustrate differences in baseline characteristics between races. Random effects longitudinal modeling, using PROC MIXED in SAS® 9.4, was used to examine race differences in short-term weight gain. Weight change was modeled over the intervention period (about 16 weeks) using the ten intervention call time points. The effects of the predictor variables on both intercept (baseline weight) and slope (rate of weight change) were examined. Quit status (0 = smoking, 1 = abstinent) was entered in level 1 as a time-varying covariate to account for the variability in smoking status at each assessment. Because it is recommended that both within- and between-person variances are considered when analyzing time-varying covariates (Hoffman, 2014; Hoffman and Stawski, 2009; Howard, 2015), we created the variable of abstinence trajectory (range: 0–100%) to represent the between-person variance of quit status and included it on level 2 as a time-invariant variable. The nature of smoking is dynamic, with most adults taking multiple attempts to quit successfully. The within-person, time-varying, effect captures the concept that for each individual, their quit status could change from one assessment to another. The between-person, time-invariant, effect captures whether people who, on average, are quit more often, weigh more than those who are quit less often or not quit at all. Accounting for whether a person is abstinent at a specific assessment point (i.e., "quit status") versus whether a person is usually abstinent or not (i.e., "abstinence trajectory") is an important distinction. Race (0 = white, 1 = African American) and intervention condition (dummy coded; 0 = control, 1 = simultaneous, 2 = sequential) were entered on level 2 to predict both the intercept and slope. Covariates of sex (0 = male, 1 = female), age (continuous), obesity (0 = not obese, 1 = obese), education level (continuous), weight concern (continuous), and exercise frequency (continuous) were included as control variables on level 2 to predict intercept. In cases of missing data on weight, all available information and weighted estimates were used. Therefore, if a participant was

Table 1
Sample characteristics aggregated across treatment groups of telephone quitline callers in a multiple behavior change intervention in the U.S. from 2013 to 2017.

Characteristic	Total (N = 2388)	African American (n = 665)	Non-Hispanic White (n = 1723)	*p*	Possible Range
Baseline variables					
Age, years, M (SD)	43.33 (12.21)	43.46 (11.65)	43.28 (12.42)	0.750	
Sex (%)[a]				<0.0001	
Male	34	36	33		
Female	66	64	67		
Education level (%)[a]				0.014	
Less than high school	20	21	20		
High school	24	27	23		
Greater than high school	56	52	57		
Cigarettes per day, M (SD)[a]	18.18 (10.71)	16.06 (15.33)	19.00 (18.48)	<0.0001	
Weight concern, M (SD)[a]	6.51 (3.04)	6.26 (3.37)	6.62 (2.90)	0.016	1–10
Exercise frequency, M (SD)[a]	2.51 (2.54)	2.73 (2.62)	2.42 (2.51)	<0.0001	0–7
Depressed mood[b] (%)	29	28	29	0.156	
Anxiety symptoms[b] (%)[a]	44	39	46	<0.0001	
Baseline BMI, M (SD)[a]	30.00 (7.16)	31.11 (7.16)	29.57 (7.11)	<0.0001	
Smoking and treatment variables					
Abstinence trajectory (% of time quit during intervention)[a]	16	16	15	<0.001	0–100
Total calls completed, M (SD)[a]	3.93 (3.07)	4.00 (3.02)	3.91 (3.10)	0.002	1–10
Total tobacco calls	2.75 (1.63)	2.76 (1.59)	2.74 (1.65)	0.436	1–5
Total weight calls	1.10 (1.58)	1.10 (1.55)	1.10 (1.59)	0.933	1–5
Simultaneous group					
Total tobacco calls	2.56 (1.65)	2.56 (1.60)	2.57 (1.67)	0.889	1–5
Total weight calls	2.34 (1.52)	2.37 (1.52)	2.33 (1.52)	0.138	1–5
Total calls[a]	3.83 (3.19)	3.96 (3.13)	3.77 (3.23)	<0.001	1–5
Sequential group					
Total tobacco calls[a]	2.83 (1.60)	2.71 (1.53)	2.88 (1.62)	<0.0001	1–5
Total weight calls[a]	0.96 (1.54)	0.78 (1.33)	1.03 (1.62)	<0.0001	1–5
Total calls[a]	3.79 (2.83)	3.49 (2.60)	3.90 (2.90)	<0.0001	1–5

[a] Significant X^2 or *t*-test comparing each variable by race ($p < .05$).
[b] Scores on Patient Health Questionnaire (PHQ)-2 or Generalized Anxiety Disorder (GAD)-2 that are ≥ 3.

