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10 Year Weight Gain in Smokers Who Quit, Smokers Who Continued Smoking And Never Smokers in the United States, NHANES 2003-2012

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Abstract

Background/Objectives—Weight gain after quitting smoking is a common concern for smokers and can discourage quit attempts. The purpose of this analysis was to describe the long term weight gain, smoking cessation attributable (SCA) weight gain and describe their relationship to cigarette consumption and body mass index (BMI) 10 years ago in a contemporary, nationally representative sample of smokers who continued to smoke and those who quit.

Subjects/Methods—12,204 adults 36 years old were selected from the 2003-2012 National Health and Nutrition Examination Survey (NHANES). Ten year weight gain for never, continuing and former smokers (who quit 1-10 years ago) was calculated by body mass index (BMI) 10 years ago and cigarettes per day (CPD). SCA weight gain was calculated by taking the difference between the adjusted mean ten year weight gain of former smokers and that of continuing smokers.

Results—Mean ten year weight gain among continuing smokers was 3.5 kg versus 8.4 kg among former smokers; 4.9 kg of SCA weight gain. After Bonferroni correction, there was no significant difference in overall weight gain between continuing and former smokers of 1-14 CPD and SCA weight gain was lowest in this group (2.0 kg, CI: 0.3, 3.7). SCA weight gain was highest for former smokers of 25 CPD (10.3 kg, CI: 7.4, 13.2) and for those who were obese (7.1 kg, CI: 2.9, 11.3) mostly due to lower than average weight gain or weight loss among continuing smokers in these groups.

Conclusions—In a current, nationally representative sample, baseline BMI and CPD were important factors that contributed to the magnitude of long term weight gain following smoking cessation. Light to moderate smokers (<15 CPD) experienced little SCA weight gain while heavy smokers (25 CPD) and those who were obese prior to quitting experienced the most.

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Conflicts of Interest: JF has done paid consulting for pharmaceutical companies involved in producing smoking cessation medications including GSK, Pfizer, Novartis, J&J, and Cypress Bioscience. SV, JY, and JZ have no conflicts to declare.

Supplementary Information: Supplementary information is available at IJO's website.

Introduction

Tobacco smoking and excess body weight are two of the leading causes of premature death and disability in the United States.¹ It is known that quitting smoking often leads to an increase in body weight, although there are differing reports of the magnitude and duration of weight gain that can be directly attributed to quitting. For instance, the 1990 Surgeon General's Report on The Health Benefits of Smoking Cessation concluded that "average weight gain after smoking cessation is only about 5 pounds [2.3 kg]" (p. 505) for smokers who had been quit between 1-6 years and that this "is approximately 4 pounds [1.8 kg] greater than that expected among continuing smokers" (p. 483).² More recently, Aubin et al. conducted a meta-analysis of smoking cessation clinical trials published between 1989 to 2010 and found that the average weight gain among smokers who quit was 10 pounds (4.5 kg) 1 year after quitting.³

People generally gain weight over time as they age, so a more accurate estimate of the long term magnitude of weight gain due to quitting smoking is one that is able to separate age-related weight gain from smoking cessation attributable (SCA) weight gain. Studies with follow ups beyond 1 year are able to provide a more comprehensive picture of SCA weight gain by taking the difference in weight gain between former smokers and continuing smokers. These studies have established that smokers who quit gain more overall weight than continuing smokers⁴⁻⁹ although the amount of weight attributable to quitting smoking has been varied with average SCA weight gains between 3 kg and 6.6 kg depending on the population.⁵⁻⁹

Quitting smoking will have an immediate and positive affect on a smoker's health but many smokers are concerned about gaining weight after quitting which can discourage them from making a quit attempt.^{10,11} An important clinical and public health goal is to remove barriers to quitting which includes addressing concerns about weight gain by providing smokers with accurate information on what to expect when they quit. However, accurate information is difficult to provide since long term studies have observed substantial variations in weight gain among smokers who quit^{3,6} suggesting that there are contributing factors to gaining weight after quitting that are not well understood. Two possible factors that have emerged as predictors of weight gain are daily cigarette consumption prior to quitting and baseline body mass index (BMI), although reports have not been entirely consistent.^{6,8,9,12-14} Some studies have found that the number of cigarettes smoked prior to quitting is positively associated with weight gain^{5,6,8,13} but the majority of studies reporting on post cessation weight gain do not discuss this effect. There have also been significant but inconsistent findings regarding the relationship between baseline BMI and post-cessation weight gain.^{6,9,13,15}

