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Associations among excess weight status and tobacco, alcohol, and illicit drug use in a large national sample of early adolescent youth

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Abstract

Adolescent substance use and overweight/obesity each are public health priorities, with unique prevalences based on race/ethnicity. Whether these biobehavioral risks are linked in today's youth is unknown, leaving critical gaps in prevention science. Utilizing a national epidemiological sample of 10th grade students (N= 19,678; M_{age} =16.09 years; 69.5% White, 14.5% Black, 16.0% Hispanic; 2008-2009 Monitoring the Future), we examined adolescent substance use behaviors (current use, grade of first use, polysubstance use) for adolescents of overweight (OV), obese (OB), or severely obese (SO) status compared to adolescents of healthy weight (HW) for each race/ethnicity group. We also examined how engagement in smoking behaviors (current, early grade at first use) were linked to other substance use behaviors for youth of varying degrees of excess weight. Relative to HW youth, White youth of excess weight, particularly SO, had higher odds of early (<grade 9) substance use, and use of some illicit substances (inhalants, cocaine, amphetamines) within the past year. Among White early smokers, OB and SO had higher odds of other substance use, whereas White OB and SO recent smokers had lower odds of other substance use. Few significant findings based on weight status were identified for Black or Hispanic youth. These findings suggest adolescent health risk behaviors co-occur uniquely for White youth, in particular those who are SO and by early adolescence. Understanding the downstream public health consequences and how risk pathways of excess weight, tobacco, and other substance use may uniquely unfold for each race/ethnicity group is imperative.

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Research involving Human Participants: The present manuscript involved secondary data analyses of de-identified data from a Monitoring the Future. Secondary analyses were approved by the Institutional Review Board with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Keywords

Adolescence; Obesity; Substance Use

Introduction

Obesity and substance use behaviors (e.g., cigarettes, alcohol, marijuana, other illicit drugs) are each significant public health concerns for today's youth. One third of adolescents in the United States are estimated to be overweight (BMI 85th and < 95th percentile) or obese (BMI 95th percentile) (Ogden, Carroll, Kit, & Flegal, 2014), with rates of severe obesity (BMI 99th percentile or BMI 120% over the 95th percentile) continuing to rise (Skinner & Skelton, 2014). Current trends also forecast the great likelihood of excess weight status persisting into adulthood along with mounting associated comorbidity risk (Merten, 2010). Substance use behavior is typically initiated in adolescence, with prevalence rates known to increase across the high school years (Chen & Jacobson, 2012; Johnston, O'Malley, Bachman, & Schulenberg, 2013), launching some on a trajectory to abuse and dependence by adulthood (Behrendt, Wittchen, Hofler, Lieb, & Beesdo, 2009; Hu, Griesler, Schaffran, Wall, & Kandel, 2012). When substance use trajectories are tracked prospectively from adolescence into young adulthood (ages 12-28), early onset is associated with later problematic substance use (Nelson, Van Ryzin, & Dishion, 2014). Early tobacco use specifically has been shown to be a unique signal of later high-risk alcohol and marijuana use (Nelson et al., 2014). Moreover, single drug exposure to tobacco, alcohol, or marijuana is rare in early adolescence, with 34% reporting polysubstance use (Moss, Chen, & Yi, 2014). Accordingly, early adolescents are key targets for prevention and intervention to address these biobehavioral risks, yet how excess weight status and substance use co-occur is less understood.

Interestingly, there is a growing empirical base that demonstrates how cigarette smoking, including smoking initiation before the 9th grade, is more prevalent among adolescents whose weight exceeds healthy guidelines (e.g., BMI 85th percentile) (Cawley, Markowitz, & Tauras, 2004; Farhat, Iannotti, & Simons-Morton, 2010; Huang, Lanza, Wright-Volel, & Anglin, 2013; Ratcliff, Jenkins, Reiter-Purtill, Noll, & Zeller, 2011; U.S. Department of Health and Human Services, 2012; Zeller, Reiter-Purtill, Peugh, Wu, & Becnel, 2015). Unique patterns based on race/ethnicity and degree of excess weight have also been reported. Our recent work with the a nationally representative sample of 10th grade students (Zeller et al., 2015) demonstrated that White youth and Black youth in all excess weight groups had increased odds of current smoking relative to healthy weight youth of the same race/ethnicity; White youth who were overweight or obese also had higher odds of first smoking before grade 9. Data characterizing whether rates of alcohol, marijuana, and/or other illicit drug use also vary for youth of excess weight are far more limited and equivocal. For example, relative to adolescents of healthy weight, being overweight or obese increased the odds of alcohol or marijuana use (Farhat et al., 2010; Fonseca, Matos, Guerra, & Pedro, 2009). Only one study has examined substance use behaviors in adolescents with severe obesity specifically, which suggested that unlike tobacco use, there were no greater risks for

using alcohol, marijuana or a wide range of illicit substances for this most extreme weight status category relative to youth of healthy weight (Ratcliff et al., 2011).

