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BMI and Rates of Suicide in the United States: An Ecological Analysis

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BMI has been inversely associated with risk of completed suicide in several cohort studies, but putative mechanisms for this association and its generalizability throughout the United States are uncertain. We ascertained recent population-based, state-level data on rates of obesity, completed suicide (by method), firearm ownership, smoking, major depression, income, education, white race, and nonmetropolitan residence, compiled from federal agencies and surveys, and determined the adjusted population-weighted correlations of statewide obesity rates with measures of completed and attempted suicide. Statewide prevalence of obesity was strongly inversely correlated with age-adjusted suicide rate (multivariable-adjusted $r = -0.66$; $P < 0.001$). The correlation was somewhat stronger for rates of nonfirearm-related ($r = -0.75$; $P < 0.001$) than firearm-related suicides ($r = -0.53$; $P < 0.001$), and was of similar magnitude as the positive correlations of firearm prevalence with suicide rate ($r = 0.75$; $P < 0.001$) or of obesity with prevalence of diabetes ($r = 0.41$; $P = 0.006$). In analyses of fatal and nonfatal suicidal acts, obesity rates were inversely correlated with rates of suicidal acts using firearms ($r = -0.53$; $P = 0.02$) and suffocation ($r = -0.76$; $P < 0.001$) but not other methods. Obesity rates were also inversely correlated with the case–fatality ratios of acts using poisoning ($r = -0.51$; $P = 0.01$). Thus, statewide rates of obesity are strongly inversely correlated with rates of completed suicide in multivariable analyses, a finding that appears to relate to fewer attempts by suffocation and a lower case–fatality ratio for poisonings, although the mechanism for the inverse correlation with firearm-related suicides requires further elucidation.

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INTRODUCTION

Suicide is a public health problem of enormous consequence, accounting for over 32,600 deaths in 2005 and representing the 11th leading cause of death in the United States (1). Although several risk factors for completed suicide are established, suicide rates have declined only slightly in recent decades (2), underscoring the need to identify new, potentially remediable suicide risk factors.

The epidemic of obesity in the United States has spurred increasing interest in its relationship with mental health disorders. If obesity is positively associated with depression and anxiety symptoms, as is commonly found (3,4), it might be hypothesized that overweight and obese individuals would have a higher risk of suicide. Surprisingly, a large series of prospective studies have now found the opposite (5–12), with relatively consistent lower risks of completed suicide with greater BMI. However, the possibility of confounding of BMI at the individual-level, particularly by changes in weight related to depression, has not been fully resolved. To date, only one nationally representative study had addressed this association (12), leaving its generalizability to the broader population of US adults uncertain. Further, no previous study has examined BMI, suicide attempts, completed suicides, and method-specific case–fatality ratios simultaneously, an approach that allows us to explore possible mechanisms empirically.

To determine the association of BMI with risk of completed suicide across the United States, we conducted an ecological analysis of statewide rates of obesity, suicide attempts, and cause-specific completed suicides, based upon representative surveys conducted throughout the United States in recent years. Because statewide rates of obesity are not subject to the same confounding factors as individual BMI, these analyses offer the opportunity to re-examine the BMI–suicide relationship with a complementary approach.

METHODS AND PROCEDURES

We compiled state-level information on risk factors and rates of attempted and completed suicides from a variety of contemporaneous sources. In virtually all cases, the rank ordering of states for these factors is nearly identical year-to-year during the time period under study.

Suicide mortality data for each state were obtained through the Centers for Disease Control and Prevention's Web-based Injury Statistics Query and Reporting System (13). Suicide data were further grouped by firearm (ICD-10 E-codes X72–X74) and nonfirearm methods (E-codes X60–X71, X75–X84, Y87.0, and U03). Reported mortality data were aggregated during the 2-year period of 2004–2005.

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Hospital admissions for deliberate self-harm were used to calculate rates of deliberate self-harm and method-specific case–fatality ratios. These data were obtained from the Healthcare Cost and Utilization Project (HCUP), which is maintained by the Agency for Healthcare Research and Quality (14). HCUP data are derived from hospital discharge summaries and abstracts. In total, 26 states provided data to HCUP in 2004 and 2005. The HCUP State Inpatient Database contains all of the community hospital inpatient discharge records from each participating state. Deliberate self-harm admissions included any hospitalization with a secondary diagnosis of ICD-9 E-codes 950.0–959.9.