Therefore, the aim of this study was to describe the long term weight gain and SCA weight gain in a contemporary, nationally representative sample of the United States population and to describe their relationship to baseline cigarettes per day (CPD), smoking cessation and BMI 10 years ago. This information could provide public health professionals and clinicians with more accurate information around which to frame discussions about cessation related weight gain with specific groups of smokers.

Subjects and Methods

The National Health and Nutrition Examination Survey (NHANES) is a cross-sectional survey conducted by the National Center for Health Statistics (NCHS) and includes a nationally representative sample of non-institutionalized, US civilians. Complete details regarding the NHANES methodology are available elsewhere.¹⁶ This analysis included 5 survey cycles from 2003-2012.

The weight history questionnaire is asked of participants 36 years old. In addition, selected participants had complete information for demographic, smoking status, height, current weight, and weight 10 years ago. To ensure stability of smoking cessation among former smokers and to isolate the effect of long term weight gain, we included only those who had been quit for at least 1 year. We did not include those who had been quit more than 10 years (n= 3,496) so that we had a sample of former smokers who had not quit prior to the time frame for reporting weight (10 years ago). Also excluded were continuing and former cigarette smokers who used any other tobacco products (n = 418), women pregnant at the time of the survey (n=41) and underweight participants (BMI <18.5 at either time point, n=226). There were 2,328 potentially eligible participants not included due to missing height and current weight (n=93), height (n=810), current weight (n=879) or weight 10 years ago (n=639).

Current height and weight were self-reported. Weight 10 years ago was assessed by asking “How much did you weigh 10 years ago?” BMI was calculated using the participant's height and weight with the standard calculation (weight in kilograms (kg)/height in meters²). BMI class was defined according to the National Institutes of Health Clinical Guidelines,¹⁷ as normal weight (BMI 18.5-24.9), overweight (BMI 25.0-29.9), and obese (BMI 30.0+). The participant's weight 10 years ago was subtracted from their current weight to create a continuous 10 year weight change variable.

Never smokers were defined as individuals who smoked less than 100 cigarettes in their lifetime. Former smokers were defined as individuals who smoked at least 100 cigarettes in their lifetime and who reported not currently smoking. Continuing smokers were those who smoked at least 100 cigarettes in their lifetime and who reported smoking “some days” or “every day” at the time of the survey. CPD were reported by smokers as the number of cigarettes they currently smoked per day while former smokers reported the number of cigarettes they usually smoked per day prior to quitting. CPD categories were created using 1-14, 15-24 and 25 CPD as cut points.

Statistical Analysis

All data were analyzed using SAS version 9.3 (SAS Institute) and were weighted as recommended by NHANES analytical guidelines.¹⁸ These procedures account for the complex sampling structure of NHANES (i.e. differential weighting, clustering and stratification) when estimating variances and confidence limits. Bivariate tests of association with smoking status (never smoker, continuing smoker, former smoker) were conducted using Rao-Scott Modified Chi-Square tests for the categorical variables of interest and

weighted ANOVA models for continuous variables. Weighted analysis of covariance (ANCOVA) models were used to estimate means and 95% confidence intervals (95% CI) for weight and smoking-related outcome variables controlling for gender, race, age and education level.

Using 10 year weight change as the dependent variable, weighted ANCOVA models were set up to accommodate the two-way interactions between the three main factors under investigation: BMI class, smoking status, and CPD. Gender, race, age, and education level were controlled for in all models. The estimated adjusted least-square means and their standard errors (SEM) of the 10 year weight change were obtained and plotted. The 95% CIs for the mean estimates were also calculated and reported. SCA weight gain was calculated by taking the difference between the adjusted mean weight gain of former smokers and that of continuing smokers. Two tailed p-values of <0.05 were considered significant and Bonferroni adjustments for multiple tests were used when necessary.

