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Associations Between Body Mass Index and Substance Use Disorders Differ by Gender: Results from the National Epidemiologic Survey on Alcohol and Related Conditions

Danielle Barry^{a,*} and Nancy M. Petry^a

^aDepartment of Psychiatry, University of Connecticut Health Center, 263 Farmington Avenue (MC 3944), Farmington, Connecticut, 06030, USA.

Abstract

Alcohol, illicit drugs, and nicotine can affect appetite and body weight, but few epidemiologic studies have examined relationships between body mass index (BMI) and substance use disorders. This study used logistic regression to examine effects of BMI and gender on risk for DSM-IV substance use disorders in a sample of 40 364 adults. Overweight and obesity were associated with increased risk for lifetime alcohol abuse and dependence in men but not women. Overweight and obesity were associated with decreased risk for past-year alcohol abuse in women. BMI was not associated with illicit drug use disorders. Overweight and obese men were at decreased risk for both lifetime and past-year nicotine dependence. Overweight women were at increased risk for lifetime nicotine dependence, and obese women were at decreased risk for past-year nicotine dependence. Further research is needed to identify reasons for observed gender differences in relationships between BMI and substance use disorders.

Keywords

Overweight; Obesity; Substance use disorders; Alcohol use disorders; Nicotine dependence; Sex/gender

1. Introduction

Overweight, obesity, and substance use disorders are significant public health problems associated with increased health risks and medical costs (Bertakis & Azari, 2005; McGinnis & Foege, 1999; Must et al., 1999). Although the greatest health risks are associated with obesity, being even moderately overweight increases risk for both physical and psychiatric illness (Barry, Pietrzak, & Petry, 2008; Colditz, Willett, Rotnitzky, & Manson, 1995; Nagaya, Yoshida, Takahashi, & Kawai, 2005; Petry, Barry, Pietrzak, & Wagner, 2008). Use of alcohol, some illicit drugs, and nicotine are known to affect appetite (Abel, 1975; Grunberg, 1982; Hetherington, Cameron, Wallis, & Pirie, 2001), but relationships between substance use and body weight appear to vary based on the specific substance used and users' demographic characteristics, particularly gender. Associations of substance use with body weight may also

*Corresponding author at: Department of Psychiatry, University of Connecticut Health Center, 263 Farmington Avenue (MC 3944), Farmington, CT, 06030, USA., Phone: (860) 679-6664, Fax: (860) 679-1312.

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differ for moderate users versus those with substance use disorders. To date, few studies have examined associations between overweight/obesity and the risk for substance use disorders.

Cross sectional studies of alcohol consumption and body weight in non-clinical populations consistently report inverse relationships between quantity of alcohol consumed and body mass index (BMI) among women (Colditz et al., 1991; Hellerstedt, Jeffery, & Murray, 1990; Liu, Serdula, Williamson, Mokdad, & Byers, 1994; Wannamethee, Field, Colditz, & Rimm, 2004). Findings for men are inconsistent, with most recent studies indicating a positive association (Colditz et al., 1991; Prentice, 1995; Schroder et al., 2007; Wannamethee & Shaper, 2003; Wannamethee, Shaper, & Whincup, 2005), but some studies showing no relationship (Hellerstedt et al., 1990). Epidemiologic research on associations between body weight and drinking patterns reveals the lowest BMI among individuals who drink frequently but consume small quantities of alcohol each time they drink (i.e., one drink per day every day) and this relationship was stronger for women than men. Individuals who consume alcohol at low frequencies but in large quantities on each occasion (e.g., occasional binge drinkers) have the highest average BMI (Breslow & Smothers, 2005).

Epidemiologic research examining risk for alcohol use disorders yields ambiguous results. Obesity has been associated with decreased risk of current alcohol use disorders (John et al., 2003), with similar findings for men and women. However, a study based on surveys carried out in thirteen countries found lower likelihood of alcohol use disorders among obese respondents in the United States but not in the other twelve countries or the sample as a whole (Scott et al., 2007). Pickering, Grant, Chou, & Compton (2007) found comparable risk for past-year alcohol abuse and dependence among normal weight, overweight, obese, and extremely obese individuals of both genders.

Relationships between BMI and illicit drug use disorders are more difficult to identify due in part to lower overall prevalence rates and differing pharmacological effects of different drugs that may influence their impact on appetite and body weight. For instance, marijuana can stimulate appetite (Abel, 1975; Foltin, Fischman, & Byrne, 1988); however, marijuana use is associated with higher caloric intake but not with increased BMI among young adults (Rodondi, Pletcher, Liu, Hulley, & Sidney, 2006). Cocaine is a stimulant and appetite suppressant (Gold & Miller, 1997). Although cocaine and heroin use disorders have been associated with poor nutrition and lower body mass, particularly in women, in clinical studies (Cofrancesco et al., 2007; Santolaria-Fernandez et al., 1995), the prevalence of overweight appears to be increasing among individuals with illicit drug use disorders just as it has in the general population (Rajs et al., 2004). Epidemiologic studies including significant numbers of individuals with drug use disorders are rare. Obesity appears to be associated with lower odds of a past-year drug dependence diagnosis although not a past-year diagnosis of drug abuse (Pickering et al., 2007). In another nationally representative study (Simon et al., 2006) obesity was associated with lower odds of a lifetime substance use disorder, a diagnosis including both alcohol and drug use disorders.

