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Heavy drinking and health promotion activities

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Abstract

Empirical evidence suggests that individuals who consume relatively large amounts of alcohol are more likely to use expensive acute medical care and less likely to use preventive or ambulatory services than other individuals. The few studies that investigated the associations between heavy drinking and health promotion activities did not try to address omitted-variable biases that may confound the relationships. To fill this void in the literature, we examined the effects of heavy alcohol use on three health promotion activities (routine physical exam, flu shot, regular seatbelt use) using the US 2006 Behavioral Risk Factor Surveillance Survey. Although specification tests indicated that omitted variable bias was not present in the majority of the single-equation probit models, we cautiously interpret our findings as evidence of strong associations rather than causal effects. Among both men and women, heavy alcohol use is negatively and significantly associated with each of our three outcomes. These findings suggest that heavy drinkers may be investing less in health promotion activities relative to abstainers and other drinkers. Policy options to address the associated externalities may be warranted.

Keywords

Alcohol consumption; Health promotion activities; Routine physical exam; Influenza vaccination; Seat belt use

Introduction

Modifiable risky behaviors (e.g. heavy drinking, smoking, physical inactivity, poor diet) are among the leading causes of morbidity and mortality in the United States (Fine, Philogene, Gramling, Coups, & Sinha, 2004; Mokdad, Marks, Stroup, & Gerberding, 2004) and account for a large percentage of U.S. health care costs (Finkelstein, Fiebelkorn, & Wang, 2003; Zarkin, Bray, Babor, & Higgins-Biddle, 2004). In addition to their direct effects, certain risky behaviors may also contribute indirectly to adverse health outcomes and increased health care costs if they act as a deterrent to engaging in health promotion activities. For example, heavy alcohol users may shun preventive or ambulatory health care

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(e.g., regular doctor check-up visits) to avoid scrutiny over their alcohol consumption (Armstrong, Midanik, & Klatsky, 1998; Hunkeler, Hung, Rice, Weisner, & Hu, 2001; Rice, Conell, Weisner, Hunkeler, Fireman, & Hu, 2000). These consumers may not seek medical attention until health problems become acute and urgent care is needed. Another contributing factor may be the cost of purchasing alcohol if it significantly reduces income available for investing in preventive health care. Moreover, individuals who consume heavy amounts of alcohol may experience impaired cognition and myopia, reducing their perception of the benefits of health promotion activities and hence their motivation to engage in them (e.g., wearing a seat belt while driving/riding in a car).

In support of these mechanisms, several earlier studies found a negative association between alcohol use and health promotion activities such as: regular check-up visits (Town, Naimi, Mokdad, & Brewer, 2006), influenza vaccination (Kee et al., 2007), or regularly wearing a seat belt (Wilson, 1990).

On the other hand, it is possible that heavy alcohol consumption will actually encourage health promotion practices because drinkers try to compensate for their risky behavior in one domain by reducing their health risks in other domains. Andrew, McNeil, Merry, and Rockwood (2004) discovered that influenza vaccination rates were higher among regular drinkers, providing a contrast to the findings of Kee et al. (2007).

A causal interpretation for any of the reported associations is tenuous due to the possibility of omitted-variable bias. More generally, it seems plausible that risky behaviors are endogenous in equations for health promotion practices because key explanatory variables (e.g., time preferences, personality traits) are significantly correlated with risky behaviors, yet unmeasured or unobservable to the analyst. Consequently, results from these earlier studies reflect correlations, but not necessarily causal effects.

We therefore aim to deepen our understanding of the contemporary relationships between a set of health promotion activities (i.e., routine physical examinations, flu shots, regular seatbelt use) and heavy alcohol consumption by applying econometric techniques to explore potential omitted-variable bias. For the reasons outlined above, our main hypothesis is that heavy alcohol consumption will decrease the probability of engaging in each of the three health promotion practices. To our knowledge, this paper is the first to examine the relationships between heavy alcohol use and health promotion decisions while also considering potential omitted variables bias.