The method used in attempted or completed suicide was grouped into four categories: (i) poisoning with solid or liquid substances (E950.0–E950.9; X60–X66, X68, X69); (ii) hanging, strangulation, and suffocation (E953.0; E953.1; E953.8; E953.9; X70); (iii) firearms (E955.0–E955.4; X72–X74); (iv) and other and unspecified means (all other E-codes).

In these analyses, we estimate the number and case–fatality ratio for suicidal acts (i.e., completed and attempted suicides), rather than individuals. The case–fatality ratio for a particular method is defined as the state-specific number of completed suicides with that method divided by the number of completed suicides and hospitalizations (estimated by HCUP) with that method. As a result, the case–fatality ratios calculated here are slight underestimates because the small number of hospitalizations that result in death are double-counted (15).

State-level data on the percentage of individuals living in households with firearms (gun prevalence) were obtained from the 2004 Behavioral Risk Factor Surveillance System (BRFSS) (16). The BRFSS, the world's largest telephone survey (303,822 respondents in 2004), is an ongoing data collection program sponsored by the Centers for Disease Control and Prevention, with all 50 states participating. Data collected are representative at the state and national level after appropriate use of the complex sampling and weighting scheme. BRFSS questionnaires and data are publicly available at www.cdc.gov/brfss. The BRFSS was also used to obtain state-level proportions of respondents with obesity (BMI derived from self-reported height and weight $\geq 30\,kg/m^2$) and current smoking in 2005 and self-reported, physician-diagnosed diabetes in 2004 (other than Hawaii, for which the mean of 2003 and 2005 estimates was used).

State-level measures of alcohol and illicit substance abuse and dependence and serious mental illness were obtained from the 2004–2005 National Survey on Drug Use and Health (17). The survey-weighted hierarchical Bayes methodology used to arrive at state estimates is described in detail elsewhere (18). Serious mental illness is defined among respondents ≥age 18 as having a diagnosable mental, behavioral, or emotional disorder that met the criteria found in the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders and resulted in functional impairment that substantially interfered with or limited one or more major life activities. Rates of alcohol or illicit substance dependence or abuse are based on definitions found in the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders. Estimates of illicit substance abuse and dependence were the percentage of respondents reporting having used any illicit drug other than marijuana in the year before the survey and includes cocaine, crack, heroin, hallucinogens, inhalants, or any prescription-type psychotherapeutic agent used nonmedically. Estimates of alcohol abuse and dependence pertain to the percentage of respondents reporting abuse or dependence in the year before the survey.

State-level data on median income, education, and urbanization derive from Census 2000. These data are publicly available (http://factfinder.census.gov/).

Statistical analysis

Because we have previously found BMI and firearm ownership to be positively associated on an individual basis in the BRFSS (19), all results were adjusted for firearm ownership. As described previously (20), we performed population-weighted Pearson correlations of state-specific rates of obesity, age-adjusted suicide, and related factors, including all 50 states. These analyses estimate the cross-sectional correlation across states of two continuously distributed characteristics—the prevalence of obesity and the age-adjusted rate of suicide—while adjusting for covariates. Population weighting gives greater influence to larger states, where more suicides occur, but we also tested our results without such weighting.

Both obesity and suicide were approximately normally distributed; joint tests of skewness and kurtosis did not reject normality in either case ($P = 0.77$ and $P = 0.10$). Initial models derived partial correlation coefficients with adjustment for firearm prevalence; multivariable models further adjusted for statewide prevalence of white non-Hispanic race/ethnicity, college education, current smoking, and nonmetropolitan area residence, and state-specific median household income and composite depression index score. To examine the magnitude of change in state-specific suicide rates with increments of rates of obesity, we performed linear regression models, using the same variables as in multivariable correlation models, with robust standard errors.

