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SUBSTANCE USE AND SUICIDAL BEHAVIORS AMONG YOUNG ADULTS

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ABSTRACT

The purpose of this paper is to examine the causal impact of alcohol and illicit drug use on suicidal behaviors among college students. Every year, more American youth die from suicide than from all leading natural causes of death combined. Substance use has been identified as a leading risk factor in suicidal behaviors. We use instrumental variables to estimate a structural model of suicidal thoughts and attempts. A reduced form equation is also estimated which directly relates the determinants of alcohol and drug use to suicidal behaviors. Data come from the Core Institute's Alcohol and Drug Surveys of College Students. The results are consistent with a causal mechanism from alcohol and illicit drug consumption to suicide thoughts and attempts.

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A.   INTRODUCTION

Every year, more American youth die from suicide than from all leading natural causes of death combined. In 1997, 13 percent of deaths in the 15-24 year old age group were the result of suicide, making suicide the third largest cause of death among youth behind accidents and homicides (Hoyert et al. 1999). In the 1999 Youth Risk Behavior Survey, a national survey of high-school students, 9 percent of respondents reported a suicide attempt, and 18 percent reported having seriously considered suicide in the past year. Community surveys indicate that between 12 and 25 percent of school-age youth engage in suicide ideation, ranging from nonspecific thoughts about suicide to suicide planning with intent to die (Brent 1989). Suicide ideation is a leading risk factor in completed suicide; moreover, clinicians believe that suicide ideation is psychologically harmful in and of itself.

The current prevalence of suicide among youth reflects long-term growth in this outcome. Between 1950 and 1990, the suicide rate among 15-24 year olds in the United States tripled. For this reason, many schools, communities, and states have made youth suicide prevention a top public health priority. Most efforts at the school and community level focus on identifying suicidal youth and targeting known risk factors for suicidal behaviors. School and community-based suicide prevention efforts are implemented in a variety of ways, such as through gatekeeper systems (e.g., systems directed by teachers, clergy or community leaders), peer support groups, suicide education, and formal screening programs. Because there is a dearth of evaluation literature in this area, however, no credible evidence exists to suggest that any of these programs are effective in reducing suicidal behaviors (O'Carroll et al. 1992).

Similarly, there is no evidence that state-level policies intended specifically to prevent suicide among youth are effective. In a survey of youth suicide prevention efforts, Metha et al.

(1998) report that nearly all 50 states have developed, and distributed widely, educational materials intended to prevent suicide. Many states also report sponsoring research on adolescent suicide and creating task forces to address youth suicide. Other states have plans for suicide prevention, or state-sponsored screening programs to identify suicidal youth. However, Metha et al. show that these state policies are uncorrelated with state-level suicide rates.

The absence of known effective policies to reduce suicidal behaviors and the seriousness and high prevalence of these behaviors necessitate additional research so that public policies can begin to effectively address the problem. Previous research has identified several risk factors that are associated with suicidal behaviors and one of the most important of these factors is substance use and abuse. There is a strong, empirical link between substance use and suicide ideation (suicidal thoughts or plans), suicide attempts, and completed suicide among youth (Crumley 1990). What remains unknown, however, is whether or not substance use has a causal effect on young people's risk of attempting suicide, completing suicide, or engaging in suicide ideation. Previous research has not established a causal relationship between substance use and suicidal behaviors because it has either failed to consider the potentially confounding effect of other causes of suicidal behaviors (e.g., depression), or because it has failed to recognize that causality may in fact run from suicide ideation to substance use and abuse.

If substance use is a causal determinant of suicidal behaviors, then policies designed to reduce the consumption of alcohol and illicit drugs may succeed in reducing suicidal behaviors as well. There is considerable evidence from the health economics literature that policy makers can influence substance use among young people through alcohol and illicit drug policies such as higher taxes and restrictions on availability (Leung and Phelps 1993; Grossman et al 1998; Pacula 1998; Saffer and Chaloupka 1999; Dee 1999). Researchers also have demonstrated that

these policies, through their impact on youthful substance use, lead indirectly to higher educational attainment, reductions in violence, and reductions in deaths from motor vehicle accidents (Cook and Moore 1993; Markowitz 2001; Wagenaar 1993).

In this paper, we examine the causal role of alcohol and drug consumption in determining suicidal thoughts and attempts by young adults. A structural model is examined to provide evidence for or against a causal relationship between substance use and these suicidal behaviors. A reduced form equation is also estimated which directly relates the determinants of consumption to suicidal behaviors. Data come from the Core Institute's Alcohol and Drug Surveys of College Students (Core). It is particularly important to study college students because even though suicide rates are higher among college-age youth compared to high-school age youth, almost all suicide prevention efforts have been targeted at high-school age youth (O'Carroll et al. 1992).

We find that substance use is strongly associated with suicide ideation and suicide attempts among college students. This relationship is consistent with a causal explanation in several cases. For example, drinking, as measured by the number of alcohol beverages consumed in a week and by binge drinking, increases the likelihood of suicide ideation even after controlling for unobserved heterogenity. Evidence for a causal relationship is less robust, but still suggestive, when suicide attempts and illicit drugs are considered. The reduced form models suggest that higher beer prices reduce suicide ideation, with the implication that substance use policies such as higher beer taxes may be useful in reducing suicide ideation among college students.

B.	SUBSTANCE USE, PSYCHIATRIC DISORDERS AND SUICIDAL BEHAVIORS

Suicidal behaviors are thought to be caused by multiple psychiatric, biological, familial, and situational factors. These factors may operate through distal, or indirect, channels, as well as proximally, or directly. Substance use and abuse are considered to be both distal and proximal causal factors for suicidal behaviors. Substance use disorders, like many other psychiatric conditions, often lead to a deteriorating life course, including social isolation, depressed mood, low self-esteem, loss of opportunities at school and work, and estrangement from family and friends (Deykin and Buka 1994; Workman and Beer 1990). In this sense, substance use disorders act as a distal causal factor, building a foundation of stresses and adverse events that may lead to suicidal behaviors (Moscicki 1995). At the same time, substance use also can be a proximal causal factor for suicidal behaviors. Substance use tends to increase impulsivity and decrease inhibitions, making one more likely to act on suicidal tendencies. Additionally, substance use can lead to personal crises, such as expulsion from school or a relationship conflict, which could precipitate suicidal behaviors (Deykin and Buka 1994).