Results

A general description of the overall sample is presented in Table 1. The proportion of never smokers, continuing smokers and former smokers was 65.2%, 25.3%, and 9.5%, respectively. Former smokers had a higher proportion of participants who were white and currently obese compared to never smokers and continuing smokers. Among continuing and former smokers, there were similar proportions of obesity 10 years ago and the largest proportion of participants in both groups smoked 1-14 CPD.

The overall adjusted mean weight gain for the entire population regardless of smoking status was 4.5 kg (CI: 4.2, 4.8), (controlling for race, education level, gender, and age). Former smokers had been quit an average of 5.7 years (CI: 5.5, 6.0). Adjusted cigarette and weight related characteristics are presented in Table 2. There was no difference in CPD among continuing and former smokers. Continuing smokers were lighter and had lower current BMIs than both never smokers and former smokers while former smokers were heavier and had a higher mean BMI than both continuing and never smokers ($p < 0.001$).

Adjusted mean 10 year weight gains and SEM by smoking status are presented in Figure 1. The overall mean SCA weight gain was 4.9 kg (CI: 3.4, 6.4). Former smokers gained significantly more weight than continuing smokers ($p < 0.001$) and this difference remained significant after Bonferroni adjustment.

10 year weight gains by BMI class are presented in Figure 2. The SCA weight gain for normal weight, overweight and obese participants was 4.4 (CI: 2.9, 5.9), 5.0 (CI: 3.3, 6.8) and 7.1 (CI: 2.9, 11.3) kg, respectively. Regardless of smoking status those who were obese 10 years ago experienced less long term weight gain than those who were normal weight and overweight 10 years ago. The general pattern of the data shows that normal weight and overweight former smokers gained about the same amount of weight while those who were obese gained the least. However, the SCA weight gain was the highest for those who were obese due to weight loss in obese continuing smokers. All differences in weight gains

between continuing and former smokers were statistically significant ($p < .002$) and remained significant after Bonferroni adjustment.

Weight gain by CPD group among continuing and former smokers is presented in Figure 3. The SCA weight gain for those who smoked 1-14, 15-24 and ≥ 25 CPD was 2.0 (CI: 0.3, 3.7), 6.0 (CI: 4.0, 7.9) and 10.3 (CI: 7.4, 13.2) kg, respectively. There was a stepwise, positive relationship between CPD and weight gain among former smokers, a pattern that is also reflected in SCA weight gain partly because continuing smokers in each CPD category gained significantly less weight over time than former smokers. The difference in weight gain between continuing and former smokers of 1-14 CPD ($p = 0.02$) did not remain significant after Bonferroni adjustment. Differences in weight gains between continuing and former smokers of 15-24 and ≥ 25 CPD were significant ($p < .001$) and remained significant after Bonferroni adjustment.

There was a similar overall pattern of results in both genders, except women gained more weight than men in most groups with the exception of obese female continuing smokers who lost more weight than men (data not shown). We have not focused on gender effects as there is some evidence from a previous study that women are more likely to underestimate historical weight.¹⁹ This pattern was also found when looking at continuing and former smokers within each CPD group by BMI (Supplementary information is available at IJO's website).

Discussion

An important finding from the analysis of this contemporary, nationally representative sample is that there is a positive, dose-response relationship between CPD and both overall weight gain and SCA weight gain in smokers who quit. While the average smoker reported 4.9 kg of weight gain that could be directly attributed to smoking, light to moderate smokers (1-14 CPD) gained much less than this (2.0 kg). In addition, the amount of 10 year weight gain reported by light to moderate smokers who quit was not significantly different (after Bonferroni adjustment) than the amount of weight gain reported by those who continued to smoke this amount.