The mechanisms behind why these biobehavioral risks may be linked, as well as why they may be linked uniquely for some race/ethnic groups, are likely complex and multi-factorial given the existing literature. Sociological theory suggests social ties are highly influential of engagement in both positive and negative health behaviors (Crosnoe, 2012; Umberson, Crosnoe, & Reczek, 2010). Using tobacco as an exemplar, adolescent smoking behavior is known to be a peer group phenomenon (Kelly et al., 2011; Schaefer, Haas, & Bishop, 2012). It is also known that adolescents who are overweight/obese are more socially marginalized (Strauss & Pollack, 2003). Further, adolescents who are socially isolated are more likely to smoke relative to others more embedded in the social network structure (Seo & Huang, 2012). Thus, it may be that as excess weight status increases, teens may have fewer friendship options and choose similarly marginalized peers, compounding peer-based influences for greater smoking behavior risks. Finally, these social contexts that promote cigarette smoking have been shown to have more impact on White adolescent smoking than for Black or Hispanic youth (Griesler & Kandel, 1998). Alternately, problem behavior theory posits the interaction of individual-level and environmental-level vulnerabilities and protective factors to account for proneness for both problem behaviors (i.e., smoking, alcohol use) as well as health-compromising behaviors (e.g., unhealthy eating, sedentary behavior) to co-occur. (Jessor et al., 2003).

Considerable gaps in this developing literature exist, with several “next steps” needed to inform the testing of more explanatory models of these potential inter-relationships. To date, no studies have taken a more comprehensive approach examining a range of substance use behaviors and across all excess weight status groups (relative to healthy weight) within the same study. This approach proves clinically relevant given BMI cut-points (e.g., overweight vs. obese vs. severely obese) are one standard criterion for referral or access to care (i.e., lifestyle modification programs, bariatric surgery programs) (Barlow et al., 2007) and from which unique risks for a specific weight status group can be identified. Accordingly, the present study aims were to (Aim 1) provide a comprehensive examination of adolescent substance use behaviors across the excess weight spectrum (overweight, obese, severely obese) relative to adolescents of healthy weight. Building on our previous work, we also (Aim 2) examined whether engagement in smoking behaviors (current, early grade at first use) were linked to other substance use behaviors and varied by excess weight. Given known race/ethnic disparities in obesity prevalence (Wang, Gortmaker, & Taveras, 2011) and substance use (Johnston et al., 2013; O'Malley, Johnston, Bachman, Schulenberg, & Kumar, 2006), as well as the differential impact of parental education and gender on both biobehavioral risks (Bachman, O'Malley, Johnston, Schulenberg, & Wallace, 2011; Martin, Frisco, Nau, & Burnett, 2012), analyses were executed separately by race (White, Black, Hispanic) and controlled for parental education and gender. To achieve these aims, we accessed a large (N=19,678) nationally representative and contemporary sample of adolescents from an ongoing epidemiological study of behaviors, attitudes, and values of youth in the US.

Methods and Procedures

Study Design and Population

The present study utilized pooled data from 10th graders in the 2008 and 2009 Monitoring the Future (MTF) Surveys (Johnston, O'Malley, Bachman, & Schulenberg, 2010; Johnston, O'Malley, Bachman, & Schulenberg, 2009). MTF is a national survey of behaviors and attitudes administered to adolescents (i.e., 8th, 10th, or 12th grade) in public and private schools and funded by the National Institute on Drug Abuse (NIDA) of the National Institutes of Health. The MTF study design, procedures, and sampling process are described in detail elsewhere (Bachman, Johnston, O'Malley, & Schulenberg, 2011). Briefly, 10th grade students voluntarily and anonymously completed surveys in a classroom setting. Sample weights are assigned to each student to take into account variations in selection probabilities that may have occurred at different stages of MTF sampling (geographic, school, students). The overall response rate for 10th grade students (school response rate × participant response rate) was 84% in 2008 (Johnston et al., 2009) and 87% in 2009 (Johnston et al., 2010).

Adolescent self-reported height and weight were included on the assessment forms for 83.3% of the combined 2008 and 2009 MTF 10th grade sample (n=26,517 of 31,838) and used to calculate BMI and BMI percentile for age and gender based on 2000 Centers for Disease Control (CDC) criteria. Participants with any additional missing data necessary for calculation of BMI percentile (i.e., age, gender, 9.2%) or with BMI values that were flagged by MTF as “biologically implausible” (i.e., too low, too high) based on the CDC criteria (0.7%) were excluded from analyses, leaving 23,882 participants. Given the aims of the study were focused on the impact of excess weight, MTF participants who were underweight (<5th percentile, n=673 of 23,882, 2.8%) were excluded from the present analyses. Finally, participants who did not identify themselves as either non-Hispanic White, non-Hispanic Black or Hispanic (Mexican American, Chicano, Cuban American, Puerto Rican, or other Hispanic or Latino) were excluded from analyses (n=3,531, 15.2%) due to missing data or insufficient sample size for other racial/ethnic groups. This resulted in a final study N of 19,678 adolescents. Secondary data analysis of MTF was approved by the Institutional Review Board at Cincinnati Children's Hospital.