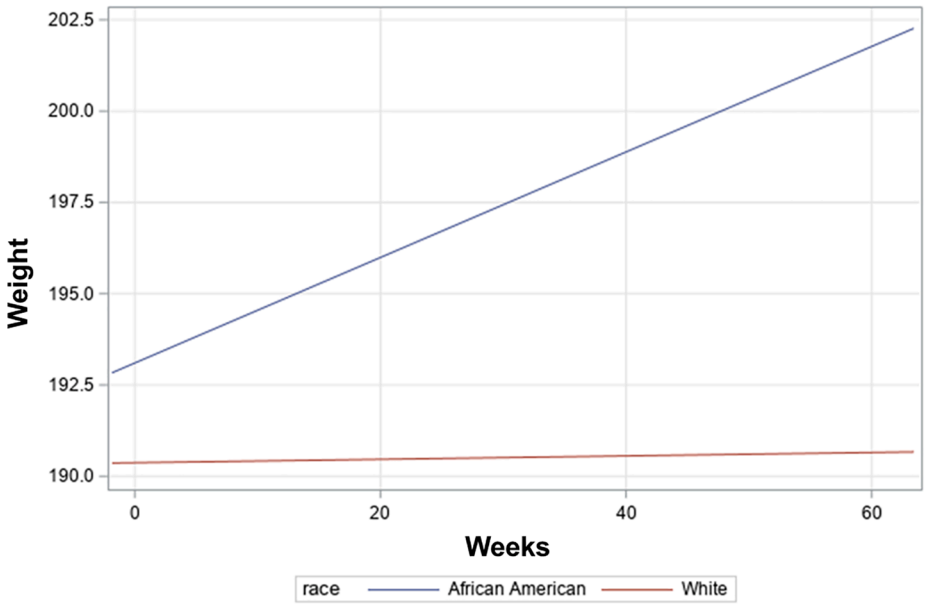

Fig. 1. Results of a mixed effects multilevel model examining change in weight over time for participants receiving a multiple behavior change intervention administered through the telephone quitline in the U.S. from 2013 to 2017. This graph is a visual representation of the effect of race on weight gain and illustrates the predicted values for African American and white participants receiving a smoking cessation and weight management treatment simultaneously.

missing measurements for a specific phone call, the entire case was not removed from analyses (Singer and Willett, 2003).

3. Results

Sample characteristics are found in Table 1. There was a higher prevalence of African Americans in the simultaneous group (35.59%) than in the sequential (32.73%) or control (31.68%) groups. At the 6-month follow-up, African Americans were more likely to report 7-day and 30-day point prevalence abstinence (OR = 1.43, $p < .05$ and OR = 1.41, $p < .05$, respectively). Overall, response rates were significantly lower for simultaneous group (42.8%), compared to control group (48.8%), but was not different from the sequential group (46.5%).

3.1. Weight gain in the overall sample

Controlling for race, sex, age, education level, weight concern, obesity, and exercise frequency, baseline weight was positively associated with abstinence trajectory (b = 10.239, SE = 3.03, $p < .001$). There were no associations between baseline weight and race ($p > .05$) or intervention group ($p > .05$). Although time-varying quit status was not predictive of weight gain over time ($p > .05$), abstinence trajectory was positively associated with the rate of weight gain (b = 0.207, SE = 0.091, $p < .05$); as the percentage of time being abstinent increased, the rate increased. The interaction of race × intervention group was significant, such that African Americans in the simultaneous group had a higher rate of weight gain (b = 0.301, SE = 0.129, $p < .05$) compared to whites in the same group (see Fig. 1 for visual depiction of interaction effect). Of note, the simple effect of the simultaneous intervention group was negatively associated with the rate (b = -0.368, SE = 0.185, $p < .05$), indicating that white participants in the simultaneous group had a slower rate of weight gain compared to those in the control group (see full results in Appendix B).

3.2 Weight. gain in the stratified sample

Analyses were then conducted separately for African American and white participants to examine whether the above predictors were significant in the race-specific sub-samples. Next, we explored variables in the stratified samples that may explain further race differences in the effects of the intervention group. We hypothesized that mood and education level might influence responsiveness to the intervention and, therefore, predict outcomes during interventions with a high participant burden of behavior change (i.e., the simultaneous group having the greatest burden). Baseline psychosocial variables of depressed mood [0 = not depressed (PHQ-2 score < 3), 1 = depressed (PHQ-2 score ≥ 3)], anxiety symptoms [0 = no anxiety (GAD-2 score < 3), 1 = anxiety (GAD-2 score ≥ 3)], and education level were included in the models to predict intercept and slope and examine interactions with intervention group. The simultaneous group was the reference group in the stratified analyses.

3.2.1. African American subsample

Overall model. In the sample of African Americans, obesity (b = 59.372, SE = 3.204, $p < .0001$), sex (b = -28.481, SE = 3.278, $p < .0001$), age (b = -0.304, SE = 0.133, $p = .023$), and weight concern (b = 1.365, SE = 0.480, $p < .01$) were associated with baseline weight; education level was not significant ($p = .686$). Neither time-varying quit status nor abstinence trajectory were associated with rate of weight change. Intervention group predicted slope, such that African Americans in the control group had a slower rate of weight gain compared to the simultaneous group (b = -0.226, SE = 0.115, $p = .049$), indicating that those in the simultaneous group gained weight quicker than those in the control group.

Exploratory analysis. Controlling for baseline covariates and smoking variables, depressed mood and anxiety symptoms were not associated with initial weight or rate of change ($p > .05$). However, there was a significant education × intervention group interaction (Table 2); those with higher education levels in both the control and sequential groups had a faster rate of weight gain than those with higher education levels in the simultaneous group (see Fig. 2 for visual depiction of the interaction effect). Furthermore, the simple effect of education level on rate of weight gain was significant, indicating that weight increased at a slower rate as education increased for all in the simultaneous group [see Eq. (C.1) in Appendices].