We first examined the associations of obesity with total suicide mortality, then examined its associations with suicide related to firearms and suffocation (methods with generally high case–fatality ratios), and poisonings. Analyses of case–fatality were restricted to the 26 states in the HCUP, although the association of BMI and suicide was similar in these states as in the entire United States. None of the associations of BMI and suicide were significantly changed if the prevalence of normal weight, rather than obesity, was used (observed correlations were in the inverse direction, as expected).

We attempted to provide context for these associations in two ways. First, we examined the correlation of obesity rates with rates of diabetes, a disorder with perhaps the best-known association with obesity. Second, we recalculated the correlation of suicide rate with firearm prevalence, which we have previously demonstrated to be very strongly associated with firearm-related suicide (16,20–24).

All analyses were performed with Stata Intercooled 10.1 (StataCorp, College Station, TX). No external funding was used for these analyses, and all analyses were conducted on publicly available, deidentified data.

RESULTS

The median proportion of adult residents who were obese was 24.4%, ranging from 17.8% in Colorado to 30.9% in Mississippi. As seen in Table 1, states with higher rates of obesity tended to have higher rates of firearm ownership and smoking and lower rates of college education and median household income.

The median age-adjusted suicide rate was 11.7 per 100,000, with extremes of 6.0 in the New York and 23.1 in Alaska. Table 2 shows the correlation of statewide prevalence of obesity with suicide. There was a strong inverse correlation of obesity ($r = -0.59$) with completed suicide rates that was strengthened ($r = -0.66$) by multivariable adjustment. In comparison, the correlation coefficient in these models for firearm prevalence was 0.75 ($P < 0.001$); the only other variable that was statistically significant was the proportion of population that was white non-Hispanic ($r = -0.36$; $P = 0.02$). The correlation coefficient of obesity with diabetes in similar models was 0.41 ($P = 0.006$).

In linear regression models, an increase in the statewide prevalence of obesity of 3% (the standard deviation in obesity rates) was associated with a decrease in the age-adjusted suicide rate of −2.6 per 100,000 (95% confidence interval, −1.5 to −3.7). This corresponds to roughly the difference between the 50th and 75th percentiles of state-specific suicide rates. When states were categorized in quartiles of obesity rates, there was a stepwise decrease in age-adjusted suicide rates across quartiles, with decreases of −0.2 (95% confidence interval, −2.8 to 2.4), −2.3 (95% confidence interval, −5.6 to 1.1), and −3.9 (95% confidence interval, −7.8 to 0.01) in ascending quartiles.

We conducted several sensitivity analyses to test the robustness of our findings. Additional adjustment for alcohol and illicit drug use and use of four mental health measures (rather than the composite depression index) did not greatly alter the correlation of obesity and completed suicide ($r = -0.65$; $P < 0.001$). The association tended to be similar in areas of lower and higher prevalence of firearm ownership, with correlation coefficients in ascending quartiles of firearm ownership of −0.34, −0.86, −0.52, and −0.50 (adjusted for actual firearm prevalence). Without population weighting, the multivariable-adjusted correlation of obesity and completed suicide was similar but numerically higher ($r = -0.68$; $P < 0.001$). The multivariable-adjusted correlation of obesity rate with the square root of state-specific suicide rate (the best fitting model form) was −0.62 ($P < 0.001$).

Table 2 also shows the association of obesity with suicide of various methods. The multivariable-adjusted correlation of obesity with nonfirearm-related suicide ($r = -0.75$; $P < 0.001$) was higher than that with firearm-related suicide. For the latter, multivariable adjustment substantially strengthened the correlation, predominately due to addition of smoking and race/ethnicity as covariates. Among nonfirearm-related methods, obesity appeared to be similarly associated with both poisonings and suffocation.