Understanding these relationships has important policy implications. The negative externalities of failing to engage in these activities could be substantial (e.g., spreading the influenza virus to family members and coworkers, shifting resources from relatively inexpensive preventive care to expensive and sometimes avoidable acute health care services, higher insurance premiums for health care and motor vehicles). Because most individuals rarely consider all possible negative externalities of their actions when making decisions, public policy tools to modify these choices (e.g., alcohol taxation, purchasing age limits, penalties for drunk driving) may be justifiable on efficiency grounds. Moreover, numerous studies have demonstrated the clinical effectiveness (McLellan, Lewis, O'Brien, & Kleber, 2000) and economic benefits (McCollister & French, 2003) of substance abuse treatment. If heavy alcohol use negatively affects the decision to participate in health promotion activities, enrollment in substance abuse treatment programs may indirectly raise involvement in health promotion activities, leading to greater social welfare.

Methodology

Conceptual background

Grossman's (1972) model of the demand for health care provides a useful conceptual background to motivate our empirical analysis. In this model, the demand for medical care and other health inputs (measured by health promotion activities in our empirical model) is derived from the demand for health. Health is demanded by consumers directly as a consumption commodity and indirectly as an investment commodity because it affects the amount of time available for leisure and work. The consumer maximizes her expected utility subject to the initial endowment of health capital as well as time and resource constraints that limit the amount of medical care and other health inputs (and other goods) she can consume.

The Grossman model suggests several determinants of the demand for health promotion activities. First, health endowment is a critical determinant of the demand for health care (Grossman, 2008). Empirical studies find support for the association between an individual's baseline health status and engagement in health promotion practices (Andrew et al., 2004), but the extent to which causality runs from health status to health promotion is unknown.

Second, education is directly associated with the demand for health, as educated individuals are more efficient in producing health capital. A comprehensive literature review (Grossman & Kaestner, 1997) supports this theory. The authors argue that schooling has a causal impact on good health through a better understanding of healthy choices and risky options. Alternatively, education may serve as a proxy for time preference, with higher education being a marker for future-oriented individuals (Fuchs, 1982). Empirical studies show that health promotion activities and educational attainment are closely correlated (Andrew et al., 2004; Kee et al., 2007).

Third, a person's health stock depreciates at an increasing rate with age. Thus, the returns to health investment decrease with age. For this reason, most studies examining health promotion activities adjust for age (Andrew et al., 2004; Urbanoski, 2003).

Fourth, household income (normalizing for household size) and the cost of engaging in health promotion practices (which depends heavily on the opportunity cost of time and the presence and type of health insurance) are expected to influence participation through a budget constraint. If health promotion activities are normal goods, then income will have a positive impact on the likelihood of participating in them. Several empirical studies show that a higher price (proxied by insurance coverage) and lower income discourage the use of preventive health care (Kamal, Madhavan, & Amonkar, 2003; Morales, Rogowski, Freedman, Wickstrom, Adama, & Escarce, 2004; Town et al., 2006).

Fifth, smoking and physical inactivity are signals for the individual's preferences for health relative to other commodities. A lower preference for health is expected to lead to a lower demand for health promotion activities. One view purports that individuals' motivation to prevent illness/disease or improve health could cause the clustering of health behaviors. In other words, health consciousness could lead an individual with a healthy lifestyle orientation (or an unhealthy tendency) to act similarly toward another health-related behavior. Numerous studies provide empirical evidence for this hypothesis (Laaksonen, Luoto, Helakorpi, & Uutela, 2002; Serdula, Byers, Simoes, Mendlein, & Coates, 1996). Being a non-smoker and engaging in physical activity are highly correlated with other health promotion activities (Andrew et al., 2004; Kee et al., 2007; Shahrabani & Benzion, 2006). Geographic-specific measures of health behaviors may also serve as a proxy for health

preferences because individuals learn their values in part from the environment in which they live.

Finally, other socio-demographic variables may proxy for preferences toward preventive care (e.g. ethnicity may proxy for trust in the health care system). Marital status, number of young children, and employment may increase motivation to remain healthy, but simultaneously increase the opportunity cost of time. Residing in a rural area may impede the use of preventive care due to access barriers. Several empirical studies find that socio-demographic variables are important factors associated with the decision to engage in health promotion activities (Andrew et al., 2004; Cryer et al., 1999; Harper, Fukuda, Uyeki, Cox, & Bridges, 2004; Kamal et al., 2003; Kee et al., 2007; Morales et al., 2004; Shahrabani & Benzion, 2006; Wilson, 1990; Wu, 2003).