On the other hand, heavy smokers (≥ 25 CPD) had much more SCA weight gain (10.3 kg) than lighter smokers which was mostly due to the combined effects of lower weight gain in continuing, heavier smokers and higher weight gain in heavier smokers who quit (versus lighter smokers who quit). Our findings on heavy smokers are consistent with other studies^{5,8,13} that have identified CPD as a predictor of extreme amounts of weight gain (> 13 kg) and they suggest that the average smoker of ≥ 25 CPD will experience a 15.7% increase in body weight after they quit smoking, 12.2% being directly attributable to quitting smoking.

When considering weight gain by BMI, we found that participants who were obese 10 years ago gained less weight than their normal or overweight counterparts regardless of their smoking status. While it may be counter-intuitive that those with higher BMIs gain less weight over time, this has been observed before in both prospective studies and clinical

trials.^{9,20} For instance, the Prospective Studies Collaboration²⁰ used measured weight for 95% of their data and found weight change over 5-9 years among those who were obese at baseline (BMI 30-50) was lower than that of those who were normal weight (change in BMI of 0.12 for obese versus change in BMI of 0.62 for normal weight participants). In addition, within the obesity category, those with higher BMIs lost weight over that time (those with a BMI 30-35 had a BMI change of 0.24 compared to those with a BMI 40-50 who had a BMI change of -0.69). This pattern of findings is consistent with the present report which found that obese former smokers experienced 2.5 kg of long term weight gain which was significantly less than that of normal weight (10.1 kg) and overweight (9.9 kg) former smokers. However, tempering this finding is the observation that obese *continuing* smokers *lost* weight over time making the magnitude of SCA weight gain higher for obese former smokers (7.1 kg) than for those who were normal weight (4.4 kg) or overweight (5.0 kg).

An important observation to note is that our overall weight gain estimate for former smokers is higher than the 1990 Surgeon General's Report on The Health Benefits of Smoking Cessation² and higher than the Clinical Practice Guideline for Treating Tobacco Use and Dependence: 2008 Update which stated that “Most [quitters] will gain fewer than 10 pounds (4.5 kg)” (p. 173).²¹ A possible reason for these differences is that a number of the studies in the above reports were clinical trials which are known to have different sample characteristics that make them difficult to generalize to population surveys.²²

Our average long term weight gain among former smokers is also higher than previously reported from older NHANES data sets (6.9 kg [1988-1991]⁵ absolute mean weight gain in those quitting for <10 years). This difference may be because of the overall increase in the prevalence of obesity across all U. S. subpopulations since this study was published²³ which is supported by the observation that even never smokers in the present study experienced a higher 10 year weight gain (4.4 kg) than previously reported (2.6 kg in 1988-1991).⁵

From 1960 to 2012, the prevalence of obesity in the U.S. jumped from less than 14% to 35%.²⁴ At the same time, a number of public health initiatives (e.g., health education campaigns, clean indoor air laws and increases in cigarette taxes) converged to successfully decrease the prevalence of smoking from a high of 42% in 1964, to its current rate of 18%.²⁵ While it is not thought that the decrease in smoking prevalence with its associated weight gain has significantly contributed to the overall U.S. prevalence of obesity,⁵ our data suggests that this overall societal weight increase may have impacted body weights among contemporary continuing and former smokers as well.

With regard to overall SCA weight gain, although our estimate of 4.9 kg is higher than the 3.3 kg reported in the 1971-1984 NHANES survey⁸ it is similar to the SCA weight gain estimate of 4.7 kg reported for the 1988-1991 NHANES surveys by Flegal et al.⁵ This suggests that even though overall weight gain in smokers and former smokers may have increased due to the general societal increase in obesity, weight gain that can be directly attributable to smoking cessation has remained fairly constant.

This study's findings highlight the complex relationship between smoking and weight control²⁶⁻²⁸ and raise questions for how to present the issue to different groups of smokers.

For smokers of 1-14 CPD who want to quit, the message can be fairly simple since the weight they gain may not be much more than if they continued to smoke. In addition, they should be reminded that weight gain occurs naturally as people age and that if they quit, relatively little of the weight they will gain over the long term may be directly attributable to quitting smoking.