Epidemiologic studies regarding relationships between overweight/obesity and nicotine dependence yield mixed results. In one study, overweight and obese men were more likely to be former daily smokers than current smokers or non-smokers, but the relationship was not observed in women (John, Meyer, Rumpf, Hapke, & Schumann, 2006). In another study, current smokers had comparable obesity risk overall to non-smokers, but risk for obesity increased with number of cigarettes per day among smokers (Chiolero, Jacot-Sadowski, Faeh, Paccaud, & Cornuz, 2007). One study of young adults found higher rates of smoking among obese individuals relative to their overweight and normal weight counterparts, and obese smokers smoked more cigarettes per day than overweight or normal weight smokers (Zimlichman et al., 2005). In a nationally representative sample, overweight, obesity and

extreme obesity were associated with lower risk for past-year nicotine dependence in men but not in women (Pickering et al., 2007).

The current study examines interactions between BMI and gender in predicting likelihood of lifetime and past-year substance use disorders in a large epidemiologic sample. The National Epidemiologic Survey on Alcohol and Related Conditions (NESARC; Grant, Moore, & Kaplan, 2003) is the largest psychiatric epidemiology study conducted to date. NESARC data were collected from a representative sample of the United States population in 2001 and 2002 with the goal of determining the prevalence of alcohol use and alcohol use disorders and examining physical and emotional disabilities associated with alcohol use. Health indices examined included self-reported height and weight, from which BMI was calculated. Substance use disorders were diagnosed based on criteria of the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV; American Psychiatric Association, 2000). Sample sizes have limited many prior studies to examining differences between obese and non-obese individuals only or to combining alcohol and other substance use disorders into a single group (e.g., Simon et al., 2006). NESARC's large sample size allowed for categorization of respondents into normal weight, overweight, and obese groups, for separate analysis of associations of BMI category with alcohol abuse, alcohol dependence, any drug use disorder, cocaine, marijuana, and opiate use disorders, and nicotine dependence, and for analysis of interactions between BMI and gender. While Pickering et al. (2007) examined associations between BMI and past-year substance use disorders in a paper focusing on associations of BMI with a variety of past-year Axis I and II disorders, the current paper extends their findings by also examining associations with risk for lifetime substance use disorders. In addition, the present study also identifies interaction effects of BMI and gender on risk for substance use disorders and evaluates effects on specific drug use disorders beyond the broader class of any drug use disorder.

2. Method

2.1. NESARC Sample

NESARC participants were non-institutionalized civilians aged 18 and over drawn from all fifty states and the District of Columbia. Young adults, aged 18 to 24, were over-sampled at a 2.25:1 ratio, and African American and Hispanic individuals were over-sampled to each constitute approximately 20 percent of the total sample. The sample was weighted to account for the selection of one person from each household and for over-sampling and other sampling methods, and to adjust for non-response at the household level. Weighting allowed adjustment of the data during analyses to represent the U.S. population on demographic variables including age, sex, race, ethnicity, and region of residence based on the 2000 Decennial Census results.

Potential NESARC respondents were informed in writing about the nature of the survey, the statistical uses of survey data, the voluntary nature of participation, and federal laws protecting confidentiality of identifiable survey information. Respondents who consented to participate after receiving this information were interviewed in person by interviewers from the U.S. Census Bureau, who entered responses directly into laptop computers. The response rate was 81%, and a total of 43 093 respondents were interviewed. The research protocol, including informed-consent procedures, received full ethical review and approval from the U.S. Census Bureau and the U.S. Office of Management and Budget.

2.2. Assessment of Body Mass Index and DSM-IV Psychiatric Disorders

Body mass index (BMI) was computed from self-reported weight in kilograms divided by self-reported height in meters squared and was available for 41 654 respondents. Although self-reports of height and weight tend to underestimate BMI somewhat (Roberts, 1995), they are

highly correlated with direct physical measurement (Cash, Counts, Hangen, & Huffine, 1989). Respondents were classified into three groups based on established guidelines (National Heart, Lung, and Blood Institute, 1998). Those with BMI values of 18.5 to 24.9 were in the normal weight category, respondents with a BMI of 25 to 29.9 were classified as overweight, and respondents with a BMI of 30 or greater were classified as obese. Individuals classified as underweight (BMI < 18.5) were excluded from the current analyses because the number of underweight individuals, particularly underweight men, was very small compared to the other BMI categories. Excluding underweight individuals left data for 40 790 respondents. Because pregnancy can temporarily increase BMI, pregnant women were also excluded, leaving a sample of 40 364.