Measures

Weight Status—BMI percentiles were used to calculate weight status groups based on 2000 CDC criteria (<http://www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm>): healthy weight (HW: 5th–84th percentile), overweight (OV: 85th–94th percentile), and obese (OB: 95th–98th percentile). The cut point for the severely obese (SO) weight status group was set at the 99th percentile (Skelton, Cook, Auinger, Klein, & Barlow, 2009).

Demographics—Demographic data were self-reported by the adolescent and included: gender, race and parent education. The highest levels of education for mother and father were averaged and scaled (1= grade school completion or less to 6= graduate or professional school).

Substance Use—Adolescents reported if they had smoked in the past 30 days. Adolescent report of use of alcohol, being drunk, and use of marijuana/hashish, and any other individual illicit drug (i.e., hallucinogens, LSD, cocaine, crack, heroin, inhalants, amphetamines, barbiturates, tranquilizers, or steroids) within the past 12 months were dichotomized (0 occasions, 1 or more occasions). Data regarding prevalence of substance use have been shown to have adequate internal consistency, reliability, and predictive and discriminant validity across adolescence (Johnston, O'Malley, Bachman, & Schulenberg, 2011). Illicit drug experimentation was defined as the number of different illicit substances other than marijuana/hashish (hallucinogens, LSD, cocaine, crack, heroin, inhalants, amphetamines, barbiturates, tranquilizers, or steroids) tried at least once in the past year, with scores ranging from 0 (none) to 10. Questions regarding grade of first use for smoking, alcohol, getting drunk, marijuana/hashish were recoded as: 0=never used the substance, 1= first used before grade 9 (“early”), and -1=first used in grades 9-10, as the broader literature indicates that the initiation of substance use at an age prior to high school (grades 9-12) is not normative (Nelson et al., 2014).

Statistical Analyses

Mplus (version 7) and SPSS (version 20) were used to conduct all analyses and included MTF survey sampling weights to adjust for the complex survey design. All analyses were performed separately by racial/ethnic category for White, Black, and Hispanic adolescents, with gender and parental education entered as covariates. Missing data for all analyses ranged between 0.6%-10.2% across White, Black, and Hispanic adolescent groups and were handled via weighted least squares estimation (Muthén & Muthén, 1998-2012) in Mplus for Aim1 and multiple imputation (M = 50 imputed datasets) with auxiliary correlates in SPSS (Version 19) for Aim 2. To evaluate the effect of weight status (OV, OB, SO versus HW) on each outcome variable, logistic regression was used to compute odds-ratios (ORs), with 95% confidence intervals (CI) obtained using bootstrapping procedures. Given the large number of comparisons completed for this Aim, the false discovery rate procedure (Benjamini, 2010) was used to control family-wise Type I error. Families were defined within weight status group for White, Black or Hispanic adolescents for three outcome domains: high prevalence substance use (i.e., alcohol, drunk, and marijuana/hashish), low prevalence illicit substance use, and grade of initiation of substance use. For Aim 2, separate logistic or linear regressions were used to evaluate whether the associations between cigarette smoking and use of other drugs were moderated by weight status group. For these moderational analyses, cigarette use (i.e., either cigarette use in the past 30 days or early grade of first use of cigarettes), weight status group, and their interaction were entered in separate logistic regression models predicting annual alcohol use, annual drunk, annual use of marijuana/hashish or in linear regression models predicting illicit drug experimentation.

Results

Sample Characteristics

Adolescent demographic data for each weight status group are presented in Table 1. Participants in the overall sample were 53% female and approximately 16 years of age. Alcohol was the most frequently used substance, followed by marijuana, and tobacco.

Given the present aims, we conducted analyses to see if those MTF participants with any missing data required to calculate BMI percentile ($n=1,770$) differed from those who did provide all information ($n=20,219$). An initial logistic regression was completed examining race/ethnicity given that we completed all analyses separately by this variable. Results suggested that non-White race/ethnicity ($OR=1.96$, 95% $CI= 1.78-2.17$) was significantly associated with non-provider status. Next, analyses with provider status as the dependent variable were completed by race/ethnic group to examine the associations of gender and parent education, as well as substance use for the most commonly used substances in our study (i.e., cigarettes in the past 30 days, annual alcohol use, and annual marijuana use). For White participants, male gender ($OR=0.75$, 95% $CI= 0.65-0.88$), lower parental education ($OR=0.83$, 95% $CI= 0.77-0.89$), and greater annual marijuana use ($OR=1.52$, 95% $CI= 1.24-1.87$) were associated with non-provider status. For Black participants, male gender ($OR=0.49$, 95% $CI= 0.38-0.64$) and lower parental education ($OR=0.87$, 95% $CI= 0.78-0.98$) were significantly associated with non-provider status. Finally, for Hispanic youth, only lower parental education ($OR=0.89$, 95% $CI= 0.79-0.99$) was significantly associated with non-provider status.

Weight Status and Alcohol, Marijuana, and Other Illicit Drug Use Within the Past Year

The associations of weight status group with use of alcohol, having been drunk, as well as use of marijuana and other illicit substances within the past year were examined after adjusting for demographic covariates (e.g., gender, parent education). Prevalence rates and ORs are reported in Table 2.