3.2.2. White subsample

Overall model. Similar to the African American subgroup, obesity (b

Table 2
Unique predictors of weight gain among African American and non-Hispanic white adult quitline callers in the U.S. from 2013 to 2017; results of a stratified analysis.

		African American	White	
Factors Associated with Initial Weight	Estimate[a](SE)	*p*	Estimate[a](SE)	*p*
Intercept	191.56 (8.031)	<0.0001	185.40 (4.430)	<0.0001
Time (in weeks)	0.456 (0.164)	0.006	0.0391 (0.075)	0.599
Control group	−0.684 (3.837)	0.858	2.561 (2.107)	0.224
Sequential group	0.122 (3.838)	0.975	0.616 (2.112)	0.770
Abstinence trajectory	9.482 (6.583)	0.150	10.835 (3.567)	0.002
Obesity	60.299 (3.296)	<0.0001	66.443 (1.791)	<0.0001
Female sex	−28.316 (3.364)	<0.0001	−34.369 (1.93)	<0.0001
Age	−0.334 (0.139)	0.017	−0.286 (0.070)	<0.0001
Education level	0.226 (0.743)	0.761	0.231 (0.401)	0.565
Exercise frequency	−0.651 (0.604)	0.282	−0.871 (0.345)	0.012
Weight concern	1.389 (0.495)	0.005	1.298 (0.322)	<0.0001
Depressed mood	−4.916 (3.80)	0.196	4.303 (2.101)	0.041
Anxiety symptoms	−0.234 (3.495)	0.947	−1.533 (1.916)	0.424
Factors Associated with or Predicting Change in Weight Over Time	Estimate[a](SE)	*p*	Estimate[a](SE)	*p*
Quit status	−0.338 (0.880)	0.701	−0.690 (0.363)	0.057
Control group[b]	**−0.684 (0.235)**	**0.004**	−0.053 (0.089)	0.549
Sequential group[b]	**−0.572 (0.271)**	**0.035**	0.077 (0.093)	0.409
Abstinence trajectory	0.265 (0.179)	0.139	0.158 (0.102)	0.121
Unique Predictors for African Americans				
Education level[b]	**−0.091 (0.032)**	**0.005**		
Education level × control group[b]	**0.101 (0.047)**	**0.032**		
Education level × sequential group[b]	**0.115 (0.055)**	**0.036**		
Unique Predictors for whites				
Depressed mood			−0.201 (0.109)	0.067
Depressed mood × control group[b]			**0.350 (0.153)**	**0.022**
Depressed mood × sequential group			0.155 (0.170)	0.364

[a] Average differences in baseline weight in pounds (lbs.) or rate of weight gain per one-unit change in the predictor variable (if continuous) or between groups (if categorical); SE = Standard Error.
[b] **Significant at $p < .05$.**

= 66.399, SE = 1.738, $p < .0001$), sex (b = -34.844, SE = 1.876, $p < .0001$), age (b = -0.287, SE = 0.068, $p < .0001$), and weight concern (b = 1.333, SE = 0.310, $p < .0001$) were associated with baseline weight; education level was not significant (p = .851). Exercise frequency was associated with baseline weight (b = -0.874, SE = 0.333, $p < .01$). Abstinence trajectory was associated with baseline weight (b = 10.657, SE = 3.444, $p < .01$), but not with rate of weight gain ($p = .065$). Additionally, intervention group predicted slope; among whites, those in the sequential group had a faster rate of weight gain compared to the simultaneous group (b = 0.165, SE = 0.077, $p = .032$).

Exploratory analysis. Controlling for baseline covariates and smoking variables, depressed mood was positively associated with initial weight. Education level × intervention was negatively associated with rate of weight gain, with rate slowing as education level increased in the control group compared to the simultaneous (b = -0.070, *SE* = 0.030, $p = 0.02$). However, depressed mood was a better predictor of the effect of intervention group on slope and included in final model (Table 2). There was a significant depressed mood × intervention group interaction; those in the control group had a faster rate of weight gain for participants who reported depressed mood compared to those with depressed mood in the simultaneous group [see equation (C.2) in Appendices].

4. Discussion

In the overall sample, the rate of weight gain was increased for African American smokers in the simultaneous group compared to white smokers in same group. In the stratified analyses, abstinence trajectory (i.e., the average time an individual was abstinent over the intervention period) was not associated with weight gain in African Americans, but a higher abstinence trajectory was associated with higher baseline weight in whites. Intervention group predicted weight gain for both groups. However, African Americans in the simultaneous group had a faster rate of weight gain, whereas whites in the simultaneous group had a similar rate, compared to the control group. Results of the exploratory analyses indicated that psychological factors (i.e., current mood symptoms) did not help explain differences in weight gain among intervention groups for African Americans, but they did have an impact in whites. In contrast, education was predictive of rate of weight gain for African Americans.