Lifetime and past-year DSM-IV substance use disorders were assessed using the NIAAA Alcohol Use Disorder and Associated Disabilities Interview Schedule-DSM-IV Version (AUDADIS-IV). Substance use disorders evaluated included abuse and dependence of alcohol, cannabis, cocaine, heroin, opiates other than heroin and methadone, stimulants, tranquilizers, sedatives, hallucinogens, inhalants/solvents, and other drugs, as well as nicotine dependence. In order to receive a diagnosis of abuse, respondents must have met at least one of four abuse criteria in a twelve month-period at any time (lifetime diagnosis) or in the twelve months prior to the interview (past-year diagnosis). All respondents with a past-year diagnosis also carried a lifetime diagnosis. AUDADIS-IV dependence diagnoses required respondents to meet at least three of seven dependence criteria during the same time periods. Respondents who met criteria for both abuse and dependence were diagnosed with dependence only, consistent with DSM-IV guidelines.

For the current analyses, drug use disorders other than nicotine and alcohol were classified into general categories of “any drug use disorder.” In addition, lifetime and past-year cocaine, marijuana, and opiate (including heroin and opiates other than heroin or methadone) use disorders were analyzed separately. DSM-IV does not include a nicotine abuse diagnosis, so nicotine dependence is the only nicotine use diagnosis included. The AUDADIS-IV has good to excellent reliability and validity for assessing DSM-IV substance use disorders (Grant & Hasin, 1991; Grant, Moore et al., 2003).

2.3. Statistical Analysis

All analyses were conducted using SUDAAN (Research Triangle Institute, 2003) a software package that adjusts for complex sampling methodology, including weighting, using Taylor series linearization.

Respondents were divided into six categories based on BMI and gender: normal weight men, normal weight women, overweight men, overweight women, obese men, and obese women. Cross-tabulations were used to compute the prevalence of each demographic characteristic and substance use disorder in each of the six groups. Prevalence rates were adjusted based on weighting to reflect general population demographics. Chi-square analysis examined omnibus differences among the six groups on categorical demographic variables, and simple regression analysis was used for continuous variables.

Logistic regression examined the relationship of BMI and substance use disorders within each gender separately, after controlling for covariates likely to moderate the relationship of BMI and gender to substance use disorders. In addition, a separate logistic regression assessed the interaction between gender and BMI on substance use disorders in the entire sample, controlling for covariates. Characteristics were included as covariates if they differed significantly across gender and BMI categories or were related to the dependent variable and were likely to contribute to associations between the independent and dependent variables.

Covariates for all logistic regression analyses included demographic characteristics (age, race/ethnicity, education, marital status, income, region of country, and urban vs. rural residence). Because previous research using this sample found them to be associated with BMI and substance use disorders (Barry et al., 2008; Grant, Stinson, Dawson, Chou, Dufour et al., 2006; Grant, Stinson, Dawson, Chou, Ruan et al., 2006; Petry et al., 2008), history of any lifetime and past-year mood disorder episode (including major depression, dysthymia, manic episode, and hypomanic episode), history of any lifetime and past year anxiety disorder episode (including generalized anxiety disorder, panic disorder without agoraphobia, panic disorder with agoraphobia, agoraphobia without panic, social phobia, and specific phobia), and history of any personality disorder (including antisocial, avoidant, dependent, obsessive-compulsive, paranoid, schizoid, and histrionic personality disorders) were also covariates in the logistic regression analyses. All mood, anxiety, and personality disorders were assessed using the AUDADIS-IV. Reliability and validity of AUDADIS-IV assessments are fair to good for mood, anxiety, and personality disorders (Grant, Dawson et al., 2003).

The prevalence of alcohol and drug use disorders is elevated among individuals with nicotine dependence (John, Meyer, Rumpf, & Hapke, 2004). In this sample, for instance, 62% of individuals who reported any lifetime alcohol use disorder also reported lifetime nicotine dependence, compared to 24% of individuals without a lifetime alcohol use disorder history. Comorbidity among alcohol and other drug use disorders was also high. Because it was possible that a comorbid substance use disorder could moderate the relationships between BMI and gender and each substance use disorder of interest, we controlled for any lifetime or past-year drug use disorder and lifetime and past-year nicotine dependence when examining effects on alcohol use disorders in our main analyses. We also controlled for any lifetime or past-year alcohol use disorder and lifetime and past-year nicotine dependence when examining effects on drug use disorders. Finally, when examining effects on nicotine dependence, we controlled for any lifetime and past-year alcohol use disorder and any lifetime and past-year drug use disorder. However, in order to clarify the effect of comorbid substance use disorders, we also present results from analyses that did not include other substance use disorders as covariates.