For each race/ethnic group, prevalence of alcohol use within the past year, including being drunk, was generally similar to that of same race adolescents of HW for all excess weight status groups, with several exceptions. Notably, higher odds for alcohol use were identified for OV-Black and OB-Hispanic, while OB-White had lower odds of having been drunk relative to same race healthy youth. Prevalence of marijuana/hashish use within the past year across race/ethnic groups was also similar to that of same race adolescents of HW, although OV-Hispanic youth had lower odds of use, relative to HW-Hispanic youth.

For White youth, prevalence of hallucinogen, LSD and crack cocaine use were the only illicit substances for which rates were similar for HW and all excess weight status groups. SO-White adolescents in particular had higher odds of use of most illicit substances including use of inhalants, cocaine and other cocaine, amphetamines, barbiturates, and tranquilizers within the past year relative to those of HW. SO-White youth, relative to HW-White youth, were more likely to have experimented with multiple drugs within the past year. OB-White youth had higher odds of having used heroin, and OV-White youth had greater odds of having used amphetamines and tranquilizers relative to same race youth of HW. For Black youth as well as Hispanic youth, prevalence rates of use of illicit drugs were overwhelmingly similar between same race youth of HW with all excess weight status groups.

Weight Status and Grade of First Use of Alcohol and Marijuana

The prevalence rates and ORs for the associations between weight status group and early grade of first use (< grade 9) of alcohol, drunk, and marijuana/hashish are presented in Table 3. Adolescents who responded “never” to these questions (alcohol 38.9%; drunk 59.9%; and marijuana/hashish 69.7%) were excluded from these analyses. As compared to same race HW youth, White youth who were OB or SO had increased odds of having initiated alcohol use and having been drunk prior to the 9th grade. For marijuana/hashish, White youth in all excess weight groups had higher odds of initiating use before the 9th grade relative to youth of HW. No significant associations were identified for Black youth or Hispanic youth.

Moderating Effects of Weight Status on Associations of Early Grade of First Smoke and Current Smoking with Alcohol, Marijuana/Hashish and Drug Variety

For the purposes of the present study, we were also interested in links between smoking behaviors and other substance use in the 10th grade. Specifically, we examined whether weight status was a potential moderator of (1) any associations of a participant reporting early initiation of smoking with being a current smoker, as well as having used alcohol, been drunk, used marijuana/hashish, or the number of other illicit substances used (i.e., summary score of illicit drug experimentation) within the past year; and (2) any associations of being a current smoker with annual alcohol, drunk, marijuana/hashish use, and illicit drug experimentation. Across all racial/ethnic groups, the main effects of early smoking initiation or current smoking were positively and significantly associated with each outcome. Below, only significant results for the interaction of weight status group with each smoking variable are reported.

Interactions of Reporting Early Smoking Initiation and Current Excess Weight Group

Among those with early initiation of smoking, OB Black youth ($\beta = 1.40$, OR= 4.06, $p=0.004$), and OV Hispanic youth ($\beta = 0.56$, OR= 1.75, $p=0.02$) had significantly higher odds of current smoking, whereas SO White youth ($\beta = -1.23$, OR= 0.29, $p<0.0001$) and SO Black adolescents ($\beta = -1.39$, OR= 0.25, $p=0.04$) had lower odds of current smoking relative to same race/ethnicity HW adolescents.

When examining associations of early smoking initiation with alcohol and marijuana use, weight status was a significant moderator for White adolescents, but not for Black or Hispanic adolescents. Specifically, for White adolescents, among those with early initiation of smoking, adolescents who were OB-White and SO-White had significantly higher odds relative to HW-White youth of using alcohol (OB: $\beta=0.42$, OR=1.52, $p<0.0001$; SO: $\beta=0.44$, OR=1.56, $p=0.04$) or being drunk (OB: $\beta=0.44$, OR=1.55, $p<0.0001$; SO: $\beta=0.54$, OR=1.71, $p=0.04$) in the past 12 months. In addition, among adolescents with early initiation, OB-White had higher odds ($\beta=0.37$, OR=1.44, $p=0.004$) of using marijuana/hashish than HW-White.

Only one significant interaction was identified between early smoking initiation and weight status in the prediction of illicit drug experimentation. Among Hispanic adolescents with early initiation of smoking, being OB was significantly associated with a greater variety of

illicit substances used ($\beta = 0.20$, $p=0.04$) within the past year relative to Hispanic youth of HW.

Interactions of Current Smoking and Excess Weight Group

Weight status moderated the associations of current smoking with alcohol and marijuana/hashish use in the past 12 months for White but not Black or Hispanic adolescents, albeit in an unexpected direction. Among current smokers, SO White youth had significantly *lower* odds of endorsing being drunk ($\beta = -0.89$, $OR=0.41$, $p=0.02$) relative to HW White adolescents, and similarly, OB ($\beta = -0.50$, $OR=0.61$, $p=0.02$) and SO ($\beta = -0.71$, $OR=0.49$, $p=0.04$) White adolescents had significantly *lower* odds of using marijuana/hashish.