Numerous researchers have assessed the empirical relationship between substance use and suicidal behaviors among young people. In samples of high-risk youth, there is a strong correlation between clinically defined substance dependence and abuse and suicidal behaviors. For example, Deykin and Buka (1994) find that among 300 chemically dependent youth (ages 15-19), 31 percent of males and 75 percent of females reported suicide ideation, and 28 percent of males and 61 percent of females reported a suicide attempt. Retrospective studies of completed adolescent suicides demonstrate that 12 to 44 percent of females and 27 to 42 percent of males met diagnostic criteria for a substance use disorder before their deaths (Marttunen et al. 1991; Shaffer et al. 1996). Substance use also is associated with suicidal behaviors in non-

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clinical samples of youth. Workman & Beer (1990) report that alcohol problems are positively correlated with suicide ideation in a sample of high school students (N=126). Wagner et al. (1996) find that in a sample of 1,050 secondary school students (ages 12-21), alcohol and illicit drug use concurrent with some substance related impairment (e.g. problems at school due to substance use) is a strong predictor of having attempted suicide. Felts et al. (1992), using a sample of 3,064 high school students, find that substance use is associated with suicide ideation and attempts.

Despite this strong correlation in both clinical and general population samples, researchers have not established that substance use and abuse have a *causal* effect on adolescents' risk of attempting suicide, completing suicide, or engaging in suicide ideation (Crumley 1990). Substance use and abuse often are correlated with other, sometimes hard to measure, causal factors for suicidal behaviors, making it difficult to establish causation. In particular, many researchers report that in addition to substance use disorders, other psychiatric conditions have been linked to suicidal behaviors among youth. Deykin and Buka (1994), Shaffer et al. (1996), Runeson (1990), Crumley (1990) and many others find that depressive disorders are one of the most common psychiatric comorbidities associated with suicidal behaviors. In a study of teenagers who completed suicide, approximately 61 percent appeared to have experienced a clinically significant mood disorder at the time of death, and approximately 35 percent appeared to have had a substance use disorder (Shaffer 2000). Suicidal youth also have been found to suffer from conduct problems, anxiety disorders, borderline personality disorder, and, in rare cases, schizophrenia (Crumley 1990; Runeson 1990; Deykin and Buka 1994; Shaffer et al. 1996). Many of these psychiatric conditions are correlated with substance use and therefore may confound empirical estimates of the causal effect of substance use on

suicidal behaviors.

Some research has addressed this problem and found that even after controlling for other psychiatric disorders, substance use remains a strong, independent predictor of suicidal behaviors. Wagner et al. (1996), for example, note that while co-morbid depression and conduct problems increase the probability that a substance abusing youngster attempts suicide, substance abuse also independently increases the probability of attempting suicide. Cutler et al. (2001) find that among adolescent respondents in the National Longitudinal Study of Adolescent Health, substance use is a statistically significant predictor of suicide attempts, after controlling for depression. Similarly, using data on adolescents and adults from the National Comorbidity Survey, Borges et al. (2000) report that alcohol and illicit drug use are statistically significant predictors of suicide attempts, even after controlling for comorbid psychiatric conditions. Despite controlling for psychiatric comorbidities, the estimates provided by these studies may be still be confounded by other unobservable factors that affect both substance use and suicidal behaviors. In addition, these papers do not directly address the issue of causality, which hinders the design of effective prevention programs that target high-risk youth.

Other literature, however, has provided indirect evidence that state-level substance use policies are related to completed suicides among youth. Two recent studies based on state-level data suggest that a higher minimum legal drinking age (MLDA), through its impact on teenage alcohol use, reduces the number of completed suicides among young people. Jones et al. (1992) find that the suicide rate among 15-24 year olds is 9.7 percent greater among youth living in states where they can drink legally compared to youth of the same age who live in states where they cannot drink legally. Similarly, Birkmayer & Hemenway (1999) find that the suicide rate among 18-20 year olds is 8 percent higher in states with a minimum legal drinking age (MLDA)

of 18 years old compared to youth living in states with a MLDA of 21 years old.

One limitation of these studies is that they only estimate the reduced form model, which links state-level policies directly to state-level suicide rates; this method does not directly address the question of causality. Furthermore, although these two studies provide interesting evidence about the potential role of state-level substance use policies in suicide prevention, this information is less relevant today because the MLDA is now uniformly 21 years old in all states. The relationship between other substance use control policies and suicidal behaviors has not been investigated. For example, there is no information on how changes in the price of beer can be used as a tool to prevent suicidal behaviors among youth, even though alcohol taxes are the most widely-used alcohol control policy.[1] Moreover, there is no research available on the impact of any substance use policy on suicide attempts and suicide ideation, two risky behaviors which often precede completed suicide.

C.   EMPIRICAL MODEL AND METHODS

Our empirical model of suicidal behaviors is based on those found in existing literature. In general, suicidal behaviors (SB_i) are a function of alcohol and/or illicit drug use (A_i), observable characteristics that affect suicidal behaviors such as age, gender, and race (X_i), and unobservable characteristics that affect suicidal behaviors such as personality traits or mental disorders (u_i). The subscript i refers to individuals, and ε_i represents a random disturbance term:

1) $SB_i = \alpha_0 + \alpha_1 A_i + \alpha_2 X_i + \alpha_3 u_i + \varepsilon_i.$

Following standard economic theory, a youth's demand function for alcohol or illicit drugs can be written as follows:

2) $A_i = \beta_0 + \beta_1 P_j + \beta_2 SB_i + \beta_3 Y_i + \beta_4 u_i + \omega_i,$

where P_j represents the full price of illicit drugs or alcohol in location j, and the vector Y_i

represents observed, individual characteristics that determine alcohol or illicit drug use.