However, the question remains as to what messages should be provided to obese and heavy smokers. Fernandez et al. have suggested that because weight gain can be barrier to smoking cessation, "It may be unwise to incorporate this message into clinical or public health practice."²⁹ However, the majority of heavy smokers have experienced weight gain on a previous quit attempt³⁰ and it is clear that they already know that significant weight gain after quitting is likely. In addition, obese smokers have been shown to be the most concerned about weight gain after quitting³¹ so avoiding this discussion may be counterproductive. The issue may be addressed by acknowledging potential weight gain and putting into perspective the substantially lowered health risks for smokers who quit regardless of their post-cessation weight. For instance, Clair et al. analyzed data from the Framingham Offspring cohort and found that smoking cessation was associated with a lower risk of cardiovascular events regardless of the associated weight gain.³² In addition, for smokers who are already obese, Freedman et al. have demonstrated that the compounded mortality risk for those who both smoke and are obese is much greater than the mortality risk of excess weight alone.³³ Therefore, although former smokers gain more weight than continuing smokers, the clinical significance of quitting outweighs the potential risks of weight gain. Heavy and obese smokers should be encouraged to use evidence based tobacco dependence treatment and they should be assured that cessation is a health priority regardless of the weight they may gain. These patients may also benefit most from weight management interventions to help attenuate future weight. While formal clinical research may be needed to identify the most efficacious interventions for these specific groups, Farley et al. reviewed the topic of concurrent smoking cessation and weight management and found modest evidence that personalized weight management support may be effective and does not appear to reduce abstinence.³⁴

There are some limitations to our findings. First, smoking status was based on self-report and was not biochemically validated. Several studies have compared self-reported smoking status with biochemically validated smoking status in population surveys such as NHANES and found that underreporting of smoking is minimal (<2% misclassification).^{35,36} A second limitation was that our weight related variables were self-reported but since NHANES includes measured current weight for some participants, we were able to calculate Bland-Altman limits of agreement. Based on the log-transformed self-reported weight and actual weight measures, the Bland-Altman plots³⁷ showed good agreement with a bias of nearly zero and limits of agreement between -0.10 and 0.096. In addition, the correlation between current self-reported weight and measured weight was +0.98 overall. No group (never smokers, continuing smokers, or former smokers and normal weight, overweight or obese) had a mean difference in self-reported and measured weight greater than ± 1.0 kg. Previous analyses of NHANES data compared measured weight 10 years ago to self-reported estimates of weight 10 years ago and found these to be more variable but still broadly accurate (correlation +0.74, with a mean under estimation of reported body weight 10 years

ago of < 0.9 kg).¹⁹ Regardless of possible variation in the self-reported data, our findings provide robust evidence of a pattern of weight gain that is unlikely to be due to minor underestimations of historical weight.

Conclusion

Baseline BMI and CPD are important factors that contribute to the magnitude of long term weight gain following smoking cessation. Light to moderate smokers (< 15 CPD) experienced relatively little weight gain that could be directly related to smoking cessation. Heavy smokers (≥ 25 CPD) and those who were obese prior to quitting experienced significant smoking cessation attributable weight gain, partly due to lower than average weight gain or weight loss among continuing smokers in these groups. For smokers of more than 24 cigarettes per day, quitting smoking resulted in a weight increase averaging 12.2% of their body weight. Obese and heavy smokers may particularly benefit from both tobacco dependence treatment and early weight management intervention during a quit attempt.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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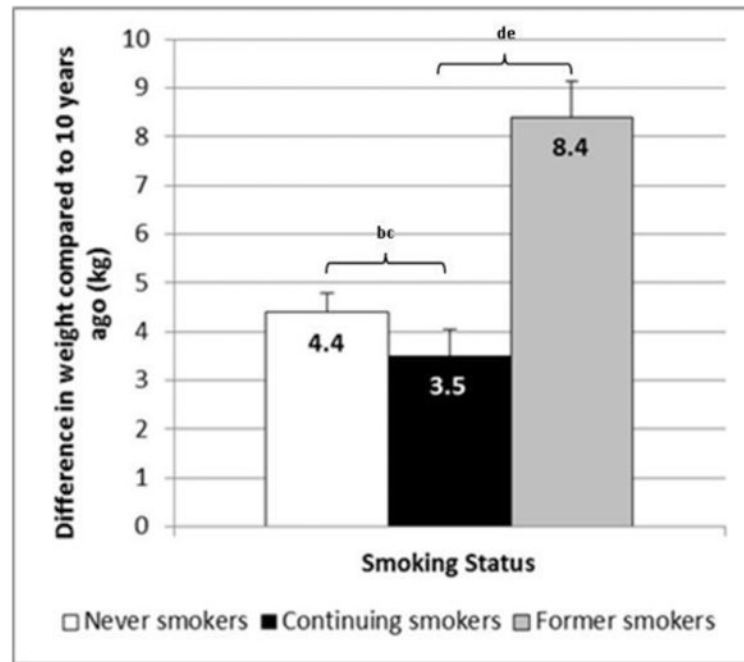