A number of significant interactions were identified between weight status and current smoking in the prediction of illicit drug experimentation. Among Black adolescents who were current smokers, being OV ($\beta = -0.42$, $p=0.001$), OB ($\beta = -0.60$, $p<.0001$), or SO ($\beta = -0.77$, $p=0.003$) was significantly associated with lower variety of illicit substances used in the past year relative to HW Black adolescents. Similarly, for White or Hispanic adolescents who were current smokers, being OB was significantly associated with lower variety of illicit substances used (White: $\beta = -0.30$, $p<0.0001$; Hispanic: ($\beta = -0.71$, $p<.0001$) relative to HW adolescents of the same race/ethnicity.

Discussion

Obesity, tobacco and substance use are each “leading health indicators” in the objectives outlined in Healthy People 2020 for improving adolescent health and lowering risk for adult chronic disease in the United States (“Leading Health Indicators”, n.d.). We previously demonstrated that smoking behaviors and excess weight status co-occurred in 10th grade students, with White adolescents of excess weight or those who are severely obese at greater smoking behavior risk, including perceiving low risk of harm from smoking (Zeller et al., 2015). The present study considerably broadens the scope of investigation with this same nationally representative sample to include alcohol, marijuana, and other illicit substance use behaviors (Aim 1), as well as their potential associations with current and early tobacco use (Aim 2). While it was evident that biobehavioral risk factors of substance use *as well as* excess weight co-occur in early adolescence, there were a number of notable variations in prevalence patterns based on race/ethnicity and degree of excess weight.

First, the present findings expand concerns regarding substance use for a White teen of severe excess weight status in early adolescence beyond tobacco to higher odds of using an illicit substance within the past year (e.g., inhalants, cocaine, barbiturates, amphetamines, tranquilizers, heroin), and with few exceptions. Second, it appears being of excess weight status increased the odds of White teens having tried alcohol and marijuana earlier, including being drunk for the first time, prior to the 9th grade. Third, Black and Hispanic 10th grade students of excess weight status generally engaged in substance use behaviors at similar rates as their same-race healthy weight peers.

For some 10th graders, acknowledgement of any smoking behavior prior to the 9th grade increased the odds they were currently using *other* substances, and not necessarily tobacco.

For example, relative to same-race healthy weight peers, White youth with severe obesity who reported earlier smoking behavior had lower odds of being a current smoker, but greater odds of alcohol use and having been drunk within the past year. Hispanic youth of excess weight who were early smokers were at increased odds of having used a greater variety of illicit substances by the 10th grade. In stark contrast, for all race/ethnic groups and unlike healthy weight peers, current smoking as a 10th grader actually *lowered* the odds for youth of many excess weight subgroups of having used other substances within the past year. At first glance, these findings appear contradictory. However, there is a common temporal ordering of substance initiation that begins with tobacco or alcohol followed by marijuana and then other illicit substances (Degenhardt et al., 2009; Degenhardt et al., 2010). While acknowledging there are several weight status/race subgroup exceptions and that the present data are cross-sectional, it may be those who engage in tobacco use early share many other risk factors and vulnerabilities, including substance using peers, that influence progression to new substances by the 10th grade, whereas risks for those who try tobacco later are attenuated.

Recognizing the cross-sectional nature of these data, results shed light on the potential importance of including weight status in future studies that examine developmental trajectories of substance use behaviors of youth aimed to identify time periods of highest risk to inform prevention efforts. Moreover, while we appropriately considered substance use behaviors within race/ethnic groups (O'Malley et al., 2006), future work that would require larger samples should explore why links between weight status and substance use behaviors look differently for Whites, Blacks and Hispanics. While beyond the scope of the present study, a growing literature demonstrates that excess weight status in adolescence has a different psychosocial impact depending on race/ethnic group. For example, White youth, including those who were severely obese, report weight has a greater impact on their quality of life and psychosocial adjustment than Black youth (Modi & Zeller, 2008; Padgett & Biro, 2003; Powell-Young, Zabaleta, Velasco-Gonzalez, & Sothorn, 2013; Wong et al., 2014). In addition, White youth who are overweight/obese are more likely to be socially marginalized compared to excess weight youth of other race/ethnicities (Strauss & Pollack, 2003). In general, socially marginalized youth tend to associate with similarly marginalized peers, for whom tobacco and substance use is more the social norm (La Greca, Prinstein, & Fetter, 2001; Seo & Huang, 2012). Thus, for White youth of excess weight, psychosocial influences may uniquely compound risks for higher rates of substance use in early adolescence.

There are several limitations to the present findings. First, the cross-sectional nature of these data, with retrospective reporting on grade of substance use initiation, does not allow for an examination of the temporal sequencing of the development of excess weight status and initiation of substance use behaviors. Second, although this study included the most predominant racial/ethnic groups in the United States, other groups were excluded based on limited sample size. Relatedly, the Hispanic category used by MTF was broad, including individuals of a variety of historical or cultural backgrounds. Lack of significant findings for Hispanic youth in the current study may be a reflection of this greater variability within group (Wallace et al., 2002) or may be due to lower statistical power, particularly when analyzing data by weight group. MTF surveillance is restricted to adolescents attending high school, and thus, may not be representative of other youth in this age group, including

adolescents who leave school early or are home-schooled. Finally, those of non-White race, males and those reporting lower parental education (SES proxy) may be under-represented in our unique MTF sample which required several data points to compute BMI percentile.