These characteristics may be the same as the determinants of suicidal behaviors, which are

represented by the vector X_i. Similarly, the vector u_i represents unobserved individual

characteristics some of which may determine both substance use and suicidal behaviors,

and ω_i is a random disturbance term.

Suicidal behaviors (SB_i) are included in the demand equation to account for the

possibility that alcohol and illicit drug use may be a consequence of, as well as a precedent

to, suicidal behaviors. About half of youths who commit suicide are intoxicated at the time

of death (Moscicki 1995). This evidence suggests that while substance use may cause

suicidal behaviors, suicidal behaviors also may be a motive for alcohol and drug

consumption. A person who wants to commit suicide may drink alcohol or use drugs to

facilitate suicide. In this case, the suicidal impulse has caused the person to use

substances.

Estimation Issues

If there are common unmeasured characteristics (u_i) that determine both suicidal

behaviors and substance use ($\alpha_3 \neq 0$ and $\beta_4 \neq 0$ in Equations 1 and 2), then the coefficient on

substance use in the suicidal behaviors equation will be correlated with the error term. For

example, suppose depression is the only underlying cause of both substance use disorders

and suicidal behaviors. If a measure of depression is not included as an independent

variable, estimates of Equation 1 will produce biased and inconsistent estimates of the

effects of substance use on suicidal behaviors.

The second potential source of endogeneity stems from suicidal behaviors being a determinant of substance use ($\beta_2 \neq 0$ in Equation 2). All previous studies on suicidal behaviors have ignored the possibility that substance use is endogenous in the suicidal behaviors equation. In this case, substance use would be correlated with the error term in the suicidal behaviors equation (Equation 1) because all of the exogenous variables that determine suicidal behaviors (including the error term) also determine substance use. This can be seen by substituting Equation 1 into Equation 2.

We begin to address these problems by first treating substance use as exogenous and by obtaining two OLS estimates of the effect of substance use on suicidal behaviors. The first estimate is obtained from a model that includes a limited set of covariates, and the second estimate is obtained from a model that includes an extensive set of individual characteristics. The addition of a rich set of explanatory variables allows us to gauge the sensitivity of the estimated effect of substance use to the inclusion of several variables thought to be significant confounders of the relationship between substance use and suicide behaviors.

We then use two-stage least squares (TSLS) to estimate Equation 1. Variables measuring the price of beer and the choice of college residence serve as instruments for substance use.[2] We believe these variables are valid instruments because there is little reason to believe that they are predictors of suicidal behaviors, holding consumption constant.

Assuming that the exclusion restrictions are valid, the success of the TSLS procedure depends on how well the identifying instruments predict alcohol and illicit drug use in the first stage (Bound et al. 1995). This issue has been the subject of a significant amount of recent research concerned with estimating the effects of substance use taxes, prices, and control policies

on the demand for substances. The findings from this research support our use of beer prices as instruments (Leung and Phelps 1993; Grossman et al. 1998; Pacula 1998).

We also use living arrangements of respondents as instruments; specifically, we use variables indicating whether or not the student lives in on-campus housing but not in a fraternity or sorority, in a fraternity/sorority, or in on-campus housing but type of residence unknown. The omitted category is off-campus housing. Campus residence is hypothesized to predict alcohol and drug consumption, but not suicidal behaviors. The rationale for using these variables is that choice of residence may affect substance use, because in a college atmosphere, where fraternities and sororities are centers for social activity and have relatively frequent parties, on-campus residents may have easier access to drugs and alcohol relative to those who live off-campus. Peer influences may also differ according to living arrangement. However, it is possible that the living arrangement is not a valid instrument. There may be some unmeasured factor that governs the suicidal impulses and choice of living arrangements.

In sum, the efficacy of the TSLS procedure we implement depends on two conditions: the strength of the empirical relationship between the instruments and substance use, and the validity of the exclusion restriction related to campus living arrangement. Below we report on tests that address these points.

D.   DATA

The data come from the University of Southern Illinois's Core Institute (a center for alcohol and drug studies) which conducts annual surveys of college students that focus on drinking, drug use, and outcomes associated with drinking and drug use. The survey used in this paper was administered to approximately 30,000 students in 1991 at private and public colleges

across the United States. Because we are interested in substance use and suicidal behaviors among young adults, we limit the analysis to survey respondents between the ages of 17 and 24.

Two variables measuring suicidal behaviors are constructed from questions relating to outcomes of alcohol or drug use. Specifically, respondents are asked how often in the past year had they "seriously thought about suicide" due to alcohol or illicit drug use. A similar question asks how often in the past year the respondent "seriously tried to commit suicide" due to alcohol or illicit drug use. In our analysis, we use dichotomous indicators of whether or not the respondent thought about suicide and whether or not the respondent tried to commit suicide. Because the incidence of suicidal thoughts and attempts is fairly low, results using the number of times the respondent thought about or attempted suicide are very similar to those shown below using the dichotomous indicators. Table 1 presents rates of suicide ideation and attempts among Core respondents.

Substance use is measured with five different variables. The first is the average number of drinks the respondent consumes in a week. The second is a measure of heavy alcohol use and is an indicator for whether or not the respondent had five or more drinks in a sitting in the past two weeks (termed binge drinking). The third is an indicator for whether or not the respondent used marijuana in the past year. The fourth is an indicator for whether or not the respondent used any drugs other than marijuana in the past year. The list of other such drugs includes cocaine, opiates, amphetamines, sedatives, hallucinogens, inhalants, ecstasy, and steroids. Lastly, an indicator for any illicit drug use (marijuana or any other illicit drug) is used. Most multi-drug users report using marijuana along with the other drugs, and only 3 percent of respondents report using drugs other than marijuana, but not marijuana. Means of the substance use variables are presented in Table 1.