Table 3 presents the correlation of obesity rates with statewide rates of suicidal acts (i.e., attempted and completed suicides) and statewide case–fatality ratios for specific methods in 26 US states. Obesity rates were not strongly associated with suicidal acts overall. However, they were strongly correlated

Table 1 Pairwise population-weighted Pearson correlation coefficients among 50 US states in prevalence of selected risk factors for suicide

	Obesity	Normal weight	Firearm ownership	White non-Hispanic	Household income	College degree	Current smoking	Depression index	Nonmetro population
Obesity	1.00								
Normal weight	−0.92	1.00							
Firearm ownership	0.68	−0.59	1.00						
White non-Hispanic	0.16	−0.05	0.50	1.00					
Household income	−0.66	0.64	−0.66	−0.16	1.00				
College degree	−0.74	0.71	−0.72	−0.26	0.89	1.00			
Current smoking	0.62	−0.51	0.59	0.51	−0.67	−0.71	1.00		
Depression index	0.09	−0.06	0.43	0.49	−0.35	−0.39	0.35	1.00	
Nonmetropolitan population	0.55	−0.46	0.84	0.56	−0.57	−0.62	0.57	0.38	1.00

Table 2 Partial population-weighted Pearson correlation coefficients among 50 US states between prevalence of obesity and completed suicide

	Total suicide	Firearm-related suicide	Poisoning-related suicide	Suffocation-related suicide	Other methods
Adjusted for firearm ownership	−0.59 ($P < 0.001$)	−0.35 ($P = 0.01$)	−0.68 ($P < 0.001$)	−0.69 ($P < 0.001$)	−0.47 ($P = 0.001$)
Multivariable-adjusted	−0.66 ($P < 0.001$)	−0.53 ($P < 0.001$)	−0.67 ($P < 0.001$)	−0.65 ($P < 0.001$)	−0.51 ($P < 0.001$)

Multivariable model included statewide prevalence of firearm ownership, white non-Hispanic race/ethnicity, college education, current smoking, and nonmetropolitan area residence, and median household income and composite depression index.

Table 3 Partial population-weighted Pearson correlation coefficients among 26 US states between prevalence of obesity and suicidal acts or method-specific case–fatality ratio

	Suicidal acts (completed + attempted)					Case–fatality ratio (completed/total)			
	Total	Firearms	Suffocation	Poisonings	Other methods	Firearms	Suffocation	Poisonings	Other methods
Adjusted for firearm ownership	–0.20 ($P = 0.34$)	–0.33 ($P = 0.12$)	–0.79 ($P < 0.001$)	–0.13 ($P = 0.54$)	–0.18 ($P = 0.38$)	–0.35 ($P = 0.08$)	0.08 ($P = 0.67$)	–0.51 ($P = 0.01$)	–0.10 ($P = 0.64$)
Multivariable-adjusted	–0.14 ($P = 0.58$)	–0.53 ($P = 0.02$)	–0.76 ($P < 0.001$)	–0.08 ($P = 0.75$)	–0.01 ($P = 0.98$)	–0.43 ($P = 0.07$)	–0.19 ($P = 0.44$)	–0.56 ($P = 0.01$)	–0.26 ($P = 0.29$)

Suicidal acts represent the sum of fatal suicidal acts reported on death certificate and suicide attempts admitted to medical hospitals. Multivariable models included statewide prevalence of firearm ownership, white non-Hispanic race/ethnicity, college education, current smoking, and nonmetropolitan area residence, and median household income and composite depression index.

with lower rates of acts using firearms and suffocation/hanging, two highly lethal methods, and almost completely uncorrelated with rates of acts using poisonings and other methods, which tend to be least lethal. In addition, obesity rates were correlated with lower state-specific case–fatality ratio for poisonings but not for other methods.

DISCUSSION

In this study of statewide rates of obesity and suicide, higher rates of obesity were strongly correlated with lower rates of completed suicide. There were lower rates of firearm-related and nonfirearm-related suicides, related to fewer firearm and suffocation-related acts and a lower case–fatality ratio for poisonings.

An emerging body of literature supports an inverse relationship of BMI with risk of suicide death. In Paffenbarger and Asnes' original study of male college students, the ponderal index (height divided by the cube root of weight—a marker of leanness) was significantly higher among men who later committed suicide than among controls (5). Subsequent studies in recent years have also found an inverse relationship of BMI and risk of suicide, particularly among Scandinavian populations (6–8,10) (who have among the highest rates of suicide worldwide); other, generally smaller studies have also suggested an inverse relationship (9,11,12). An ecological study in the Caribbean Islands was null, but did not account for firearm availability (25). In the Norwegian HUNT Study, BMI was inversely associated with risk of suicide despite a generally positive association with depression (7).