4.1. Abstinence predicts weight gain for white and not African American smokers

Weight gain was not significantly different between African American and white smokers in those receiving only a tobacco intervention (control group). This is consistent with a previous study that showed no race differences in observed post-cessation weight gain among smokers receiving behavioral treatment plus NRT for smoking (O'Hara et al., 1998). When looking at racial groups separately, the effect of abstinence trajectory on weight gain is not present among African American smokers. For white smokers, abstinence trajectory is still positively associated with weight, which is consistent with previous studies illustrating an average weight gain of 4–10 lbs (1.8–4.5 kg) after quitting (Aubin et al., 2012). This finding is not surprising; associations seen in post-cessation weight gain literature may be driven by the large sampling of white smokers, as many previous studies had small samples of non-white participants or did not report the racial makeup of the sample (Aubin et al., 2012). Yet, recent studies of smokers [with representative samples of African American smokers (e.g., >30%)] undergoing smoking cessation and weight management treatment found no association between abstinence and weight gain at one and two years post-cessation (Bush et al., 2018; Johnson et al., 2017). Our results show that time-varying quit status is not predictive of short-term weight gain for African Americans, so there may be other attributes to weight gain in the population of African American smokers who are undergoing treatment for both smoking cessation and weight management. This is notable as there were differences in abstinence rates in this sample; African Americans had higher quit rates at six months post intervention. Further, studies documenting disparities in post-cessation weight gain had longer follow up periods (from 5 to 15 years) (Klesges et al., 1998; Williamson et al., 1991) compared to those that did not find race differences (from 2 weeks-2 years) (Bush et al., 2018; Johnson et al., 2017; Weg et al., 2001). This indicates that racial disparities in post-cessation weight gain may be pronounced several years after quitting. It is also possible that other factors, which may not be directly related to the immediate resulting biological mechanisms of smoking cessation (Filozof et al., 2004), are contributors to weight gain among African

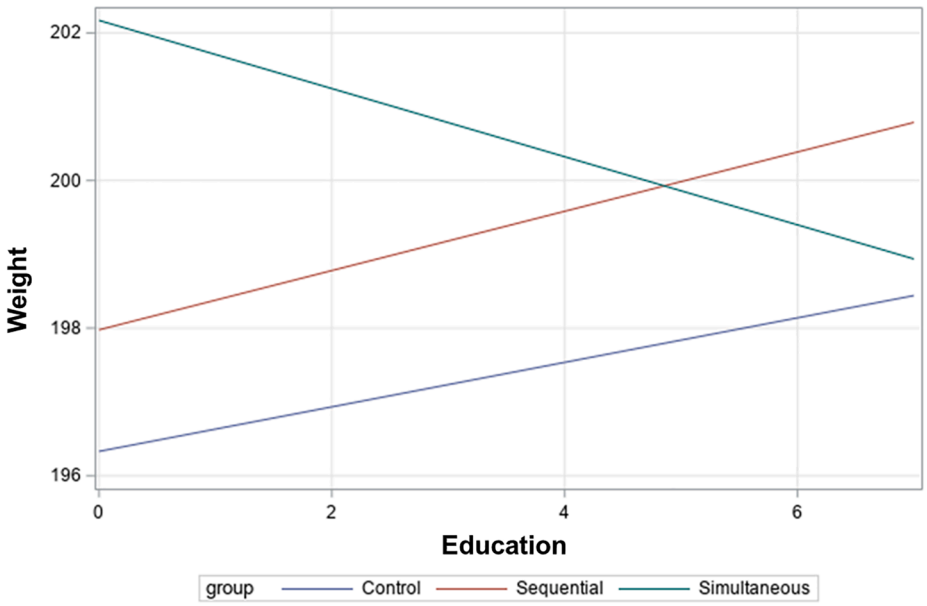

Fig. 2. This graph is a visual representation of an interaction effect of education level and intervention group on weight gain over time for African American quitline callers. This graph illustrates the predicted values for African Americans in each intervention group of a randomized controlled trial testing efficacy of adding a weight management intervention to a telephone quitline tobacco cessation intervention in the U.S. from 2013 to 2017.

Americans over time. Exploring psychosocial and environmental factors among African American ex-smokers may be necessary to understand observed racial disparities in long-term weight gain upon smoking cessation.

4.2. Education predicts weight gain for African Americans

Education level moderated the effect of the simultaneous group on rate of weight change controlling for the effects of quitting, except the direction of the effect differed by race. As education level increased for African Americans in the simultaneous group, the rate of weight change *decreased* compared to the control group. Conversely, for whites in the simultaneous group, the rate *increased* compared to the control as education level increased. Although higher rates of weight gain are seen for African Americans in the simultaneous group in the overall sample, education level appears to be protective for this group alone. Research on education and obesity among African Americans has shown mixed findings. Previous studies have shown that African American women who were higher educated weighed more over time than those who were lower educated (Lewis et al., 2005; Wang and Beydoun, 2007; Bennett et al., 2007). Yet, more recent studies have shown a null association among African Americans; these studies took a nuanced approach at examining education and measures of obesity (Cohen et al., 2013; Yu, 2012). Our finding is more consistent with literature in the overall population that shows an inverse association between education and obesity in high-income countries, such as the U.S (Cohen et al., 2013), and with a study conducted with treatment-seeking African American women (Yu, 2012). While intensive, multiple behavior change treatment may be burdensome to some smokers, higher educated African Americans may be more equipped and likely to respond to simultaneous treatment to reduce weight gain. For example, Barnes and Kimbro (Barnes and Kimbro, 2012) identified a large sample of educated (60% had at least a college degree) African American women who lost and maintained $\geq$10% of body weight over five years using both dietary and physical activity strategies, as well as monitoring their weight using a scale (Barnes and Kimbro, 2012). The weight management intervention in the current study consisted of setting goals around similar strategies, including reducing caloric intake and increasing activity, and participants engaged in monitoring their weight. Although we are unable to conclude based on results of the current study the reasons that African American women and men with higher education levels in the simultaneous group (in contrast to whites) had a slower rate of weight gain, self-monitoring of weight may be important to examine as a weight reduction strategy for this group, specifically. Participants also may have been more likely to employ strategies to reduce weight gain that were similar to strategies that helped them successfully quit smoking, as African Americans had a higher quit rate in simultaneous group than whites. An additional result to explore is that African Americans in the simultaneous group initiated more adhoc calls for weight than their white counterparts (who initiated more adhoc calls for tobacco), although the average number of adhoc weight calls was small [e.g., 3.8% of African Americans made $\geq$ 1 call (range: 0–2 calls) vs. 3.1% of whites]. This finding is intuitive as African Americans had a higher BMI at baseline and may have been more interested in weight control, with higher educated individuals being more likely to seek out additional treatment. Thus, observed differences in weight outcomes between races in the simultaneous group may not be a direct result of intervention components, but rather a function of differing motivations to change certain behaviors (weight for African Americans vs. tobacco use for whites). It is worth noting that the nature of the simultaneous intervention (i.e., discussing two behaviors during one call) highlighted this differential motivation and preference for targeting a specific behavior. In addition, dietary quality (e.g., fruit and vegetable intake), which is associated with both education level and obesity, is a factor that warrants further exploration to better understand the association between educational attainment and weight gain in a treatment-seeking sample of smokers.