The socioeconomic and demographic information on respondents in the Core survey includes the respondent's gender, age, class (freshman, sophomore, junior, senior, graduate, and non-matriculated), grade point average, race, marital status, employment status, and parental history of alcohol and drug problems. These variables, along with three indicators of the region of the country in which the college is located, are included in all models. Means are presented in Table 1. While these variables represent a wide variety of personal characteristics, they do not account for the presence of psychiatric disorders which are important correlates of both substance use and suicidal impulses. Since the Core data do not contain any measures of psychiatric disorders, all models include the number of days in the past year on which the respondent used tobacco. Many studies have shown that smoking is a strong correlate of psychiatric disorder, but tobacco use is not expected to have a direct impact on suicidal behaviors (Brown et al. 2000, Breslau et al. 1998, Choi et al. 1997). Thus, this variable may be a good proxy for psychiatric disorders, as well as other personality traits correlated with both suicide behavior and substance use.[3] Note that the omission of psychiatric disorders will not bias the substance use coefficients in the TSLS models so long as these disorders are not correlated with the instruments.

The price of alcohol is measured by the real price of beer in 1982-84 dollars in the state in which the college is located. We use the price of beer instead of the liquor or wine price because beer is the most heavily consumed alcoholic beverage, and because beer is the beverage of choice among college students. The money price of beer is taken from the Inter-City Cost of Living Index, published quarterly by the American Chamber of Commerce Researchers Association (ACCRA various years) for between 250 and 300 cities. The specific beer price collected by ACCRA is the price of a six-pack (six-12 ounce cans) of Budweiser or Miller Light.

In addition to obtaining information on the prices of a variety of consumer goods, the ACCRA constructs a city-specific cost of living for each city with an average for all cities in a given quarter and year equal to one.

The Core Survey used in this paper was conducted during the fall semester of 1991. Since the suicide questions pertain to the previous year, the beer price matched to the survey data is a four-quarter average of the prices in the first two quarters of 1991 and the last two quarters of 1990. Before averaging, each quarterly ACCRA beer price is converted to a real price by dividing it by a quarter- and city-specific cost of living index. This index is the ACCRA city-specific cost of living index multiplied by the quarterly Bureau of Labor Statistics' CPI for the U.S. as a whole (1982-84 = 1). Quarterly state prices are then computed as population weighted averages of city prices, and annual prices are obtained by averaging these prices over the four relevant quarters.

It is worth mentioning that the real price of beer is likely measured with error because the price data pertain to the state in which the respondent attends college rather than to the city in which the college is located. In addition, the cost of living index reflects expenditure patterns of middle-income households. These patterns may differ from those of college students.

E.   RESULTS

Table 2 shows rates of the suicidal behaviors by substance use status. In all cases, respondents who drink or use drugs are much more likely to have suicidal tendencies than those who do not use substances. For example, Table 2 shows that 8.15 percent of college students who report binge drinking thought about committing suicide and 2.34 percent report attempting suicide. The corresponding rates for those who do not binge drink are 3.05 percent and 0.87 percent, respectively. Similar comparisons hold for students who drink any positive quantities,

who use marijuana and who use other illicit drugs. It is important to note that these results establish a correlation between substance use and suicidal behaviors, but do not address the issue of causality.

Table 3 shows the impact of drinking, as measured by the average number of drinks consumed in a week, on suicidal thoughts and suicide attempts in a multivariate analysis. OLS estimates are listed in columns (1), (2), (4) and (5), and TSLS estimates are shown in columns (3) and (6). In all cases, standard errors are calculated taking account of the correlation among individuals living in the same state (Huber 1967). As previously noted, we estimate two models by OLS. The first excludes three important correlates of suicidal behaviors and substance use: maternal history of alcohol/drug problems, paternal history of alcohol/drug problems and the number of days in the past year on which the respondent used tobacco. A comparison of the results from models with and without these three variables included indicates how much influence these family and individual factors have on the substance use coefficients. If the substance use coefficient changes only slightly when these three additional variables are included in the model and if these three variables are strong predictors of suicidal behaviors, it may be reasonable to conclude that there is relatively little unobserved heterogeneity left in the error term. On the other hand, if the substance use coefficient changes dramatically after the inclusion of these variables, this finding suggests that the error term contained important characteristics that could be accounted for by measures of family history of substance abuse and mental illness. In the end, however, using this informal test, we cannot conclude definitively whether or not a significant amount of heterogeneity remains in the error term.

The OLS estimates in Columns 1 and 4 confirm the results from Table 2 and show that drinking is positively related to suicidal behaviors. When the model is extended to include

parental substance use and the respondent's tobacco use, the estimated effects of drinking fall by a third for suicidal thoughts, but do not change when attempts are considered. Columns 3 and 6 show the TSLS estimates. Both estimates are positive and of comparable magnitude to the OLS estimates, although only the estimate associated with suicidal thoughts is statistically significant.

At the bottom of Table 3, we report the results of tests related to the efficacy of the TSLS procedure. The partial F-statistic associated with the excluded instruments is 16.95 and highly significant.[4] An F-statistic of this magnitude provides evidence that the correlation between our instruments and drinking is sufficiently strong. Overidentification tests indicate that our exclusion restrictions are valid. We also implemented a second, less formal test, to check the validity of the exclusion restrictions related to living arrangements, since the theoretical argument for excluding these variables is not as strong as the argument for the beer price. To implement this informal test, we obtained OLS estimates from a model that includes the living arrangement variables. Holding substance use constant, an F-test indicated that these variables have no effect on suicidal behaviors.[5]

We note that the standard errors of the TSLS estimates are relatively large—approximately 4 times the size of the OLS standard errors—and that this imprecision warrants a cautious interpretation of our results. For example, the Hausman test cannot reject the consistency of OLS even though the TSLS estimate of the effect of drinking on suicidal thoughts is 50 percent larger than the OLS estimate. However, given the large value of the partial F-statistic, and the valid overidentification test, we believe that the TSLS procedure is valid. More importantly, the positive sign on the OLS and TSLS estimates suggest that drinking has a positive causal effect on suicidal behaviors. There is no evidence that once the potential

endogeneity of drinking is accounted for, the positive relationship between drinking and suicide thoughts and suicide attempts is diminished.