Comparison and/or replication of the present findings with other data sources should consider the following. The BMI percentile-based categorization of weight status groups was reliant on the MTF methodology of utilizing self-reported heights and weights. While other large epidemiological studies of adolescents have shown a high correlation between self-reported and measured height and weight values (Brener, McManus, Galuska, Lowry, & Wechsler, 2003), it remains possible that the present findings may actually underestimate the extent of excess weight in the MTF sample, given self-reporting bias leans to an overestimation of height and underestimation of weight (i.e., a lower BMI). Prior to release, MTF also flagged BMI values considered “biologically implausible” (i.e., too low, too high) using 2000 CDC guidelines. Based on the observed upward trend of severe obesity in this decade (Skinner & Skelton, 2014), it is possible that the very upper extremes of severe obesity in these 2008-2009 MTF data were excluded. Nonetheless, these data expand the BMI window considerably from our previous work with the 2007 YRBSS surveillance (Ratcliff et al., 2011) where publically released data parameters for implausible BMI values were set at 55kg/m². Finally, we defined the severely obese group using a BMI value cut-point of the 99th percentile for age and gender in order to be consistent with our 2007 YRBSS report. However, a new nomenclature and severe obesity metric (i.e., “percentage of the 95th percentile”) are growing in use in an attempt to refine this weight category to improve tracking of BMI change over time and allow further delineation of severely obese sub-groups (Flegal et al., 2009; Kelly et al., 2013; Skinner & Skelton, 2014). Post hoc examination using the current sample indicated that the 99th percentile approximated 130% of the 95th percentile, suggesting that the obesity cut-point we employed was in fact, conservative. Finally, MTF does not include any objective validation of the self-report measures of drug-use and thus, under-reporting is possible.

Conclusions

Recent data released from MTF monitoring shows trends over the past two decades of declining rates among certain types of substance use among adolescents (alcohol, cigarettes, many other illicit drugs), and growing concerns regarding electronic cigarette use (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2015). Further, while stable rates of marijuana use are also reported, it is coupled with decreases in perceived harm and disapproval, with recent evidence of increased use when states decriminalize its use (Miech et al., 2015). In parallel, rates of pediatric obesity surged and remain at epidemic levels, with rates of severe obesity continuing to rise. Understanding the downstream public health consequences and how risk pathways of excess weight, tobacco, and other substance use may unfold, and whether they are unique for each race/ethnicity group, is imperative. Public health messaging targeting youth that encourages the adoption of health-promoting behaviors simultaneously (versus in isolation) while also depicting youth across the weight spectrum (versus merely healthy weight teens) has the potential to broaden public awareness of co-occurrence of health risk behaviors. From a clinical vantage point, youth who carry excess weight, particularly White youth prior to adolescence (< grade 9), are high-risk targets for

discussions regarding tobacco, alcohol, and illicit substance use. Pediatric care providers, including those in pediatric weight management and bariatric surgery programs should screen for tobacco, alcohol, and illicit drug use, be primed with prevention messaging, and be prepared with referral sources. Adolescent patients may find websites such as “NIDA for Teens” (<http://teens.drugabuse.gov>) a helpful resource.

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Table 1

Demographics Characteristics of Study Sample (N=19678) of 10th Grade Students after Excluding Underweight Adolescents (Monitoring the Future 2008, 2009).

	White (n=13679)	Black (n=2859)	Hispanic (n=3140)	Total (N=19678)
%Body Mass Index Categories				
Healthy (5 th –84 th percentile)	75.3%	63.9%	67.8%	72.5%
Overweight (85 th –94 th percentile)	14.0%	19.4%	17.5%	15.3%
Obese (95 th –98 th percentile)	8.8%	13.3%	12.1%	10.0%
Severely Obese (99 th percentile)	1.9%	3.5%	2.6%	2.2%
% Female	52.5%	54.9%	53.5%	53.0%
Mean Age (SD) in years	16.09 (0.43)	16.15 (0.57)	16.06 (0.52)	16.09 (0.47)
Modal Parental Education ^a	4	3	1	4
Smoked in the past 30 days ^b	14.4%	6.2%	11.8%	12.8%
Alcohol in past 12 months ^c	54.7%	43.9%	58.6%	53.8%
Marijuana in the past 12 months ^d	26.0%	21.9%	28.4%	25.8%
Illicit drug experimentation in past 12 months ^e	17.9%	7.2%	18.8%	16.5%

^aMissing data for 4.9% of the sample. 1= grade school completion or less; 2= some high school; 3= high school completion; 4= some college; 5= college completion; and 6= graduate or professional school.

^bMissing data for 2.1 %.

^cMissing data for 4.6%.