Econometric approach

The core econometric specification is as follows:

$$HP = f(\beta_A A + BC' \beta_{BC} + P' \beta_P + \beta_I I + X' \beta_X + E' \beta_E) \quad (1)$$

where HP is a measure of health promotion activity, A is a measure of heavy alcohol use, BC' is a vector of behavioral characteristics (e.g. smoking, exercise) excluding current alcohol use, P' is a vector of health insurance indicators, I is household income, X' is a vector of socio-economic variables, personal characteristics, and environmental factors, and E' is a vector of health endowment. β_A , β_{BC} , β_P , β_I , β_X , and β_E are the coefficients to be estimated. The function f is probit in this analysis because our measures of HP are dichotomous. We selected the probit over the logit model to facilitate comparison of the single-equation estimates with simultaneous equations results (see below).

Addressing potential omitted variable bias is one of the central statistical challenges in the estimation of Equation (1). Conceptually, heavy alcohol use may be significantly correlated with important omitted variables that are unmeasured or unobservable to the analyst (e.g., risk aversion, discipline), but predictive of health promotion activities. If the estimation of Equation (1) does not consider these omitted variables, then β_A will be biased because it incorporates not only the effect of heavy alcohol use on HP , but also the effects of some of these omitted variables. Because both the explanatory variable of interest and the outcome variables are dichotomous, we estimated a recursive bivariate probit model to test for possible omitted-variable bias. The following specification estimates HP and A simultaneously:

$$HP^* = \beta_A A + BC' \beta_{BC} + P' \beta_P + \beta_I I + X' \beta_X + E' \beta_E + \varepsilon, \quad HP = 1 \text{ if } HP^* > 0, 0 \text{ otherwise} \quad (2)$$

$$A^* = IV' \delta_{IV} + BC' \delta_{BC} + P' \delta_P + \delta_I I + X' \delta_X + E' \delta_E + \nu, \quad A = 1 \text{ if } A^* > 0, 0 \text{ otherwise} \quad (3)$$

$$E[\varepsilon] = E[\nu] = 0$$

$$\text{Var} [\varepsilon] = \text{Var} [v] = 1$$

$$\text{Cov} [\varepsilon, v] = \rho$$

where Equation (3) is a quasi alcohol demand equation, IV' is a vector of instrumental variables for A , δ_{IV} is a corresponding coefficient vector, ε and v are disturbance terms for the health promotion activities and alcohol demand equations, and all other variables and coefficients are the same as defined earlier. Under the assumption that ε and v are jointly normally distributed with means equal to zero, variance equal to one, and correlation equal to ρ , this system of equations can be estimated as a recursive bivariate probit model using maximum likelihood methods (Greene, 2008).

Greene (2008) and others have shown that if ρ is not significantly different from zero, then the above model reduces to two independent probit equations, which can be estimated separately as there is no statistical advantage to employing a simultaneous system technique. If the null hypothesis of $\rho = 0$ is rejected, then the recursive bivariate probit will generate consistent estimates even if the same unmeasured and unobservable factors simultaneously influence heavy alcohol use and health promotion activities.

Because estimation of recursive bivariate probit models is still relatively rare in the literature, we also estimated a two-stage least-squares model as an alternative approach. According to Wooldridge (2002), the linear model will produce reasonable estimates of the average treatment effect of interest. Moreover, Angrist (2001) argues that causal inference with binary dependent variables “is not fundamentally different from causal inference with continuous outcomes” and the main challenge associated with binary endogenous regressors in models with binary outcomes is selecting valid instruments.

Another concern related to our empirical specification is the potential endogeneity of some of our control variables, such as smoking, physical activity, marital status, or educational attainment. Although we did not directly address this issue in the core models, we conducted various sensitivity analyses, which indicated that the potential endogeneity of some of our covariates does not appreciably alter the main study results (see Sensitivity Analysis section for details).

Many studies have shown that men and women have different consumption patterns and experience different effects from alcohol (Hupkens, Knibbe, & Drop, 1993; Robbins & Martin, 1993; Wilsnack, Vogeltanz, Wilsnack, & Harris, 2000). Moreover, women seem to be more attentive of their health status than men (Lee, Naguel, Gyurech, & Schilling, 2003) and are more likely to wear seat belts and participate in other health promotion activities (Begg & Langley, 2000). Thus, we estimated separate equations for men and women.