The results of binge drinking, marijuana use, other drug use and any drug use are shown in the different panels of Tables 4. The five substance use measures are included separately in each model because of collinearity, particularly in the TSLS models, arising from the fact that the substance use measures are highly correlated and are predicted with the same set of variables. In Table 4, only the coefficients on the substance use measures and the related test statistics are displayed. The results of the individual characteristics do not change across the models and therefore are omitted from Table 4 for brevity. Panel A of Table 4 includes the indicator for binge drinking; Panel B includes the indicator for marijuana use; Panel C includes the indicator for other drug use; and Panel D includes the indicator for any drug use.

As with drinking, the OLS models all show that binge drinking and drug use are positively related to suicide thoughts and suicide attempts. Moreover, TSLS estimates of the effect of these substances on suicidal behaviors are positive and have roughly similar magnitudes as the OLS estimates, although many of the TSLS estimates in Table 4 are not statistically significant. In addition, the partial F-statistics on the excluded instruments are relatively large; 30.93 for binge drinking, 13.2 for marijuana use, 7.34 for other drug use, and 12.01 for any drug use. The overidentification tests support the validity of the exclusion restrictions.

Still, we are concerned about the imprecision of the estimates. Ideally, the efficacy of the TSLS procedures would be such that we could confidently interpret the insignificant estimates as indicative of the absence of a true effect. However, this ideal is rarely achieved in practice. The magnitude of the estimates, and the similarity of the TSLS estimates to the OLS estimates, suggest that there is a true causal effect. In addition, although we know that the problem of weak

instruments tends to bias TSLS estimates toward the OLS estimates, conventional tests to detect this problem suggest that our instruments are reasonably strong, and that this is not the explanation. Finally, the consistency of the results across substances and outcomes is theoretically justified and provides additional evidence to support the conclusion that substance use is a causal determinant of suicidal behaviors.

Individual Characteristics

Many of the student characteristics are also important determinants of suicidal behaviors. The impacts of these characteristics do not vary with the substance that is included in the model or the type of estimation technique used. There is a difference, however, in a few of the characteristics that predict suicidal thoughts versus suicide attempts. Being older and having a higher grade point average both reduce the probability of suicidal thoughts and attempts, while being female increases these probabilities. Being black or Hispanic generally has no impact on suicidal behaviors, although being of another race increases the probabilities of these behaviors. Class levels generally have no impact on suicidal behaviors. Note, however, that the impact of class level may be subsumed by age. Part time students are more likely to engage in both suicidal behaviors. Being married lowers the probability of suicidal thoughts while being divorced increases both thoughts and attempts. Employment status has no impact on either behavior. Having parents who have problems with alcohol or illicit drugs will increase suicidal thoughts and attempts. Lastly, tobacco use is positively associated with suicide thoughts and attempts. Recall that it is not expected that tobacco use has a direct impact on suicidal behaviors; rather, it is included to proxy for psychiatric disorders, as well as other personality traits correlated with both suicidal behaviors and substance use.

Reduced Form Models

Table 5 present results from the reduced form models, which show the direct impact of the beer price and living arrangement variables on suicidal behaviors. The reduced form is derived by substituting equation 2 into equation 1. These models are presented with and without the three dummies for the region of the country in which the respondent lives because as the results show, the coefficients on the beer price are highly sensitive to the inclusion or exclusion of these regional dummies.

The coefficient on the beer price in Table 5 is always negative, but is only statistically significant when the regional dummies are excluded in column 2. In addition, the coefficients on the campus living arrangements are all positive, but are not statistically significant at conventional levels. Even though the impact of higher beer prices and campus living arrangements are measured imprecisely, the signs are consistent with a causal explanation of alcohol and drug use on suicidal behaviors. As discussed previously, there is no reason to believe that higher prices or living arrangements have a direct impact on suicidal behaviors, rather these variables work through the consumption of drugs and alcohol. The negative beer price coefficient is consistent with the notion that higher prices lower consumption, which in turn lowers suicidal behaviors. Similarly, the positive signs on the on campus living arrangements indicate that students living on campus are more likely to engage in suicidal behaviors due to their higher drug and alcohol use than those living off campus.

F.   CONCLUSION

In summary, our results are consistent with a causal mechanism in which alcohol and

illicit drug use increases the likelihood of suicidal thoughts and attempts. This evidence comes from TSLS estimation, where statistically significant instruments and valid overidentification restrictions generate coefficient estimates that are similar to OLS coefficients. The reduced form equation shows indirect evidence of causality by linking the determinants of drug and alcohol use directly to the suicidal behaviors. Although these are measured imprecisely, these results indicate that raising the price of beer, and living off campus will reduce the number of suicidal thoughts and attempts by college students.

These findings have important implications for policy. Suicidal behaviors are leading risk factors for completed suicide and are thought to interfere with functioning even when they do not result in completed suicide. However, there has been little previous research on how public policy can be used to effectively prevent these risky, prevalent behaviors. This paper suggests that those policies that prevent substance use also may prevent suicidal behaviors. In this study, we identify beer prices and college living arrangements as potential policy tools, although future research may identify other such policies. This research is a first step towards expanding policy makers' ability to prevent suicidal behaviors, and their tragic consequences, among college students.

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<center>Footnotes</center>

[1] Sloan et al. (1994) do find that higher beer prices are associated with lower adult state-level suicide rates after controlling for a range of time-varying state characteristics and state fixed effects.

[2] We experimented with models which include as additional instruments the price of cocaine and an indicator for whether the state had decriminalized the possession of small amounts of marijuana for personal use. These instruments are excluded since they have no empirical correlation with the substance use measures. This is most likely due to measurement error in the prices (Manski et al. 2001).

[3] One drawback to these models is that there may be a multicollinearity problem present due to the correlation between smoking status and use of drugs and alcohol. Models were tested that exclude the tobacco use variable and results do not change.

[4] The first stage results are presented in Appendix Table 1.

[5] Results are available upon request.