^dMissing data for 2.1%.

^eMissing data for 3.2%.

Table 2

Prevalence rates and Odds Ratios for Alcohol Use, Getting Drunk, and Marijuana/Hashish Use as well as other Illicit Substance Use in the Past 12 Months for White, Black, or Hispanic 10th Grade Students by Weight Status Group.

	Healthy			Overweight			Obese			Severely Obese		
	%	%	%	OR	95% CI	%	OR	95% CI	%	OR	95% CI	%
White												
Alcohol	54.9	54.8	1.03	1.03	0.97-1.09	52.1	0.95	0.88-1.02	54.7	1.05	0.91-1.21	
Drunk	35.1	34.9	1.04	1.04	0.99-1.10	30.4	0.89**	0.83-0.96	31.0	0.91	0.77-1.08	
Marijuana/Hashish	25.7	27.5	1.08	1.08	1.00-1.17	25.9	1.03	0.96-1.09	27.5	1.12	0.97-1.32	
Inhalants	5.4	6.5	1.07	1.07	1.00-1.15	6.0	1.06	0.95-1.17	8.9	1.33**	1.11-1.59	
Hallucinogens	4.6	4.3	0.94	0.94	0.84-1.05	4.1	0.96	0.85-1.08	2.3	0.88	0.68-1.13	
LSD	2.0	2.0	1.03	1.03	0.89-1.19	1.6	0.94	0.78-1.12	1.2	0.94	0.63-1.42	
Cocaine	2.3	2.9	1.02	1.02	0.88-1.18	2.6	1.10	0.95-1.29	3.5	1.26*	1.03-1.54	
Crack	0.8	1.3	1.12	1.12	0.90-1.39	1.1	1.19	0.98-1.45	1.5	1.19	0.45-3.13	
Other Cocaine	2.1	2.3	0.98	0.98	0.83-1.16	2.3	1.05	0.89-1.23	3.5	1.33**	1.08-1.63	
Heroin	0.7	0.7	0.98	0.98	0.80-1.19	1.0	1.34***	1.14-1.57	1.9	1.37	0.94-2.00	
Amphetamines	7.5	8.6	1.10*	1.10*	1.02-1.19	7.8	1.00	0.91-1.11	13.1	1.35***	1.14-1.61	
Barbiturates	7.6	8.7	1.08	1.08	1.00-1.16	7.5	1.00	0.91-1.09	10.8	1.30**	1.08-1.55	
Tranquilizers	5.5	7.1	1.4***	1.4***	1.07-1.21	5.4	1.00	0.89-1.11	8.1	1.40**	1.12-1.76	
Illicit Drug Experimentation	17.4	19.3	1.07	1.07	0.96-1.19	19.3	1.09	1.01-1.19	23.0	1.24**	1.05-1.47	
Black												
Alcohol	42.8	45.6	1.15***	1.15***	1.04-1.26	44.8	1.03	0.89-1.20	52.4	1.32	0.95-1.83	
Drunk	17.9	16.8	0.95	0.95	0.83-1.09	18.7	1.00	0.83-1.19	22.8	1.17	0.92-1.48	
Marijuana/Hashish	20.9	22.6	1.12	1.12	1.00-1.26	23.8	1.09	0.93-1.28	28.3	1.22	0.96-1.54	
Inhalants	2.3	2.7	1.19	1.19	0.95-1.49	2.9	1.10	0.79-1.52	3.1	1.26	0.82-1.94	
Hallucinogens	0.7	1.3	1.42	1.42	1.04-1.95	1.3	1.42	0.99-2.03	1.1	1.00	0.09-12.77	
LSD	0.5	0.6	0.99	0.99	0.32-3.00	0.3	0.99	0.18-5.46	1.1	1.14	0.07-19.61	
Cocaine	0.6	1.1	1.19	1.19	0.69-1.82	0.0	0.99	0.98-1.00	1.1	1.11	0.05-23.15	
Crack	0.3	0.9	1.45	1.45	0.85-2.45	0.0	0.99	0.98-1.01	1.1	1.27	0.08-20.39	