Lastly, we employed the sampling weights available in the Behavioral Risk Factor Surveillance Survey (BRFSS) to generate nationally-representative estimates. Generalized estimating equations with independent error structures were used to adjust standard errors for potential clustering among respondents within a state.

Data and measures

Sample

We analyzed individual-level data from the 2006 cross-section of the BRFSS. The BRFSS is a large, annual, state-administered, cross-sectional telephone survey of the non-institutionalized adult population in the U.S. It is an ongoing data collection program designed to measure behavioral risk factors in the U.S. population, ages 18 years and older, living in households. The Centers for Disease Control and Prevention (CDC, 2006) act in collaboration with the states to maintain the BRFSS.

The analysis sample for the present study includes 235,366 individuals (61% women) between the ages of 21 and 64 (inclusive). Elderly persons are excluded from our analysis as there are significant changes in alcohol consumption, health status, and health promotion activity once individuals reach and then pass typical retirement age. Respondents under age 21 are excluded because possession of alcohol among persons under this age is illegal in the U.S., which could lead to reporting biases among this subgroup. For each health promotion activity, respondents who did not provide valid responses were excluded from the analysis. Despite this strict criterion, only 0.2% to 1.3% (0.1% to 1.1%) of the sample was lost for men (women), depending on the particular health promotion activity.

Dependent variables

Health promotion activities—We selected three health promotion activities that pertain to behaviors during the previous year. Specifically, three dichotomous variables were set equal to one if the respondent reported a routine physical exam, a flu vaccine, or always using a seat belt when driving or riding in a car. We chose these health promotion measures because each is thought to play an important role in maintaining health and minimizing negative externalities.

Explanatory variables

Heavy alcohol use—We constructed a single indicator variable for heavy alcohol use, our key independent variable. The measure was designed to capture two aspects of risky alcohol use: frequent consumption and binge drinking. Respondents were asked how often they consumed alcoholic beverages within the past 30 days and the average number of beverages they consumed on drinking days. BRFSS administrators combined these two items to generate a measure of frequent drinking. A frequent drinker was defined in the BRFSS as a man (woman) who consumed more than two (one) drinks per day on average. Male (female) respondents were then asked the number of times they consumed at least five (four) or more drinks on one occasion in the past 30 days. Respondents reporting at least one occasion were defined as binge drinkers. We then constructed a dichotomous variable indicating heavy alcohol use for respondents reporting frequent drinking and/or binge drinking in the 30 days before the interview date. We chose this alcohol use measure in order to compare heavy drinkers' health promotion behavior to a comparison group that does not include either type of problematic drinking (frequent or binge).

Control variables—All models included the following covariates: age and age squared; race/ethnicity (African American, Asian, Hispanic, and other non-white, with white as the reference group and Latinos of any race assigned to the “Hispanic” category); educational attainment (high school education, some post-secondary education, and university degree, with less than high school completion as the comparison group); current employment; marital status (divorced, separated, widowed, and never married, with married or cohabiting as the comparison group); total equivalent household income in the past year; number of household members; number of children under age 18 in the household; residence outside of

a Metropolitan Statistical Area (MSA); current smoking status (current smoker and former smoker, with never smoker as the comparison); and regular engagement in physical activity. Three binary health status indicators were included in all specifications as proxies for health endowment: fair or poor self-reported health; activity limitations due to physical, mental, or emotional problems; and the presence of health problems requiring the use of special equipment. Dichotomous variables indicating current health insurance status and having a personal doctor or health care provider were used as proxies for access to health services. Finally, we included three state-specific measures (state prevalence rates for regular exercise, eating a healthy diet, and smoking), as these health-related behaviors represent community involvement in health promotion activities.