Table 1
Definitions, Means and Standard Deviations of Variables

Variable	Definition	Mean, Standard Deviation
Suicide thoughts	Dichotomous variable that equals 1 if the respondent seriously thought about suicide due to drinking or drug use in the past year	0.05, 0.22
Suicide attempts	Dichotomous variable that equals 1 if the respondent seriously tried to commit suicide due to drinking or drug use in the past year	0.02, 0.12
Number of drinks	Average number of drinks the respondent consumes in a week	5.10, 8.51
Binge drink	Dichotomous variable that equals 1 if the respondent consumed five or more drinks at a sitting in the past two weeks.	0.45, 0.50
Marijuana use	Dichotomous variable that equals 1 if the respondent used marijuana in the past year	0.27, 0.44
Other drug use	Dichotomous variable that equals 1 if the respondent used drugs other than marijuana such as cocaine, opiates, amphetamines, sedatives, hallucinogens inhalants, ecstasy, or steroids in the past year	0.13, 0.34
Any drug use	Dichotomous variable that equals 1 if the respondent used any illegal drugs in the past year	0.30, 0.46
Real beer price	Real price of beer	2.60, 0.18
Lives in on-campus housing	Dichotomous variable that equals 1 if respondent lives in on-campus housing	0.40, 0.49
Lives in a fraternity/sorority	Dichotomous variable that equals 1 if respondent lives in a fraternity or sorority	0.02, 0.14
On campus residence unknown	Dichotomous variable that equals 1 if respondent lives in on-campus housing, but type of housing is unknown	0.06, 0.25
Age	Respondent's age	20.22, 1.67
Female	Dichotomous variable that equals 1 if respondent is female	0.59, 0.48
Black	Dichotomous variable that equals 1 if respondent is black, non-Hispanic	0.06, 0.24
Hispanic	Dichotomous variable that equals 1 if respondent is Hispanic	0.05, 0.21
Other race	Dichotomous variable that equals 1 if respondent is of another race/ethnicity	0.06, 0.24
Grade point average	Respondent's cumulative grade point average	8.82, 1.88
Sophomore	Dichotomous variable that equals 1 if respondent is a sophomore	0.23, 0.42
Junior	Dichotomous variable that equals 1 if respondent is a junior	0.23, 0.42
Senior	Dichotomous variable that equals 1 if respondent is a senior	0.21, 0.41

Graduate student	Dichotomous variable that equals 1 if respondent is seeking a graduate or professional degree	0.02, 0.14
Non-matriculated	Dichotomous variable that equals 1 if respondent is not seeking a degree	0.01, 0.08
Married	Dichotomous variable that equals 1 if respondent is married	0.04, 0.20
Divorced	Dichotomous variable that equals 1 if respondent is divorced	0.01, 0.08
Part-time student	Dichotomous variable that equals 1 if respondent attends school part-time	0.06, 0.23
Works full-time	Dichotomous variable that equals 1 if respondent works full-time	0.07, 0.26
Works part-time	Dichotomous variable that equals 1 if respondent works part-time	0.50, 0.50
Mother has alcohol/drug problem	Dichotomous variable that equals 1 if respondent's mother had alcohol or drug problems	0.05, 0.21
Father has alcohol/drug problem	Dichotomous variable that equals 1 if respondent's father had alcohol or drug problems	0.16, 0.36
Tobacco	Number of days in the past year on which the respondent smoked cigarettes	60.02, 123.92
Northeast	Dichotomous variable that equals 1 if the respondent attends college in the Northeast	0.21, 0.40
Midwest	Dichotomous variable that equals 1 if the respondent attends college in the Midwest	0.31, 0.46
South	Dichotomous variable that equals 1 if the respondent attends college in the South	0.30, 0.46

Table 2
Suicidal Behaviors By Substance Use

		Thought about suicide	Attempted suicide
Number of drinks	>0 per week	6.85%	1.91%
	0 per week	2.34%	0.78%
Binge drink	Yes	8.15%	2.34%
	No	3.05%	0.87%
Use marijuana	Yes	10.28%	2.83%
	No	3.47%	1.04%
Use other drugs	Yes	15.06%	4.84%
	No	3.80%	1.00%
Use any drugs	Yes	10.41%	2.97%
	No	3.18%	0.92%

Table 3
Drinking

	Suicide Thoughts			Suicide Attempts		
	OLS (1)	OLS (2)	TSLS (3)	OLS (4)	OLS (5)	TSLS (6)
Number of drinks	0.003 (9.03)	0.002 (6.83)	0.004 (2.26)	0.001 (6.11)	0.001 (5.06)	0.002 (1.25)
Age	-0.002 (-1.87)	-0.004 (-3.79)	-0.003 (-3.07)	-0.002 (-2.71)	-0.002 (-3.79)	-0.002 (-3.11)
Female	0.016 (6.31)	0.014 (5.93)	0.019 (2.53)	0.008 (4.40)	0.007 (4.17)	0.009 (1.73)
Black	-0.015 (-2.43)	-0.010 (-1.50)	-0.006 (-0.71)	0.005 (1.30)	0.006 (1.55)	0.008 (1.27)
Hispanic	0.003 (0.41)	0.007 (0.90)	0.008 (1.03)	0.003 (0.95)	0.004 (1.48)	0.005 (1.59)
Other race	0.009 (1.74)	0.012 (2.36)	0.014 (2.62)	0.010 (2.28)	0.010 (2.54)	0.012 (2.55)
GPA	-0.006 (-5.76)	-0.005 (-5.32)	-0.004 (-4.46)	-0.002 (-4.20)	-0.002 (-3.82)	-0.002 (-2.38)
Sophomore	0.002 (0.38)	0.004 (1.03)	0.003 (0.88)	-0.002 (-0.75)	-0.001 (-0.39)	-0.001 (-0.50)
Junior	-0.006 (-1.18)	0.001 (0.13)	-0.001 (-0.30)	-0.004 (-1.41)	-0.002 (-0.72)	-0.003 (-0.90)
Senior	-0.010 (-2.05)	-0.002 (-0.38)	-0.005 (-0.92)	-0.007 (-2.35)	-0.005 (-1.52)	-0.005 (-1.60)
Graduate Student	-0.013 (-1.48)	-0.001 (-0.08)	-0.002 (-0.24)	-0.005 (-0.97)	-0.001 (-0.13)	-0.001 (-0.22)
Not enrolled for degree	0.049 (1.59)	0.051 (1.79)	0.051 (1.78)	0.044 (1.81)	0.044 (1.90)	0.044 (1.89)
Married	-0.011 (-1.77)	-0.014 (-2.12)	-0.010 (-1.46)	0.007 (1.34)	0.005 (1.14)	0.007 (1.21)
Divorce	0.108 (4.36)	0.082 (3.62)	0.078 (3.62)	0.079 (2.83)	0.072 (2.55)	0.068 (2.56)
Part-time student	0.016 (2.37)	0.013 (2.08)	0.013 (2.21)	0.011 (2.55)	0.010 (2.37)	0.010 (2.43)
Works full time	0.009 (1.48)	0.005 (0.85)	0.007 (1.02)	0.003 (0.76)	0.002 (0.43)	0.002 (0.48)
Works part time	0.004 (1.64)	0.002 (0.89)	0.004 (1.26)	-0.001 (-0.66)	-0.002 (-1.00)	-0.001 (-0.58)
Mother alcohol/drug problem		0.065 (6.62)	0.064 (6.38)		0.035 (6.94)	0.035 (6.83)
Father alcohol/drug problem		0.023 (5.12)	0.023 (5.00)		0.005 (1.63)	0.005 (1.51)
Tobacco		0.0002 (9.82)	0.0001 (3.33)		0.0001 (4.89)	0.00004 (1.61)
Northeast	-0.008 (-1.38)	-0.008 (-1.42)	-0.011 (-1.94)	0.0004 (0.15)	0.003 (0.22)	-0.0004 (-0.09)
Midwest	-0.018 (-3.62)	-0.015 (-3.39)	-0.017 (-3.11)	-0.005 (-2.36)	-0.002 (-1.73)	-0.004 (-1.44)
South	-0.023 (-4.05)	-0.021 (-4.70)	-0.022 (-4.99)	-0.005 (-1.56)	-0.003 (-1.41)	-0.004 (-1.41)
R-squared	0.02	0.04	0.03	0.02	0.02	0.02
Overidentification test			2.738 [0.434]			1.985 [0.575]
F test on instruments			16.950 [0.000]			16.950 [0.000]
Hausman test			0.793 [0.373]			0.142 [0.706]