3. Results

3.1. Demographic Characteristics

Table 1 shows demographic characteristics of the sample stratified by BMI category and gender. All demographic features differed significantly across the six categories. Subsequent analyses therefore controlled for all these demographic features as well for as for mood, anxiety and personality disorders, as noted earlier.

3.2. Prevalence of DSM-IV Substance Use Disorders

Figure 1 depicts lifetime and past-year prevalence rates of alcohol use disorders for each gender in the three BMI categories before controlling for covariates. Table 2 shows odds ratios (OR) and 95% confidence intervals (CI) resulting from the logistic regression analyses, controlling for covariates, with alcohol use disorders as the dependent variables. Relative to normal weight men, overweight and obese men had significantly higher rates of alcohol abuse and dependence. BMI was not associated with lifetime alcohol abuse or dependence in women. Overweight and obese women had significantly decreased odds of past-year alcohol abuse compared to normal weight women, and BMI was not associated with likelihood of past-year alcohol abuse or dependence in men. Analyses of interactions indicated significant gender by BMI interaction effects on the likelihood of lifetime and past-year alcohol abuse, and lifetime alcohol dependence. When lifetime and past year drug use disorders and nicotine dependence covariates were removed, the positive association between BMI and lifetime alcohol dependence was no longer significant in men, $F(2)=2.58$, $p=.08$, and the negative association

between obesity and past-year alcohol dependence became significant in women, $F(2)=3.22$, $p<.05$, $OR=0.68$, $CI=0.50-0.96$. All other findings were unchanged.

Figure 2 shows lifetime and past-year prevalence rates of any drug use disorder, any cocaine use disorder, any marijuana use disorder, and any opiate use disorder for each gender and BMI category before controlling for covariates. Table 3 shows ORs and CIs resulting from the logistic regression analyses, controlling for covariates, with drug use disorders as the dependent variables. BMI was not significantly associated with lifetime or past-year “any drug use disorder” in either gender. Analysis of specific drug use disorders revealed a trend toward increased risk for any lifetime opiate use disorder among overweight women but the finding was not significant, nor was BMI significantly associated with risk for any opiate use disorder among men. There were no significant interactions between BMI and gender for any lifetime or past-year drug use disorder. Removing lifetime and past-year alcohol use disorders and nicotine dependence covariates resulted in the emergence of a negative association between obesity and any past-year drug use disorder in men, $F(2)=3.77$, $p<.05$, $OR=0.66$, $CI=0.49-0.90$.

Figure 3 depicts lifetime and past-year prevalence of nicotine dependence for each gender by BMI category before controlling for covariates. Table 4 shows ORs and CIs resulting from the logistic regression analyses, controlling for covariates, with nicotine dependence as the dependent variable. The prevalence of lifetime and past year nicotine dependence was significantly lower for overweight and obese men relative to normal weight men. In women, overweight was significantly and positively associated with lifetime nicotine dependence, whereas obesity was significantly and inversely associated with past-year nicotine dependence after controlling for covariates. The interaction between BMI and gender was significant for lifetime and past-year nicotine dependence. Removing lifetime and past-year alcohol and drug use disorders as covariates did not change relationships between BMI and nicotine dependence.

4. Discussion

This study identified interaction effects of BMI and gender on predicting likelihood of lifetime and past-year alcohol use disorders and lifetime and past-year nicotine dependence. BMI was positively associated with lifetime risk for alcohol abuse and dependence in men and inversely associated with past-year risk in women. Overweight and obesity were associated with decreased odds for both lifetime and past-year nicotine dependence among men. Among women, overweight was associated with increased odds of lifetime nicotine dependence, and obesity was associated with decreased odds of past-year nicotine dependence. Overweight and obesity were not related to prevalence of lifetime or past-year illicit drug use disorders in either gender, with no significant interactions.

Our findings on BMI and alcohol use disorders are consistent with other studies examining associations between alcohol consumption and body weight. Prior research suggests that men who consume alcohol do not consume fewer calories from other food sources than men who do not drink (Colditz et al., 1991). It is therefore not surprising that men with alcohol use disorders, who in most cases consume higher quantities of alcohol than men without disordered drinking, should be heavier than their counterparts without alcohol use disorders. The lack of association with past-year alcohol use disorders may reflect a gradual process of alcohol associated weight gain in men. Nicotine and/or drug use appear to attenuate the relationship between BMI and alcohol dependence, as the association was no longer significant when they were removed as covariates.