Instrumental variables

Our potential instruments included the cost-of-living adjusted price of beer¹ (The Council for Community and Economic Research - ACCRA Cost of Living Index, 2006; unpublished alcohol price data from ACCRA), the percentage of the state's population residing in dry counties² (The Brewer's Almanac, 1998), and the population per licensed alcohol outlet (Adams Liquor Handbook, 2005). Because they directly reflect the monetary cost of drinking, alcohol prices are commonly used in the literature to instrument for the consumption of alcohol (Auld, 2005; Kenkel & Ribar, 1994; Yamada, Kendrix, & Yamada, 1996). The assumption that the individual's environment affects his/her drinking behavior motivates the use of instruments such as the percentage of the state's population living in dry areas (Chatterji, 2006; Feng, Zhou, Butler, Booth, & French, 2001; Kenkel & Ribar, 1994) and the population per licensed alcohol outlet (Jones, Miller, & Salkever, 1999).

One concern raised in the literature centers on the fact that state-level instruments may be correlated with unobserved determinants of cross-state variation in the outcome variables (Chatterji, 2006; Dee & Evans, 2003; Rashad & Kaestner, 2004). State-specific cultural attributes or social attitudes that lead a state to set higher excise taxes on alcohol might also lead them to implement policies that promote healthy living. To address this policy endogeneity concern, we have tried to capture time-invariant state-specific sentiments that affect policy enactment by controlling for state-level explanatory variables that are directly correlated with health promotion (i.e., state prevalence rates for regular exercise, eating a healthy diet, and smoking).

Descriptive statistics

Table 1 presents weighted summary statistics for the variables used in the analysis, by drinking category. Consistent with earlier studies, heavy alcohol use is more prevalent among men in our sample. Around 24 percent of men are either frequent drinkers or occasional binge drinkers (or both), whereas only 13 percent of women satisfy this condition.

Although most of control variables have significantly different mean values across drinking groups, differences in health promotion activities are the primary focus. Among both men and women, current heavy drinkers are less likely to engage in health promotion than the combined group of abstainers and non-heavy drinkers (see Table 1). About 58% (70%) of abstainers and non-heavy drinking men (women), but only 49% (65%) of heavy drinking men (women) reported a routine physical exam in the past year. The same relationship can

¹We used the cost-of-living adjusted average price (in dollars) of a six-pack of Heineken beer in 12-ounce containers as a proxy for the price of alcohol.

²The most recent dry county information available was collected in 1998, but anecdotal information suggests that these percentages changed little over the ensuing years.

be observed for getting a flu vaccine and always wearing a seat belt in the past year. For men, approximately 25% (79%) of abstainers and non-heavy drinkers reported getting a flu vaccine (always wearing a seat belt), whereas only 19% (70%) of heavy drinkers reported this behavior. For women, 28% (87%) of abstainers and non-heavy drinkers reported getting a flu vaccine (always wearing a seat belt), whereas only 21% (83%) of heavy drinkers reported this health promotion activity.

Estimation results

Our intuitively plausible instruments were empirically investigated using standard statistical tests (see Table 2). The predictive power of the instruments was tested by examining the individual and joint significance of the variables in the heavy alcohol use equation of the recursive bivariate probit model [Equation (3)], as well as first stage linear probability models. The selected instruments were individually predictive ($p \leq 0.05$) in all equations and χ^2 tests indicated strong joint significance ($p \leq 0.001$) in all specifications [ONLINE APPENDIX TABLE A]. Moreover, we estimated first-stage linear probability regressions and found that the F-statistic of joint explanatory power exceeds 10 in all specifications, which is the threshold commonly used in the literature to assess the instrument strength.

Tests of over-identifying restrictions (Bollen, Guilkey, & Mroz, 1995) indicated that the exclusion of the additional instruments from the health promotion activities equations was valid in five of the six specifications (see Table 2). The only exception was the population per licensed alcohol outlet instrument in the flu shot equation for men. In the Sensitivity Analysis section, we show that using just two (excludable) instruments does not appreciably affect the results. The test of over-identifying restrictions hinges on the assumption that the instrument(s) used to identify the endogenous variable in the just-identified model is not correlated with the error term in the structural equation (Murray, 2006). As all our instruments are measured at the state level, we explored the robustness of the results by using an individual level instrumental variable in our Sensitivity analysis section below.

Finally, the correlation of the error terms in the health promotion activities and heavy alcohol use equations was formally examined through likelihood ratio tests for $\rho = 0$. We failed to reject the null hypothesis of $\rho = 0$ in all but one specification. Specifically, recursive bivariate probit estimation is necessary to consistently estimate the probability of having a routine physical exam in the past year for heavy male drinkers. In this specification, ρ is barely significant at the 5% level. The point estimates of ρ , which measures the direction and strength of the correlation of the residuals from the two models, are positive in four out of six specifications. Most of the estimates are very small in magnitude.