Figure 1.

Adjusted mean differences (and SEMs^a) in weight compared to 10 years ago by smoking status (controlling for race, gender, education level, age) **Legend:** ^a SEM=Standard error of the mean; ^b P=0.03; ^c Did not remain significant after Bonferroni adjustment; ^d P <0.001; ^e Remained significant after Bonferroni adjustment.

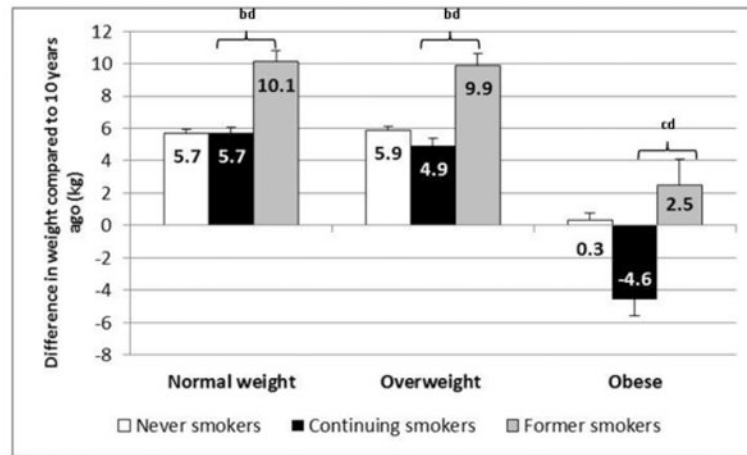


Figure 2.

Adjusted differences (and SEMs^a) in weight compared to 10 years ago by smoking status and BMI class 10 years ago (controlling for age, gender, race, education level) **Legend:** ^a SEM=Standard error of the mean; ^b P<.001; ^c P<.002; ^d Remained significant after Bonferroni adjustment.

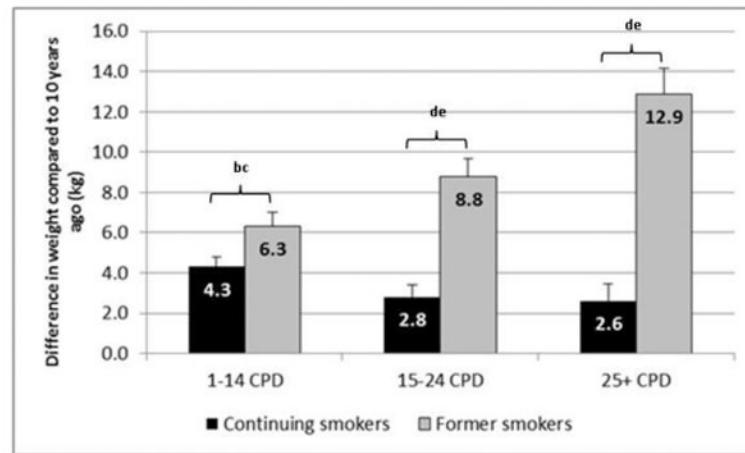


Figure 3.