The inverse association between BMI and past-year alcohol use disorders among women is consistent with previous studies showing negative associations between quantity of alcohol

consumed and BMI in women in the general population. Prior research also suggests that women who consume alcohol substitute alcohol calories for other sources of energy (Colditz et al., 1991). If decreased caloric intake explains lower body weight among women with alcohol use disorders, effects of reduced food intake on body weight could be temporary. This could explain why the category of women with lifetime alcohol use disorders, most of whom do not currently meet criteria, do not differ from women without a history of problem alcohol use. The failure to find an association between BMI and alcohol dependence may indicate that women who drink most heavily are consuming excessive calories from alcohol, thereby replacing calories avoided through reduction in food intake. Removing nicotine dependence and drug use disorder covariates resulted in a significant negative association between obesity and past-year alcohol dependence, suggesting that the alcohol dependent women who smoke or use illicit drugs may consume fewer calories than those who do not.

BMI was not associated with risk for illicit drug use disorders in general or any specific drug use disorder. Although there was a trend toward increased risk for lifetime opiate use disorders among overweight women, the association between BMI and risk for opiate use disorders was not significant. Our results do not support the commonly held belief that opiate abuse leads to weight loss (Torpy, 2004).

Marijuana enhances appetite, and medications based on its main psychoactive ingredient, tetrahydrocannabinol (THC), have been used to improve appetite and restore body weight in patients with AIDS-related wasting (Wilkins, 2006). Cocaine suppresses appetite, and there is evidence that desire for weight control motivates many cocaine users, particularly women (Cochrane, Malcolm, & Brewerton, 1998). Although this study did not examine drug effects on appetite, marijuana and cocaine use disorders are not related to body weight in this large epidemiologic sample.

It is unclear why relationships between BMI and nicotine dependence were more robust and consistent for men compared to women. Given the findings in men, it is not surprising that obese women were less likely than normal weight women to have past-year nicotine dependence. The fact that overweight women were *more* likely to have a lifetime history of nicotine dependence is a bit more *puzzling*. Nicotine use is generally associated with weight loss (Schechter & Cook, 1976), and cessation of use is associated with weight gain (Caan et al., 1996; Klesges et al., 1997). Male smokers generally smoke more cigarettes per day than female smokers (Etter, Prokhorov, & Perneger, 2002). By smoking fewer cigarettes per day, female smokers may decrease exposure to nicotine's effects on appetite or metabolism. In the NESARC sample, male smokers with past-year nicotine dependence smoked an average of 19.5 cigarettes per day compared to 17.2 per day for past-year female smokers, and the difference was statistically significant ($F=32.2, p<.001$). It is therefore possible that the level of nicotine absorbed by women who currently smoke is sufficient to avoid obesity but not overweight. The category of lifetime nicotine dependence includes former smokers, so the higher risk among overweight women could be due to post-cessation weight gain, a problem that affects women more frequently than men (O'Hara et al., 1998).

Although scientists have long speculated, and evidence increasingly shows, that similar brain mechanisms underlie addictions to alcohol, drugs, and nicotine and excessive food intake (Grigson, 2002; Simansky, 2005; Volkow & Wise, 2005), only a handful of studies have looked at associations between overweight and obesity and various substance use disorders. Negative associations between substance use disorders and overweight and/or obesity would support the hypothesis that compulsive overeating and compulsive use of substances compete for the same reward systems in the brain. Our results do not provide consistently strong support for this hypothesis. Our findings suggest that excessive and dysfunctional substance use can co-occur with overweight and obesity, and in some cases the risk for substance use disorders is elevated

among individuals with higher BMI. It therefore appears that many individuals with substance use disorders are sensitive to the rewarding properties of both psychoactive substances and food. Gender differences in relationships between BMI and substance use disorders require further investigation. For instance, although prior research indicates that women who drink alcohol consume fewer calories from other sources (Colditz et al., 1991), it is not clear why alcohol calories replace food calories among women but not men.

Strengths of this study include the large sample size, careful diagnosis of DSM-IV substance use disorders, and evaluation of a range of specific substance use disorders. We were also able to control for a variety of other psychiatric disorders that may independently impact BMI and substance use disorders. Weaknesses of this study must be acknowledged. It is a cross sectional study and therefore does not provide information about the direction of causality. Although prior research suggests that use of various substances can affect body weight, the possibility that overweight and obesity enhance or attenuate risk for various substance use disorders, rather than the other way around, can not be ruled out. Although it used a large, representative sample of U.S. adults, this study, like most prior epidemiologic studies examining substance use disorders, included relatively small numbers of individuals with specific drug use disorders. It is therefore possible that some null findings for specific drug use disorders were due to insufficient power. Another concern is that self-reported height and weight were used to calculate BMI, which could lead to underestimation (Flood, Webb, Lazarus, & Pang, 2000; Kuczmarski, Kuczmarski, & Najjar, 2001). Finally, one strength of this study, the large sample, can also be viewed as a weakness. With samples this large, even fairly small effects are significant, and their clinical significance may be questionable. Some of the significant odds ratios we found are fairly modest, but in the population as a whole, even a modestly increased risk for substance use disorders can have detectable effects in terms of costs to society, such as treatment costs, associated medical costs and effects on crime.