Table 3 reports selected estimation results for our three health promotion measures for men (top panel) and women (bottom panel). We present results of both linear and non-linear models. Bolded coefficient estimates correspond to the preferred model based upon specification tests (see Table 2), with alternative estimates offered for comparison purposes. Baseline proportions are also reported to provide a reference point for assessing the practical significance of the marginal effects. Overall, the estimated marginal effects from probit models for heavy alcohol use are always negative, supporting our hypothesis that heavy drinking is inversely associated with health promotion activities. The majority of the single-equation estimates are statistically significant at the 1% level (the only exception is the marginal effect for heavy drinking women in the routine physical exam specification, which is significant at the 5% level). Estimates from the linear probability models are very similar in sign, magnitude, and statistical significance relative to the probit results.

When the recursive bivariate probit technique is used, the results are consistent in sign but the standard errors become larger, leading to less precision in the estimates. With two exceptions, the marginal effects are not statistically significant at conventional levels (i.e., 10% or lower). Two-stage least-squares estimates are mostly consistent in sign with the core models, suggesting a negative association between heavy alcohol use and health promotion activities. However, standard errors are relatively high so the estimates do not reach statistical significance in five out of six specifications.

Because, with one exception, our specification tests cannot reject the null of exogeneity of our alcohol use regressor, we focus on the results of the single-equation probit models in our discussion. For men, results from single-equation estimation show that heavy drinking is associated with a 4.1 percentage point decrease in the probability of a routine physical exam. For women, heavy alcohol use is associated with a 1.7 percentage point decrease in the likelihood of a routine check-up in the past year. Heavy alcohol use is associated with a 2.9 (3.9) percentage point decrease in the probability of getting a flu vaccine in the past year for men (women). Both marginal effects are statistically significant at the 1% level. Heavy drinking is also associated with a 6.4 (3.0) percentage point decrease in the probability of always wearing a seat belt for men (women). Both estimates are statistically significant at the 1% level.

We present the estimated marginal effects of all other explanatory variables for the routine check-up specification for both men and women in Appendix Table B [ONLINE APPENDIX TABLE B]. The marginal effects for age and age squared show a convex relationship between age and the likelihood of having a routine check-up. Higher education increases the probability of engaging in health promotion for men (the three dichotomous variables are jointly statistically significant at the 10% level). African-American and Hispanic men (women) are more likely than White men (women) to have a routine physical exam. Also, a higher household equivalent income, fair or poor self-reported health status, a physical health problem that requires special equipment, having health insurance, and having a personal doctor or health care provider are all positively correlated with the likelihood of a routine check-up. The number of children under age 18 in the household is negatively associated with the decision to have a routine physical exam for women (the negative marginal effect for men is not statistically significant), whereas being currently employed and living in a rural area are negatively correlated with health promotion for men. Current smokers are less likely to engage in health promotion. Although the marginal effect of smoking is larger than the marginal effect of heavy drinking for women, results from parsimonious models that exclude smoking are consistent in sign, magnitude, and statistical significance with the core models. For both men and women, higher state prevalence rates for eating a healthy diet and smoking are associated with a higher probability of having a routine check-up. The majority of these results are consistent in sign and statistical significance across different outcomes.

Sensitivity analysis

We performed various sensitivity analyses to examine the robustness of our findings. Results are available upon request. First, multicollinearity concerns prompted us to drop the three state-level control variables. Second, due to concerns about possible endogeneity with some of our control variables, we estimated parsimonious versions of our core models containing only the arguably exogenous covariates (i.e., age, race, ethnicity, marital status, education, urbanicity, income, employment status, and household size). Third, we re-estimated all models using unweighted data. All these sensitivity tests found the results to be consistent with the core models.

One of the specification tests (see Table 2) raised a question about the validity of an instrument (the population per licensed alcohol outlet) in the flu vaccine equations. Therefore, we employed the cost-of-living adjusted price of beer and the percentage of residents living in dry areas to identify the heavy alcohol use equation. After the exclusion of this instrument, statistical tests indicated that the remaining two instruments were still valid in all specifications. The specification tests recommended the same models and the estimation results were similar to those reported in Table 3.