Our results extend these previous findings in several potentially important ways. First, studies of BMI and health outcomes are prone to individual-level confounding (26) by health conditions and behaviors (like smoking (27)) that lead to both lower weight and higher risk of completed suicide. Depression has been hypothesized to be one such confounder, although it is possible that adiposity itself influences mood, implicating depression as a potential intermediate rather than a confounder alone. Regardless, statewide levels of obesity are highly unlikely to be influenced by weight loss related to medical conditions such as depression, a supposition supported by the weak correlation of obesity and depression at the state level. As a result, our results strongly imply that the lower risk of completed suicide associated with heavier BMI is not merely the result of confounding by such factors.

Second, ours is the first study to our knowledge to relate obesity to method-specific rates of suicide attempts, completed suicides, and case–fatality ratio. Our results preliminarily implicate specific mechanisms that may play a role in the observed BMI–suicide association, although these will require confirmation in prospective studies. For example, obesity rates were associated with lower case–fatality ratios from poisoning, a result that, while intuitive, has not been previously established. Also, obesity rates were associated with lower rates of acts by suffocation (which primarily includes hanging), a method that tends to have a high case–fatality ratio (28,29). Although the rationale for this lower rate is necessarily speculative, the steps involved in hanging may be burdensome, uncomfortable, or otherwise aversive for heavier individuals. The correlation of obesity rates with lower rates of completed suicides and suicidal acts using firearms requires further investigation. However, firearm suicides often appear impulsive (30,31), and hence this observation is consistent with the hypothesis that high circulating insulin levels influence tryptophan metabolism and reduce impulsivity (6,32,33).

Third, our results provide the most current and generalizable information available to date about BMI and suicide in the US population. Because of the relative rarity of suicide in cohort studies, they necessarily require very large, typically unrepresentative samples followed for long periods of time to accrue sufficient numbers of completed suicides. As a result, even recent studies of this topic rely upon measurements of BMI collected one to two decades in the past, and do not necessarily reflect the current experience of the broader US population. Our findings, synthesized within the last few years from high-quality, nationally representative surveys administered by highly experienced federal agencies, extend the results of cohort studies to a larger and more contemporaneous audience.

Even if the relationship observed in this study were causal, the risks of obesity far outweigh any potential benefit on suicide prevention. Indeed, using this same approach, we clearly identified the expected strong correlation between rates of obesity and diabetes. However, the magnitude of correlation with obesity was nearly identical for diabetes and completed suicide, despite the far greater body of evidence linking adiposity with diabetes. Given this, we urge that more attention and resources be devoted to the mechanisms by which obesity may influence suicide risk, given how strongly these factors relate.

Our analyses have strengths but also limitations. All ecological studies are limited by an inability to infer that the observed relationships apply to individuals, rather than to the groups (in this case, the states) under study. That is, the BMI of individuals who commit suicide may not, in fact, differ across states regardless of overall state rates of obesity. However, our previous findings from cohort studies provide substantial reassurance that BMI and suicide are indeed linked at both the individual and state levels. We were also limited to 50 units of observation (i.e., states) for analyses of completed suicide and to 26 states for analyses that included attempted suicide, restricting the power of our analyses, and to rates of obesity and suicide measured at a single cross-section in time. Further studies that evaluate changes in obesity and suicide rates longitudinally may provide additional insight into these issues (24); on a national level, the 1990s saw increases in obesity rates but declines in suicide rates that support our findings (2).

In conclusion, states with higher rates of obesity tend to have lower adjusted rates of completed suicide, with a magnitude of correlation similar to other well-established correlates of obesity and suicide. Obesity rates also tend to be associated specifically with lower rates of suicidal acts using firearms and suffocation, two of the methods most likely to prove fatal, and with a lower case–fatality ratio for poisonings. Given the strength of the observed relationships, further research to identify its mechanisms could lead to important insights into prevention of this important cause of death.

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DISCLOSURE

The authors declared no conflict of interest.

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