Our findings on associations of BMI with past-year substance use disorders differ somewhat from those of Pickering et al. (2007) using the same sample, which we believe resulted from methodological differences between their study and ours. Pickering et al. (2007) divided their obese sample further into obese and extremely obese subsamples, and dividing the sample in this way could have reduced the likelihood of identifying significant findings as the number of extremely obese respondents was small, particularly when the sample was further divided by gender. In addition, those authors controlled for a number of additional covariates including eleven past-year medical conditions, and twelve past-year stressful life events. We chose not to control for these variables because both overweight/obesity and substance use disorders appear to increase risk for medical conditions and many of the life stressors examined rather than be caused by them (Chou, Grant, & Dawson, 1996; Klein et al., 2004; Laitinen, Power, Ek, Sovio, & Jarvelin, 2002; Pingitore, Dugoni, Tindale, & Spring, 1994; Poirier et al., 2006; Rohde et al., 2007; Stein, 1999). Although controlling for all possible contributing variables is a rigorous and appropriate approach to examining causal relationships, we felt it would mask some genuine associations in this study of population associations between the conditions of interest.

In conclusion, we found both positive and negative associations of BMI with various substance use disorders, and significant gender differences in those relationships. Further research is needed to identify potential reasons for gender differences and to understand potential neurological, metabolic, and psychosocial contributions to the different relationships among men and women.

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Lifetime Alcohol Use Disorders

Past Year Alcohol Use Disorders

Figure 1.

Prevalence of lifetime and past-year alcohol use disorders by BMI and gender

*Indicates a significant effect of the interaction between BMI and gender.

Lifetime Drug Use Disorders

Past-Year Drug Use Disorders

Figure 2.

Prevalence of lifetime and past-year drug use disorders by BMI and gender

Figure 3.
Prevalence of lifetime and past-year nicotine dependence by BMI and gender
*Indicates a significant effect of the interaction between BMI and gender.

Table 1
Demographic characteristics by body mass index (BMI) category and sex

	Normal Weight BMI 18.50–24.99		Overweight BMI = 25.00–29.99		Obese BMI ≥ 30.00		Statistic
	Male	Female	Male	Female	Male	Female	
N	5957	10048	7822	6657	4215	5665	
Age ^a	41.99 (0.30)	44.14 (0.27)	45.68 (0.27)	48.21 (0.33)	45.13 (0.27)	47.57 (0.30)	F(5, 65) = 75.90, <i>p</i> < .001
Race-ethnicity							$\chi^2(20) = 106.86, p < .001$
Black/African American	9.86 (0.76)	7.54 (0.56)	9.15 (0.58)	13.32 (0.92)	12.07 (0.87)	19.47 (1.12)	
American Indian	1.91 (0.26)	1.91 (0.23)	1.94 (0.21)	1.99 (0.26)	2.64 (0.37)	2.82 (0.35)	
Asian	7.36 (1.16)	5.86 (0.74)	3.43 (0.44)	3.03 (0.46)	1.68 (0.34)	1.78 (0.33)	
Hispanic/Latino	11.67 (1.19)	9.53 (1.01)	12.48 (1.37)	13.15 (1.68)	12.20 (1.56)	11.59 (1.35)	
White	69.20 (2.02)	75.17 (1.63)	73.01 (1.55)	68.51 (1.87)	71.42 (1.73)	64.34 (1.70)	
Education							$\chi^2(10) = 96.79, p < .001$
Less than high school	16.08 (0.67)	11.92 (0.49)	14.97 (0.68)	17.21 (0.92)	16.64 (0.93)	20.16 (0.86)	
High school graduate	27.40 (0.88)	27.69 (0.73)	28.16 (0.90)	30.29 (0.74)	31.41 (0.93)	33.39 (0.87)	
Some college or higher	56.51 (1.05)	60.39 (0.81)	56.87 (0.94)	52.50 (0.96)	51.95 (1.10)	46.45 (0.96)	
Marital status							$\chi^2(15) = 197.56, p < .001$
Married/living with partner	54.48 (0.84)	58.46 (0.77)	69.80 (0.62)	61.49 (0.84)	70.58 (0.97)	56.63 (0.83)	
Widowed	2.80 (0.25)	9.39 (0.33)	2.52 (0.17)	11.54 (0.44)	1.55 (0.18)	11.41 (0.48)	
Divorced/separated	8.88 (0.38)	11.70 (0.38)	9.59 (0.36)	12.36 (0.44)	9.87 (0.48)	14.93 (0.52)	
Single (never married)	33.84 (0.90)	20.44 (0.71)	18.09 (0.57)	14.61 (0.65)	18.01 (0.86)	17.02 (0.59)	
Income							$\chi^2(15) = 168.29, p < .001$
\$10,000 per year or less	9.53 (0.46)	11.51 (0.45)	5.85 (0.35)	11.02 (0.50)	5.79 (0.44)	12.86 (0.58)	
\$10,001–\$25,000	20.40 (0.74)	20.16 (0.54)	17.21 (0.59)	24.63 (0.65)	17.24 (0.75)	25.89 (0.71)	
\$25,000–\$50,000	31.90 (0.84)	28.27 (0.63)	31.75 (0.73)	30.35 (0.62)	33.27 (1.01)	32.51 (0.84)	
Over \$50,000	38.18 (1.08)	40.07 (1.02)	45.18 (0.99)	34.00 (0.98)	43.69 (1.25)	28.74 (0.92)	