Our specification tests in Table 2 recommend the recursive bivariate probit for routine physical exam for men, but not for women. We conducted an alternative exogeneity test. We assumed linearity and estimated the physical exam equation for men with two-stage least-squares regression. The Durbin-Wu-Hausman test failed to reject the null of exogeneity of our alcohol measure, suggesting that single-equation probit or OLS is the most appropriate estimation method.

Because the bias from IV estimation is an increasing function of the number of weak instruments, Angrist and Pischke (2009) suggest picking a single “best” instrument and estimating a just-identified model. We used the percentage of the state's population residing in dry counties as our sole instrument. The instrument is highly predictive of heavy alcohol use (statistically significant at the 1% level). According to specification tests, single equation probit is always the recommended estimation technique. Results from IV specifications are largely consistent with those from our core models.

Finally, we carefully examined the BRFSS dataset with the intent to find a suitable individual-level instrumental variable. We used an indicator for diabetes to instrument for heavy drinking in the ‘seat belt’ model. Most diabetics are encouraged to reduce their alcohol consumption, especially of beer and wine, which are relatively high in calories. We found that having diabetes has a strong negative correlation with heavy drinking. On the other hand, being diabetic should not have a direct effect on the decision to use a seat belt. According to specification tests using this instrument, single-equation probit is still the recommended method.

Discussion

This research fills an important gap in the literature by rigorously examining the relationships between heavy alcohol use and three relatively common and professionally recommended (Department of Health and Human Services [DHHS], 2007; Task Force on Community Preventive Services, 2001) health promotion activities. The data are recent, the econometric techniques are advanced, and the robustness checks are extensive.

As a point of departure from the existing studies in the literature, we used three state-level instrumental variables to assess the endogeneity of heavy alcohol use in our health promotion equations. Although our specification tests reject the null hypothesis of exogeneity in only one model, the relatively high standard errors introduce some concern about the strength of our IVs and the validity of the corresponding tests. Thus, we cautiously interpret our results as evidence of strong associations rather than causal relationships *per se*. The empirical results confirmed our primary hypothesis and were largely consistent with the existing literature. We consistently found statistically significant inverse relationships between heavy alcohol use and each of the three health promotion activities. Numerous sensitivity tests demonstrated the robustness of these results. With the exception of getting a flu vaccine, the negative correlation between heavy alcohol use and health promotion practices was twice as large for men as for women.

Despite the improved econometric rigor compared to earlier studies, this research is not without limitations or simplifying assumptions. First, both heavy alcohol use and health promotion activities were self-reported. The presence of any misreporting within our sample is impossible to verify and measure, but the likely impact (if present) is lower coefficient estimates. Even if misreports in heavy alcohol use and health promotion activities are independent, measurement error can bias coefficients towards zero (Greene, 2008).

Second, this paper focuses on the effects of heavy alcohol consumption, but it would also be informative to examine clinical diagnoses of alcohol abuse and/or dependence. However, such measures were not available in our dataset.

Third, we are not able to address possible reverse causality (i.e., health promotion activities affecting heavy alcohol use) because the BRFSS dataset is cross-sectional rather than longitudinal. Nevertheless, it seems unlikely that regular seatbelt use or flu vaccinations would have a causal impact on heavy alcohol consumption. Although it is possible that some physicians counsel their patients on heavy alcohol use during routine physical exams, survey evidence suggests that primary care doctors rarely discuss these matters with their patients, as only 6.3% of all patients and 11.9% of excessive drinkers were asked about alcohol consumption by their physicians (Aalto, Pekuri, & Seppa, 2002). Thus, we believe that reverse causality is unlikely to be a serious concern.

Fourth, our estimates identify the full association between heavy alcohol use and health promotion activities, but cannot separate out substitution between alcohol purchases and health promotion purchases or the substitution between health promotion and acute medical care services. Unfortunately, like other related studies in the literature, data limitations do not allow us to distinguish between all possible mechanisms.

Finally, although the BRFSS is conducted every year with a new sample, the health promotion measures used in this analysis are not available in each wave. Thus, we analyzed the 2006 cross-sectional data, the most recent information available and health promotion practices.