4.3. Strengths and limitations

The prospective and within-person study design allowed for a rigorous look at specific factors that influence weight change for each racial group. However, the study consisted of smokers who proactively called the quitline for cessation help, so the sample may not be generalizeable to non-treatment-seeking smokers. Diet/eating habits are well-known factors that contribute to weight gain, and we were not able to account for this in the model. Similarly, although we included a measure of exercise frequency at baseline, we did not have a measure of

exercise or other physical activity that occurred during the intervention. Nicotine replacement therapy has been shown to limit weight gain, and NRT use was not available for this analysis. Depression and anxiety symptom measures were brief and did not indicate a diagnosis of a mood disorder; it is unknown whether participants in this sample experienced and/or received treatment for mood symptoms during this intervention. Furthermore, current smoking status and weight measures were collected using self-report data. Although biochemically verifying smoking status is preferred, population-based tobacco research studies have standardly used self-report measures of smoking. Self-reported weight is generally a concern because of biased reporting (i.e., under-reporting) and differential reporting by race (e.g., white adults having higher degree of underreporting compared to African Americans), especially as the degree of overweight/obesity increases. Yet, participants self-reported weight several times, and the within-subjects reporting should hold bias constant in this study.

Finally, results should be interpreted in light of limitations of the data. Education was examined continuously to explore potential race differences in trends in its effect on weight gain; however, this coding assumed equal distances between values. The call completion rate during the intervention was about half of the calls offered, which is similar to the completion rate of quitline callers and expected for this community sample of quitline callers (Bernstein et al., 2016; Lien et al., 2016; Vickerman et al., 2015). The low call rates for the weight component could be due to the limited availability of coaches trained on weight management compared to those trained on tobacco only; this resulted in delays in coaching calls for the simultaneous and sequential groups. The differences in call completion (sequential group received fewer weight calls than the simultaneous) and in response rate at 6 months (simultaneous group had lower rate than control) could represent differential effects in implementation of the weight intervention rather than the intervention itself. Therefore, we controlled for treatment group separately in the model to account for differences in intervention receptivity, as well as focused our discussion on comparisons of the simultaneous group to control (cessation-only) group. We were still able to compare races given the tobacco and weight call completion rates within the simultaneous treatment group were similar between races. Of note, differences in weight change between races and among intervention groups were small. Because the study was limited to short-term weight gain, we did not expect large group differences or changes in weight over the four-month period.

5. Conclusion

Recent research has highlighted the importance of targeting shared risk factors for chronic diseases, including tobacco use and obesity. In this community sample of quitline callers, we found differences in weight gain between African American and white smokers who received an intervention to foster smoking cessation and weight management simultaneously, with African American smokers gaining weight at a quicker rate over about four months. However, having higher educational attainment reduced this rate of weight gain for African Americans. These results help to identify protective factors for African Americans at high-risk for weight gain and obesity, and support the need to target groups on socioeconomic variables when designing behavioral interventions to improve weight outcomes in African Americans. Future research with more robust data and uniform intervention delivery should explore how socioeconomic (e.g., education level) and psychosocial factors contribute to weight management intervention receptivity among African Americans. Specifically, studies with quality of educational attainment, longitudinal measures of energy expenditure, longitudinal mood symptomatology, and objective measures of weight and smoking cessation are warranted.

Funding

This work was supported by the National Institute of Drug Abuse of the National Institutes of Health (NIH; RO1DA31147). This work was also supported by a National Institutes of Health Ruth L Kirschstein Postdoctoral Fellowship (T32CA193193) to MT. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

CRediT authorship contribution statement

Marcia M. Tan: Conceptualization, Methodology, Formal analysis, Visualization, Writing - original draft. **Terry Bush:** Funding acquisition, Resources, Writing - review & editing. **Jennifer C. Lovejoy:** Resources, Data curation. **Harold Javitz:** Software, Data curation. **Alula Jimenez Torres:** Project administration. **Ken Wassum:** Resources, Project administration. **Bonnie Spring:** Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors at Alere Wellbeing (TB, AJT, and KW) declare that they are employed by Alere Wellbeing (a subsidiary of Optum) which provides tobacco cessation and weight management services to states and commercial clients. They have no other competing interests. MT, JCL, HJ, and BS have no conflicts to disclose. No financial disclosures were reported by the authors of this paper.