Note: Huber t-statistics in parentheses, p-values in brackets, and intercept not shown. N=28,657

Table 4
Binge Drinking, Marijuana Use, Other Drug Use, Any Drug Use

	Suicide Thoughts			Suicide Attempts		
	OLS (1)	OLS (2)	TSLS (3)	OLS (4)	OLS (5)	TSLS (6)
PANEL A						
Binge drink	0.049	0.039	0.072	0.015	0.011	0.025
(N=29,188)	(12.37)	(10.99)	(2.24)	(7.34)	(5.99)	(1.28)
Overidentification test			2.884 [0.410]			1.524 [0.677]
F test on instruments			30.930 [0.000]			30.930 [0.000]
Hausman test			1.073 [0.300]			0.494 [0.482]
R-squared	0.02	0.04	0.03	0.01	0.02	0.02
PANEL B						
Marijuana use	0.064	0.048	0.065	0.017	0.010	0.025
(N=28,993)	(10.21)	(7.97)	(1.85)	(7.04)	(5.12)	(0.87)
Overidentification test			3.518 [0.318]			2.245 [0.523]
F test on instruments			13.200 [0.000]			13.200 [0.000]
Hausman test			0.247 [0.619]			0.272 [0.602]
R-squared	0.03	0.04	0.04	0.01	0.02	0.02
PANEL C						
Other drug use	0.108	0.092	0.094	0.037	0.031	0.038
(N=29,036)	(11.15)	(9.85)	(1.13)	(7.02)	(6.31)	(0.67)
Overidentification test			6.997 [0.072]			3.058 [0.383]
F test on instruments			7.340 [0.000]			7.340 [0.000]
Hausman test			0.0007 [0.979]			0.016 [0.899]
R-squared	0.04	0.05	0.05	0.02	0.03	0.03
PANEL D						
Any drug use	0.068	0.053	0.072	0.020	0.013	0.026
(N=29,093)	(11.61)	(9.40)	(1.75)	(7.65)	(6.13)	(0.82)
Overidentification test			3.981 [0.264]			1.706 [0.636]
F test on instruments			12.010 [0.000]			12.010 [0.000]
Hausman test			0.207 [0.649]			0.164 [0.686]
R-squared	0.03	0.04	0.04	0.02	0.02	0.02

Note: Huber t-statistics in parentheses, p-values in brackets, and intercept not shown.