	Healthy			Overweight			Obese			Severely Obese		
	%	%	%	OR	95% CI	%	OR	95% CI	%	OR	95% CI	%
White												
Other Cocaine	0.5	0.7	0.96	0.30-3.01	0.0	1.05	0.96-1.03	1.1	1.33	0.05-23.97		
Heroin	0.3	0.2	0.94	0.19-5.08	0.3	1.10	0.17-7.19	1.1	1.30	0.09-18.65		
Amphetamines	2.0	3.0	1.21	0.98-1.50	3.0	1.20	0.88-1.64	6.3	1.61	1.05-2.46		
Barbiturates	2.3	2.8	1.13	0.82-1.55	3.3	1.12	0.86-1.44	4.3	1.28	0.76-2.17		
Tranquilizers	0.9	1.1	1.08	0.76-1.53	1.1	0.90	0.19-4.32	3.2	1.51	0.39-5.91		
Illicit Drug Experimentation	6.2	7.7	1.26	1.06-1.50	9.8	1.21	0.99-1.49	13.2	1.45	1.08-1.94		
Hispanic												
Alcohol	57.9	59.4	1.00	0.88-1.15	61.5	1.12*	1.02-1.22	57.1	0.95	0.70-1.30		
Drunk	32.2	31.5	0.95	0.82-1.09	30.2	0.97	0.85-1.09	24.3	0.78	0.57-1.05		
Marijuana/Hashish	28.6	27.7	0.88**	0.81-0.96	28.4	1.01	0.90-1.12	27.5	0.93	0.73-1.19		
Inhalants	6.8	8.3	1.11	0.92-1.34	8.8	1.19	1.01-1.41	8.5	1.16	0.76-1.78		
Hallucinogens	4.2	4.4	1.09	0.91-1.31	4.8	1.05	0.79-1.39	2.4	0.76	0.13-4.44		
LSD	1.7	2.0	1.12	0.85-1.48	2.7	1.13	0.67-1.90	2.5	1.10	0.21-5.75		
Cocaine	4.4	5.0	1.01	0.89-1.16	4.8	1.05	0.85-1.29	6.1	1.19	0.65-2.18		
Crack	2.2	2.4	0.99	0.79-1.24	1.3	0.91	0.65-1.26	1.2	0.82	0.05-13.18		
Other Cocaine	4.1	4.1	0.95	0.82-1.10	4.0	0.94	0.74-1.19	4.9	1.12	0.66-1.90		
Heroin	1.0	0.2	0.99	0.96-1.02	0.5	0.79	0.05-12.17	2.4	1.62	0.88-2.99		
Amphetamines	6.1	6.9	1.05	0.88-1.25	7.5	1.22	0.98-1.51	8.6	1.22	0.78-1.90		
Barbiturates	6.7	7.7	1.05	0.88-1.25	7.3	1.10	0.90-1.33	6.1	0.95	0.55-1.65		
Tranquilizers	5.0	5.0	1.02	0.87-1.18	3.0	0.79	0.58-1.07	4.9	1.12	0.73-1.73		
Illicit Drug Experimentation	18.3	19.9	1.05	0.93-1.18	19.9	1.11	0.92-1.35	18.8	0.92	0.67-1.25		

Note. Weight status groups are defined using % Body Mass Index categories as follows: Healthy (5th-84th percentile), Overweight (85th-94th percentile), Obese (95th-98th percentile), and Severely Obese (99th percentile). **Illicit drug experimentation** was defined as using at least one substance (hallucinogens, LSD, cocaine, crack, heroin, inhalants, amphetamines, barbiturates, tranquilizers, or steroids) on 1 or more occasions in the past year. Only significant results are noted after applying a false discovery rate procedure to control for Type I errors.

* $p < .05$.

** $p < .01$.

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Table 3

Prevalence rates and Odds Ratios for Initiation Prior to 9th Grade for Alcohol Use, Getting Drunk, and Marijuana/Hashish Use for White, Black, or Hispanic 10th Grade Students by Weight Status Group.

	Healthy			Overweight			Obese			Severely Obese		
	%		%	OR	95% CI	%	OR	95% CI	%	OR	95% CI	%
White												
<u>Early grade (<grade 9) at first use</u>												
Alcohol	33.0	35.8	1.03	0.97-1.13	38.5	1.23 ^{***}	1.11-1.36	38.8	1.38 ^{***}	1.16-1.64		
Drunk	16.1	17.0	0.99	0.90-1.10	19.2	1.30 ^{***}	1.16-1.46	21.0	1.36 ^{**}	1.08-1.71		
Marijuana/Hashish	11.6	14.3	1.12 ^{**}	1.05-1.20	15.1	1.21 ^{**}	1.07-1.38	17.6	1.31 [*]	1.05-1.63		
Black												
<u>Early grade (<grade 9) at first use</u>												
Alcohol	32.4	34.2	0.97	0.82-1.15	36.4	1.21	0.96-1.53	42.5	1.23	1.00-1.52		
Drunk	9.8	11.8	1.14	0.87-1.49	11.2	1.11	0.86-1.43	18.8	1.53	0.92-2.55		
Marijuana/Hashish	12.6	16.2	0.99	0.78-1.25	16.6	1.11	0.80-1.54	17.0	0.74	0.50-1.11		
Hispanic												
<u>Early grade (<grade 9) at first use</u>												
Alcohol	43.3	44.1	0.93	0.80-1.07	45.9	1.06	0.87-1.29	41.9	1.16	0.82-1.64		
Drunk	20.8	20.0	0.90	0.79-1.03	21.1	1.11	0.94-1.31	16.2	1.15	0.76-1.73		
Marijuana/Hashish	18.7	18.1	0.92	0.72-1.17	22.1	1.17	0.91-1.50	15.6	0.89	0.45-1.77		

Note. Weight status groups are defined using % Body Mass Index categories as follows: Healthy (5th-84th percentile), Overweight (85th-94th percentile), Obese (95th-98th percentile), and Severely Obese (99th percentile).

* $p < .05$.

** $p < .01$.

*** $p < .001$.