Acknowledgements

The authors thank the study participants, and the participating quitlines and employers for permitting the original trial to be conducted with their enrollees. The authors gratefully acknowledge the efforts of Alere Wellbeing's service delivery staff, the clinical teams and the support staff from both the tobacco treatment groups and the weight management teams.

Appendix A

Table A1
Call schedule for a smoking cessation and weight management multiple behavior change intervention delivered via the telephone quitline in the U.S. from 2013 to 2017. The 'control group' received the standard tobacco cessation calls offered by the quitline; the 'simultaneous group' received the standard calls plus added weight management calls administered during the same phone call; the 'sequential group' received the standard tobacco calls plus weight management calls delivered following the completion of the tobacco calls. The healthy living calls were administered to the 'control' and 'simultaneous' groups to match the 'sequential' group on contact time.

	Control group (i.e., standard tobacco intervention)	Simultaneous group	Sequential group
Call 1	Tobacco	Tobacco + Weight	Tobacco
Call 2	Tobacco	Tobacco + Weight[a]	Tobacco
Call 3	Tobacco	Tobacco + Weight	Tobacco
Call 4	Tobacco	Tobacco + Weight	Tobacco
Call 5	Tobacco	Tobacco + Weight	Tobacco
Call 6	Healthy living	Healthy living	Weight
Call 7	Healthy living	Healthy living	Weight
Call 8	Healthy living	Healthy living	Weight
Call 9	Healthy living	Healthy living	Weight
Call 10	Healthy living	Healthy living	Weight

[a] During Call 2, participants were transferred to a registered dietician to receive the weight content.

Appendix B

Table B1
Predictors of weight change among overall sample of African American and non-Hispanic white adults undergoing a quitline multiple-behavior change intervention.

Factors Associated with Initial Weight	Estimate[a]	SE	p
Intercept	185.53	4.206	<0.0001
Time (in weeks)	0.165	0.131	0.209
Simultaneous group	−1.259	1.813	0.487
Sequential group	−1.132	1.781	0.525
Abstinence trajectory	10.239	3.030	0.001
African American race	2.729	1.628	0.094
Obesity	64.639	1.533	<0.0001
Female sex	−32.893	1.616	<0.0001
Age	−0.294	0.061	<0.0001
Education level	0.169	0.338	0.617
Exercise frequency	−0.864	0.287	0.003
Weight concern	1.296	0.258	<0.0001
Factors Associated with or Predicting Change in Weight Over Time	**Estimate[a]**	**SE**	***p***
Quit status	−0.5309	0.3617	0.1423
African American race	−0.1612	0.09065	0.0754
Simultaneous group[b]	−0.3684	0.1846	0.0461
Sequential group	0.04562	0.1990	0.8187
African American race × Simultaneous group[b]	0.3010	0.1293	0.0200
African American race × Sequential group	0.05645	0.1438	0.6947
Abstinence trajectory[b]	0.2068	0.09092	0.0230

[a] Average differences in baseline weight in pounds (lbs.) or rate of weight gain per one-unit change in the predictor variable (if continuous) or between groups (if categorical); SE = Standard Error.
[b] Significant at $p < .05$.

Appendix C. Final combined multilevel models of weight change within African American and white quitline callers receiving a multiple behavior change intervention

C.1. African American subsample

$$\text{Weight}_{it} = \beta_{00} + \beta_{01}(\text{Control}_i) + \beta_{02}(\text{Sequential}_i) + \beta_{03}(\text{Abstinence trajectory}) + \beta_{04}(\text{Obesity}_i) + \beta_{05}(\text{Sex}_i) + B_{06}(\text{Age}_i) + \beta_{07}(\text{Education}_i) + \beta_{08}(\text{Exercise}_i) + \beta_{08}(\text{Weight concern}_i) + \beta_{09}(\text{Depressed}_i) + \beta_{010}(\text{Anxiety}_i) + \beta_{10}(\text{Time}_{it}) + \beta_{11}(\text{Quit}_{it}) + \beta_{12}(\text{Control}_i \times \text{Time}_{it}) + \beta_{13}(\text{Sequential}_i \times \text{Time}_{it}) + \beta_{14}(\text{Abstinence trajectory}_i \times \text{Time}_{it}) + \beta_{15}(\text{Education}_i \times \text{Time}_{it}) + B_{16}(\text{Education}_i \times \text{Control}_i \times \text{Time}_{it}) + \beta_{17}(\text{Education}_i \times \text{Sequential}_i \times \text{Time}_{it}) + r_{0i} + r_{1i}(\text{Time}_{it}) + e_{it}$$