Table 5
Reduced Form

	Suicide Thoughts		Suicide Attempts	
	(1)	(2)	(3)	(4)
Beer price	-0.012	-0.029	-0.004	0.001
	(-1.49)	(-3.21)	(-0.59)	(-1.49)
Lives in on-campus housing	0.004	0.003	0.001	0.005
	(0.93)	(0.64)	(0.51)	(0.61)
Lives in a fraternity/sorority	0.013	0.011	0.006	0.004
	(1.60)	(1.32)	(1.37)	(1.17)
On-campus status unknown	0.011	0.010	0.004	-0.002
	(1.45)	(1.45)	(1.05)	(1.10)
Age	-0.004	-0.004	-0.002	0.003
	(-3.67)	(-3.65)	(-3.97)	(-4.11)
Female	0.004	0.004	0.003	0.002
	(1.74)	(1.74)	(2.00)	(2.00)
Black	-0.018	-0.020	0.003	0.004
	(-2.69)	(-3.36)	(0.66)	(0.54)
Hispanic	0.005	0.006	0.004	0.008
	(0.53)	(0.66)	(1.27)	(1.37)
Other race	0.006	0.007	0.008	-0.002
	(1.19)	(1.38)	(1.93)	(1.88)
GPA	-0.006	-0.006	-0.002	-0.001
	(-6.77)	(-7.01)	(-4.63)	(-4.75)
Sophomore	0.003	0.003	-0.001	-0.002
	(0.83)	(0.73)	(-0.52)	(-0.48)
Junior	0.002	0.0003	-0.002	-0.004
	(0.42)	(0.08)	(-0.59)	(-0.67)
Senior	-0.0003	-0.003	-0.004	-0.001
	(-0.06)	(-0.63)	(-1.44)	(-1.56)
Graduate Student	-0.001	-0.005	-0.001	0.044
	(-0.17)	(-0.72)	(-0.12)	(-0.25)
Not enrolled for degree	0.048	0.049	0.043	0.003
	(1.70)	(1.70)	(1.84)	(1.87)
Married	-0.019	-0.019	0.003	0.072
	(-3.15)	(-2.93)	(0.63)	(0.59)
Divorce	0.084	0.085	0.072	0.009
	(3.58)	(3.55)	(2.58)	(2.56)
Part-time student	0.012	0.012	0.009	0.002
	(1.69)	(1.69)	(1.98)	(2.09)
Works full time	0.004	0.004	0.002	-0.003
	(0.62)	(0.75)	(0.48)	(0.58)
Works part time	0.0003	0.001	-0.003	0.035
	(0.14)	(0.34)	(-1.42)	(-1.30)
Mother alcohol/drug problem	0.067	0.068	0.035	0.005
	(6.68)	(6.78)	(6.50)	(6.49)
Father alcohol/drug problem	0.023	0.024	0.005	0.0001
	(5.36)	(5.44)	(1.92)	(1.95)
Tobacco	0.0002	0.0002	0.0001	0.0001
	(13.01)	(13.18)	(6.72)	(6.66)
Northeast	-0.004		0.004	
	(-0.67)		(1.23)	
Midwest	-0.012		-0.001	
	(-2.95)		(-0.71)	
South	-0.018		-0.002	
	(-4.19)		(-0.76)	
R-squared	0.03	0.03	0.02	0.02

Note: Huber t-statistics in parentheses, and intercept not shown.

	Number of Drinks	Binge Drink	Use Marijuana	Use Other Illicit Drugs	Use Any Illicit Drugs
Beer price	-2.556	-0.079	-0.220	-0.071	-0.195
	(-3.27)	(-1.72)	(-2.68)	(-2.09)	(-2.49)
Lives in on-campus housing	0.682	0.060	0.001	-0.017	0.0002
	(1.70)	(2.36)	(0.06)	(-2.52)	(0.02)
Lives in a fraternity/sorority	4.264	0.249	0.138	0.067	0.127
	(7.25)	(10.98)	(6.45)	(4.55)	(6.33)
On-campus status unknown	0.487	0.040	0.019	0.001	0.014
	(2.77)	(2.95)	(1.95)	(0.10)	(1.37)
Age	-0.216	-0.006	-0.001	-0.003	-0.003
	(-3.12)	(-1.70)	(-0.39)	(-1.55)	(-0.93)
Female	-3.784	-0.125	-0.032	-0.013	-0.018
	(-15.62)	(-13.07)	(-4.65)	(-1.93)	(-2.29)
Black	-2.993	-0.214	-0.077	-0.074	-0.094
	(-7.51)	(-10.75)	(-2.95)	(-9.13)	(-3.51)
Hispanic	-0.461	-0.002	-0.051	-0.026	-0.052
	(-1.08)	(-0.07)	(-3.54)	(-2.56)	(-3.35)
Other race	-1.646	-0.141	-0.089	-0.031	-0.087
	(-6.96)	(-9.28)	(-5.77)	(-2.69)	(-5.15)
GPA	-0.321	-0.023	-0.010	-0.005	-0.012
	(-6.54)	(-12.21)	(-5.00)	(-4.31)	(-6.37)
Sophomore	0.350	0.026	0.008	-0.011	0.006
	(2.22)	(2.06)	(0.83)	(-2.03)	(0.75)
Junior	1.089	0.070	0.027	-0.004	0.027
	(3.83)	(4.99)	(1.97)	(-0.61)	(1.93)
Senior	1.543	0.093	0.033	-0.004	0.032
	(3.72)	(5.10)	(2.11)	(-0.43)	(2.07)
Graduate Student	0.815	0.050	-0.014	-0.038	-0.021
	(1.68)	(1.90)	(-0.68)	(-2.20)	(-0.89)
Not enrolled for degree	-0.075	-0.019	-0.003	0.006	-0.009
	(-0.17)	(-0.62)	(-0.13)	(0.26)	(-0.29)
Married	-2.210	-0.229	-0.140	-0.061	-0.140
	(-9.76)	(-10.42)	(10.17)	(-7.50)	(-9.94)
Divorce	2.935	-0.002	-0.050	0.115	-0.009
	(2.81)	(-0.04)	(-1.28)	(3.29)	(-0.21)
Part-time student	-0.145	-0.029	0.018	0.016	0.015
	(-0.40)	(-1.34)	(1.03)	(1.20)	(0.76)
Works full time	-1.052	-0.032	-0.042	-0.011	-0.025
	(-3.64)	(-1.63)	(-3.11)	(-1.30)	(-2.16)
Works part time	-1.005	-0.045	-0.013	0.006	-0.007
	(-6.45)	(-5.73)	(-1.49)	(1.27)	(-0.85)
Mother alcohol/drug problem	0.980	0.0005	0.098	0.089	0.099
	(3.19)	(0.03)	(8.83)	(5.96)	(8.58)
Father alcohol/drug problem	0.410	0.017	0.032	0.033	0.038
	(2.91)	(2.01)	(4.16)	(4.95)	(4.79)
Tobacco	0.018	0.001	0.001	0.001	0.001
	(19.52)	(23.18)	(31.27)	(18.14)	(31.95)
Northeast	1.820	0.076	-0.005	-0.044	-0.008
	(3.36)	(2.57)	(-0.13)	(-3.57)	(-0.24)
Midwest	1.090	0.069	-0.047	-0.025	-0.043
	(2.67)	(2.17)	(-1.15)	(-1.79)	(-1.14)
South	0.923	0.017	-0.025	-0.001	-0.018
	(3.74)	(0.67)	(-0.95)	(-0.05)	(-0.73)
R-squared	0.17	0.14	0.16	0.10	0.15

Note: Huber t-statistics in parentheses, and intercept not shown.