Adjusted differences (and SEMs^a) in weight compared to 10 years ago for continuing and former smokers by current cigarettes per day (CPD) or CPD prior to quitting (controlling for race, gender, education level, age) **Legend:** ^a SEM=Standard error of the mean; ^b P=0.02; ^c Did not remain significant after Bonferroni adjustment. ^d P<.001 ^e Remained significant after Bonferroni adjustment.

Table 1
Weighted study population characteristics of participants aged 36+ in NHANES
2003-2012 by smoking status (n=12,204)

	Never Smoker (n=7914)	Continuing Smoker (n=3105)	Former Smoker (n=1185)	p-value
% Female	59.9	45.3	49.7	<0.001
Mean Age (SEM [*])	54.5 (0.27)	50.6 (0.23)	54.2 (0.47)	<0.001
% White	71.9	72.3	76.6	0.04
% College educated	35.6	12.0	23.5	<0.001
Mean Current BMI [*] (SEM)	28.7 (0.11)	27.8 (0.12)	29.6 (0.22)	<0.001
Current BMI Class, N (%)				<0.001
Normal weight (BMI 18.5 to <25)	2155 (28.8)	1062 (36.0)	268 (22.1)	
Overweight (BMI 25 to <30)	2943 (37.4)	1068 (33.5)	427 (36.5)	
Obese (BMI ≥ 30)	2816 (33.9)	975 (30.4)	490 (41.3)	
Mean BMI 10 years ago (SEM)	27.2 (0.10)	26.3 (0.10)	26.7 (0.18)	<0.001
BMI Class 10 years ago, N (%)				<0.001
Normal weight (BMI 18.5 to <25)	2987 (40.2)	1383 (47.0)	474 (42.6)	
Overweight (BMI 25 to <30)	2896 (35.6)	1092 (33.6)	438 (35.8)	
Obese (BMI ≥ 30)	2031 (24.2)	630 (19.4)	273 (21.6)	
Mean CPD [*] (SEM)	-	17.6 (0.67)	16.6 (0.39)	0.151
CPD Category, N (%)				0.007
1-14	-	1550 (43.4)	554 (44.5)	
15-24	-	1015 (38.0)	368 (32.3)	
≥ 25	-	436 (18.6)	250 (23.2)	

^{*} Abbreviations: SEM= Standard Error of Mean; BMI= Body mass index; CPD= Cigarettes per day, currently or prior to quitting; CI= Confidence interval.

Table 2
Mean (95% CI*) values for cigarette and weight related characteristics controlling for race, education level, gender, and age

	Never Smoker (n=7914)	Continuing Smoker (n=3105)	Former Smoker (n=1185)	p-value
CPD *	-	12.5 (11.9, 13.1)	13.6 (12.4, 14.8)	0.07
Years smoked	-	34.9 (34.6, 35.2)	29.8 (29.2, 30.5)	<0.001
Current weight (kg) ^{a, b, d}	81.7 (81.1, 82.3)	77.7 (76.7, 78.7)	84.2 (82.7, 85.7)	<0.001
Weight 10 years ago (kg) ^{a, c, e}	77.4 (76.7, 78.0)	74.2 (73.4, 75.1)	75.9 (74.7, 77.1)	<0.001
Current BMI ^{a, b, d}	29.1 (28.9, 29.3)	27.5 (27.2, 27.9)	29.8 (29.3, 30.2)	<0.001
BMI 10 years ago ^{a, c, d}	27.5 (27.3, 27.7)	26.3 (26.0, 26.5)	26.8 (26.4, 27.2)	<0.001

* Abbreviations: BMI= Body mass index; CPD= Cigarettes per day, currently or prior to quitting; CI= Confidence interval.

¹ 1 kilogram (kg) = 2.2 pounds;

^a Difference between Never Smoker and Continuing Smoker p < 0.001;

^b Difference between Continuing Smoker and Former Smoker p < 0.001;

^c Difference between Continuing Smoker and Former Smoker p < 0.02;

^d Difference between Never Smoker and Former Smoker p < 0.004;

^e Difference between Never Smoker and Former Smoker p < 0.02.