C.2. White subsample

$$\text{Weight}_{it} = \beta_{00} + \beta_{01}(\text{Control}_i) + \beta_{02}(\text{Sequential}_i) + \beta_{03}(\text{Abstinence trajectory}) + \beta_{04}(\text{Obesity}_i) + \beta_{05}(\text{Sex}_i) + B_{06}(\text{Age}_i) + \beta_{07}(\text{Education}_i) + \beta_{08}(\text{Exercise}_i) + \beta_{08}(\text{Weight concern}_i) + \beta_{09}(\text{Depressed}_i) + \beta_{010}(\text{Anxiety}_i) + \beta_{10}(\text{Time}_{it}) + \beta_{11}(\text{Quit}_{it}) + \beta_{12}(\text{Control}_i \times \text{Time}_{it}) + \beta_{13}(\text{Sequential}_i \times \text{Time}_{it}) + \beta_{14}(\text{Abstinence trajectory}_i \times \text{Time}_{it}) + \beta_{15}(\text{Depressed}_i \times \text{Time}_{it}) + B_{16}(\text{Depressed}_i \times \text{Control}_i \times \text{Time}_{it}) + \beta_{17}(\text{Depressed}_i \times \text{Sequential}_i \times \text{Time}_{it}) + r_{0i} + r_{1i}(\text{Time}_{it}) + e_{it}$$

Definition of terms: β_{0i} = average baseline weight (intercept); β_{1i} = average rate of weight gain (slope); r_{0i} = error component of intercept; r_{1i} = error component of slope; e_{it} = overall random error

References

Aubin, H.-J., Farley, A., Lycett, D., Lahmek, P., Aveyard, P., 2012. Weight gain in smokers after quitting cigarettes: Meta-analysis. BMJ 345 (jul10 2), e4439. https://doi.org/10.1136/bmj.e4439.

Barnes, A.S., Kimbro, R.T., 2012. Descriptive study of educated African American women successful at weight-loss maintenance through lifestyle changes. J. Gen. Intern. Med. 27 (10), 1272–1279. https://doi.org/10.1007/s11606-012-2060-2.

Bennett, G.G., Wolin, K.Y., James, S.A., 2007. Lifecourse socioeconomic position and weight change among Blacks: The Pitt County Study. Obesity 15 (1), 172. https://doi.org/10.1038/oby.2007.522.

Bernstein, S.L., Weiss, J.-M., Toll, B., Zbikowski, S.M., 2016. Association between utilization of quitline services and probability of tobacco abstinence in low-income smokers. J. Subst. Abuse Treat. 71, 58–62. https://doi.org/10.1016/j.jsat.2016.08.014.

Bush, T., Lovejoy, J., Javitz, H., Magnusson, B., Torres, A.J., Mahuna, S., Benedict, C., Wassum, K., Spring, B., 2016. Comparative effectiveness of adding weight control simultaneously or sequentially to smoking cessation quitlines: study protocol of a randomized controlled trial. BMC Public Health 16 (1). https://doi.org/10.1186/s12889-016-3231-6.

Bush, T., Lovejoy, J., Javitz, H., et al., 2018. Simultaneous vs. sequential treatment for smoking and weight management in tobacco quitlines: 6 and 12 month outcomes from a randomized trial. BMC Public Health 18 (1), 678.

Centers for Disease Control and Prevention. Healthy Weight. 2014; http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html#Interpreted.

Chinn, S., Jarvis, D., Melotti, R., Luczynska, C., Ackermann-Liebrich, U., Antó, J.M., Cerveri, I., de Marco, R., Gislason, T., Heinrich, J., Janson, C., Künzli, N., Leynaert, B., Neukirch, F., Schouten, J., Sunyer, J., Svanes, C., Vermeire, P., Wjst, M., Burney, P., 2005. Smoking cessation, lung function, and weight gain: a follow-up study. Lancet 365 (9471), 1629–1635. https://doi.org/10.1016/S0140-6736(05)66511-7.

Cohen, A.K., Rai, M., Rehkopf, D.H., Abrams, B., 2013. Educational attainment and obesity: a systematic review: Educational attainment and obesity. Obes. Rev. 14 (12), 989–1005. https://doi.org/10.1111/obr.12062.

Cohen, A.K., Rehkopf, D.H., Deardorff, J., Abrams, B., 2013. Education and obesity at age 40 among American adults. Soc. Sci. Med. 78, 34–41. https://doi.org/10.1016/j.socscimed.2012.11.025.

Farley, A.C., Hajek, P., Lycett, D., Aveyard, P., 2012. Interventions for preventing weight gain after smoking cessation. Cochrane Database Syst. Rev. 1, CD006219.

Filozof, C., Fernandez Pinilla, M.C., Fernandez-Cruz, A., 2004. Smoking cessation and weight gain. Obesity Rev. 5 (2), 95–103. https://doi.org/10.1111/j.1467-789X.2004.00131.x.

Hoffman, L., 2014. Longitudinal Analysis: Modeling Within-Person Fluctuation and Change. Taylor & Francis Group, New York, NY.

Hoffman, L., Stawski, R.S., 2009. Persons as contexts: evaluating between-person and within-person effects in longitudinal analysis. Res. Hum. Dev. 6 (2–3), 97–120. https://doi.org/10.1080/15427600902911189.

Howard, A.L., 2015. Leveraging time-varying covariates to test within- and between-person effects and interactions in the multilevel linear model. Emerg. Adulthood 3 (6), 400–412. https://doi.org/10.1177/2167696815592726.