	Normal Weight BMI 18.50–24.99		Overweight BMI = 25.00–29.99		Obese BMI ≥ 30.00		Statistic
	Male	Female	Male	Female	Male	Female	
Region of country							$\chi^2 (15) = 28.61, p < .050$
Northeast	18.79 (3.71)	20.03 (3.56)	21.03 (3.47)	20.46 (3.61)	17.90 (2.84)	18.22 (3.09)	
Midwest	22.10 (3.30)	22.59 (3.39)	22.95 (3.13)	22.56 (3.23)	25.67 (3.13)	24.72 (3.23)	
South	34.22 (3.47)	34.05 (3.44)	34.53 (3.26)	35.91 (3.38)	36.73 (3.10)	37.22 (3.14)	
West	24.89 (4.18)	23.33 (3.75)	31.49 (3.42)	21.08 (3.61)	19.70 (3.10)	19.84 (3.17)	
Urban vs. Rural							$\chi^2 (5) = 35.49, p < .001$
Urban	82.54 (1.65)	81.74 (1.62)	80.00 (1.67)	79.95 (1.76)	76.66 (1.82)	78.14 (1.78)	
Rural	17.46 (1.65)	18.26 (1.62)	20.00 (1.67)	20.05 (1.76)	23.34 (1.82)	21.86 (1.78)	

Values represent percentages (unless otherwise noted) and numbers in parentheses are standard errors.

^aValues represent means.

Table 2
Odds ratios (ORs) of DSM-IV alcohol use disorders by body mass index (BMI) category for males and females.

	Male		Male Only	Female	Female Only	Interaction
	Overweight BMI=25.00–29.99	Obese BMI ≥ 30.00	F (df=2)	Overweight BMI=25.00–29.99	Obese BMI ≥ 30.00	F (df=2)
Alcohol Abuse						
Lifetime, OR	1.23	1.24	10.37, $p < .001$	0.94	1.08	11.65, $p < .001$
(95% C.I.)	(1.11–1.37)*	(1.11–1.39)*		(0.83–1.07)	(0.93–1.26)	
Past Year, OR	1.08	1.05	0.33, $p = .72$	0.76	0.65	7.35, $p < .01$
(95% C.I.)	(0.90–1.29)	(0.86–1.28)		(0.59–0.98)*	(0.48–0.88)*	
Alcohol Dependence						
Lifetime, OR	1.23	1.28	7.15, $p < .01$	0.93	0.87	9.54, $p < .001$
(95% C.I.)	(1.08–1.40)*	(1.11–1.47)*		(0.78–1.10)	(0.73–1.04)	
Past Year, OR	1.19	0.91	2.56, $p = .09$	0.87	0.73	1.84, $p = .17$
(95% C.I.)	(0.95–1.49)	(0.71–1.18)		(0.65–1.17)	(0.54–1.00)	

Wald F values report effect of BMI on likelihood of substance use disorder within gender and effect of the interaction of BMI and gender on likelihood of substance use disorder in the total sample. Odds ratios (ORs) obtained using normal weight as reference group. Normal weight and male gender are comparators for interactions. Analyses control for age, level of education, race/ethnicity, income, marital status, region of country, urban vs. rural residence, and lifetime and past-year DSM-IV diagnoses of any mood disorder, any anxiety disorder, any personality disorder, any drug use disorder, and nicotine dependence.

* Indicates that Wald F is significant, and OR is significantly different from 1.00 within that gender.

Table 3
Odds ratios (ORs) of DSM-IV substance use disorders by body mass index (BMI) category for males and females.

	Male		Male Only		Female		Female Only		Interaction
	Overweight BMI=25.00–29.99	Obese BMI ≥ 30.00	F (df=2)	Obese BMI ≥ 30.00	Overweight BMI=25.00–29.99	Obese BMI ≥ 30.00	F (df=2)		
Any Drug Use Disorder									
Lifetime, OR	0.95	0.87	1.32, <i>p</i> =.27		0.98	1.08	0.62=.54	1.10, <i>p</i> =.34	
(95% C.I.)	(0.83–1.09)	(0.73–1.03)			(0.80–1.21)	(0.84–1.32)			
Past Year, OR	0.95	0.79	1.29, <i>p</i> =.28		1.00	0.99	0.00, <i>p</i> =.99	0.32, <i>p</i> =.72	
(95% C.I.)	(0.75–1.22)	(0.58–1.06)			(0.65–1.43)	(0.64–1.55)			
Any Cocaine Use Disorder									
Lifetime, OR	1.14	1.11	0.27, <i>p</i> =.76		0.95	1.19	1.01, <i>p</i> =.37	0.25, <i>p</i> =.75	
(95% C.I.)	(0.81–1.35)	(0.84–1.47)			(0.71–1.28)	(0.86–1.65)			
Past Year, OR	0.89	0.71	0.28, <i>p</i> =.76		0.75	1.18	0.28, <i>p</i> =.75	0.46, <i>p</i> =.63	
(95% C.I.)	(0.42–1.90)	(0.29–1.76)			(0.28–2.03)	(0.44–3.19)			
Any Marijuana Use Disorder									
Lifetime, OR	0.97	0.92	0.46, <i>p</i> =.63		1.02	1.13	0.67, <i>p</i> =.51	0.57, <i>p</i> =.57	
(95% C.I.)	(0.84–1.12)	(0.77–1.10)			(0.81–1.28)	(0.90–1.14)			
Past Year, OR	0.88	0.84	0.80, <i>p</i> =.45		0.88	0.81	0.35, <i>p</i> =.70	0.03, <i>p</i> =.97	
(95% C.I.)	(0.67–1.16)	(0.60–1.16)			(0.53–1.45)	(0.48–1.38)			
Any Opiate Use Disorder									
Lifetime, OR	1.23	1.17	0.80, <i>p</i> =.45		1.55	1.49	3.00, <i>p</i> <.06	0.48, <i>p</i> =.62	
(95% C.I.)	(0.88–1.71)	(0.81–1.70)			(1.03–2.33)	(0.97–2.28)			
Past Year, OR	0.78	0.82	0.37, <i>p</i> =.69		1.08	2.01	1.99, <i>p</i> =.15	0.96, <i>p</i> =.39	
(95% C.I.)	(0.42–1.45)	(0.43–1.57)			(0.52–2.25)	(0.97–4.17)			

Wald F values report effect of BMI on likelihood of substance use disorder within gender and effect of the interaction of BMI and gender on likelihood of substance use disorder in the total sample. Odds ratios (ORs) obtained using normal weight as reference group. Normal weight and male gender are comparators for interactions. Analyses control for age, level of education, race/ethnicity, income, marital status, region of country, urban vs. rural residence, and lifetime and past-year DSM-IV diagnoses of any mood disorder, any anxiety disorder, any personality disorder, any alcohol use disorder, and nicotine dependence.

* Indicates that Wald F is significant, and OR is significantly different from 1.00 within that gender.

Table 4
Odds ratios (ORs) of DSM-IV nicotine dependence by body mass index (BMI) category for males and females.

	Male		Male Only		Female		Female Only		Interaction	
	Overweight BMI=25.00–29.99	Obese BMI ≥ 30.00	F (df=2)		Overweight BMI=25.00–29.99	Obese BMI ≥ 30.00	F (df=2)		F (df=2)	
Nicotine Dependence										
Lifetime, OR	0.77	0.83	11.01, <i>p</i> <.001		1.16	1.01	3.26, <i>p</i> <.05		10.48, <i>p</i> <.001	
(95% C.I.)	(0.69–0.87) *	(0.73–0.94) *			(1.03–1.31) *	(0.90–1.14)				
Past Year, OR	0.71	0.74	17.28, <i>p</i> <.001		1.09	0.84	5.59, <i>p</i> <.01		9.21, <i>p</i> <.001	
(95% C.I.)	(0.63–0.81) *	(0.64–0.86) *			(0.94–1.27)	(0.73–0.96) *				

Wald F values report effect of BMI on likelihood of substance use disorder within gender and effect of the interaction of BMI and gender on likelihood of substance use disorder in the total sample. Odds ratios (ORs) obtained using normal weight as reference group. Normal weight and male gender are comparators for interactions. Analyses control for age, level of education, race/ethnicity, income, marital status, region of country, urban vs. rural residence, and lifetime and past-year DSM-IV diagnoses of any mood disorder, any anxiety disorder, any personality disorder, any alcohol use disorder, and any drug use disorder.

* Indicates that Wald F is significant, and OR is significantly different from 1.00 within that gender.