Johnson, K.C., Thomas, F., Richey, P., Tran, Q.T., Tylavsky, F., Miro, D., Coday, M., 2017. The primary results of the treating adult smokers at risk for weight gain with interactive technology (TARGIT) study: weight gain prevention after smoking cessation. Obesity 25 (10), 1691–1698. https://doi.org/10.1002/oby.21968.

Klesges, R.C., Ward, K.D., Ray, J.W., Cutter, G., Jacobs Jr., D.R., Wagenknecht, L.E., 1998. The prospective relationships between smoking and weight in a young, biracial cohort: the Coronary Artery Risk Development in Young Adults Study. J. Consult Clin. Psychol. 66 (6), 987–993.

Kroenke, K., Spitzer, R.L., Williams, J.B.W., 2003. The Patient health questionnaire-2: validity of a two-item depression screener. Med. Care 41 (11), 1284–1292. https://doi.org/10.1097/01.MLR.0000093487.78664.3C.

Kroenke, K., Spitzer, R.L., Williams, J.B.W., Monahan, P.O., Löwe, B., 2007. Anxiety disorders in primary care: prevalence, impairment, comorbidity, and detection. Ann. Intern. Med. 146 (5), 317. https://doi.org/10.7326/0003-4819-146-5-200703060-00004.

Lewis, T.T., Everson-Rose, S.A., Sternfeld, B., Karavolos, K., Wesley, D., Powell, L.H., 2005. Race, education, and weight change in a biracial sample of women at midlife. Arch. Intern. Med. 165 (5), 545–551.

Lien, R.K., Schillo, B.A., Goto, C.J., Porter, L., 2016. The effect of survey nonresponse on quitline abstinence rates: Implications for practice. Nicotine Tob. Res. 18 (1), 98–101.

Marcus, B., Lewis, B., Hogan, J., King, T., Albrecht, A., Bock, B., Parisi, A., Niaura, R., Abrams, D., 2005. The efficacy of moderate-intensity exercise as an aid for smoking cessation in women: a randomized controlled trial. Nicot. Tobac. Res. 7 (6), 871–880. https://doi.org/10.1080/14622200500266056.

Mukhopadhyay, S., Wendel, J., 2011. Is post-smoking-cessation weight-gain a significant trigger for relapse? Appl. Econ. 43 (24), 3449–3457. https://doi.org/10.1080/00036841003652430.

O'Hara, P., Connett, J.E., Lee, W.W., Nides, M., Murray, R., Wise, R., 1998. Early and late weight gain following smoking cessation in the lung health study. Am. J. Epidemiol. 148 (9), 821–830. https://doi.org/10.1093/oxfordjournals.aje.a009706.

Perkins, K.A., 1993. Weight gain following smoking cessation. J. Consult. Clin. Psychol. 61 (5), 768–777.

Singer, J.D., Willett, J.B., 2003. Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence. Oxford University Press, New York, NY.

Spring, B., Pagoto, S., Pingitore, R., Doran, N., Schneider, K., Hedeker, D., 2004. Randomized controlled trial for behavioral smoking and weight control treatment: effect of concurrent versus sequential intervention. J. Consult. Clin. Psychol. 72 (5), 785–796.

Spring, B., Howe, D., Berendsen, M., et al., 2009. Behavioral intervention to promote smoking cessation and prevent weight gain: a systematic review and meta-analysis. Addiction 104 (9), 1472–1486.

Swan, G.E., Carmelli, D., 1995. Characteristics associated with excessive weight gain after smoking cessation in men. Am. J. Public Health 85 (1), 73–77. https://doi.org/10.2105/AJPH.85.1.73.

Tan, M.M., Okuyemi, K.S., Resnicow, K., Dietz, N.A., Antoni, M.H., Webb Hooper, M., 2018. Association between smoking cessation and weight gain in treatment-seeking African Americans. Addictive Behav. 81, 84–90. https://doi.org/10.1016/j.addbeh.2018.02.002.

Vickerman, K.A., Zhang, L., Malarcher, A., Mowery, P., Nash, C., 2015. Cessation outcomes among quitline callers in three states during a national tobacco education campaign. Prev. Chronic Dis. 12, E110.

Wang, Y., Beydoun, M.A., 2007. The obesity epidemic in the United States–gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. Epidemiol. Rev. 29, 6–28.

Weg, M.W., Klesges, R.C., Eck Clemens, L.H., Meyers, A.W., Pascale, R.W., 2001. The relationships between ethnicity, gender, and short-term changes in energy balance following smoking cessation. Int. J. Behav. Med. 8 (2), 163–177. https://doi.org/10.1207/S15327558IJBM0802_06.

Williamson, D.F., Madans, J., Anda, R.F., Kleinman, J.C., Giovino, G.A., Byers, T., 1991. Smoking cessation and severity of weight gain in a National Cohort. N. Engl. J. Med. 324 (11), 739–745. https://doi.org/10.1056/NEJM199103143241106.

Yeh, H.C., Duncan, B.B., Schmidt, M.I., Wang, N.Y., Brancati, F.L., 2010. Smoking, smoking cessation, and risk for type 2 diabetes mellitus: a cohort study. Ann. Intern. Med. 152 (1), 10–17.

Yu, Y., 2012. Educational differences in obesity in the United States: a closer look at the trends. Obesity (Silver Spring) 20 (4), 904–908.