In summary, the findings of this study are in line with expectations and offer an interesting backdrop to the inconclusive and sometimes counterintuitive relationships between alcohol consumption and acute medical services such as inpatient hospital care and emergency room visits (Anzai et al., 2005; Rice et al., 2000; Zarkin et al., 2004). A possible public health implication of these findings is that heavy drinkers may experience serious long-term health problems (e.g., liver disease, hypertension) as a direct consequence of their drinking, but their health promotion decisions today could lead to immediate consequences for themselves and negative externalities for others. Economic evaluations of policies aimed at reducing heavy drinking should consider these indirect effects.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1
Descriptive Statistics for Men and Women, Age 21-64 Years

Variable	Men		Women	
	Heavy drinkers ¹ (n=19,981)	Abstainers and non-heavy drinkers (n=71,194)	Heavy drinkers ¹ (n=17,032)	Abstainers and non-heavy drinkers (n=127,159)
<i>Health Promotion Activities (past year)</i>				
Routine physical exam (%)	49.01	58.45	65.40	70.15
Flu vaccine (%)	18.86	25.61	21.24	27.55
Always wear seatbelt (%)	70.34	79.23	82.66	87.43
<i>Instrumental Variables</i>				
Percentage of residents living in dry areas (%)	3.42	3.97	3.09	4.01
Cost of living adjusted price of beer ²	7.08 (1.05)	7.10 (1.07)	6.99 (1.07)	7.10 (1.07)
Population per licensed alcohol outlet (100s)	5.91 (3.07)	6.24 (3.71)	5.87 (3.02)	6.22 (3.69)
<i>Socio-demographics</i>				
Age (years)	37.64 (11.58)	42.67 (11.91)	37.83 (11.86)	42.24 (12.05)
White (%)	80.98	76.33	84.45	76.61
African American (%)	7.35	10.10	7.36	11.88
Asian (%)	1.71	3.91	1.32	2.89
Other non-White race (%)	9.96	9.66	6.87	8.62
Hispanic (%)	14.64	14.59	10.73	14.59
Married (%)	62.99	72.70	59.38	69.30
Divorced/Separated/Widowed (%)	11.43	10.88	16.27	17.02
Never married (%)	25.58	16.42	24.35	13.68
Number of children under age 18 in the household	0.86 (1.13)	0.93 (1.20)	0.90 (1.12)	1.06 (1.26)
Household size	3.21 (1.51)	3.28 (1.62)	3.14 (1.45)	3.30 (1.62)
Less than high school education (%)	10.70	10.86	6.58	9.74
High school education (%)	28.62	26.04	24.15	26.52
Some post-secondary education (%)	27.26	24.90	29.76	28.25
University education (%)	33.42	38.20	39.51	35.49
Currently employed (%)	84.74	80.85	72.22	63.97
Household equivalent income (\$10,000s) ³	1.53 (2.35)	1.44 (2.20)	1.47 (2.15)	1.24 (1.89)
Household income missing (%)	7.03	7.77	8.47	10.79
Not in an MSA (%)	18.51	18.11	15.63	18.58
<i>Health Status Measures</i>				

Variable	Men		Women	
	Heavy drinkers ¹ (n=19,981)	Abstainers and non-heavy drinkers (n=71,194)	Heavy drinkers ¹ (n=17,032)	Abstainers and non-heavy drinkers (n=127,159)
Fair or poor self-reported health (%)	11.61	13.97	8.62	15.10
Activity limitation (%)	13.70	18.09	14.21	19.93
Physical health problem that requires special equipment (%)	2.88	6.11	2.00	4.89
<i>Health Behaviors</i>				
Current smoker (%)	36.72	20.12	37.05	17.41
Former smoker (%)	24.42	24.44	22.41	19.04
Any leisure time physical activity (%)	81.48	78.24	82.53	75.20
<i>Health Care Access</i>				
Any health insurance (%)	78.65	82.07	84.29	83.40
Has a personal doctor or health care provider (%)	66.47	74.29	81.11	83.87
<i>State-level Variables (past 30 days)</i>				
Adults who participated in physical activity (%)	76.33	76.03	76.43	76.02
Adults who consumed five or more fruit and vegetable servings per day (%)	24.35	24.36	24.57	24.33
Adults who are current smokers (%)	19.67	19.65	19.53	19.70

Notes: Standard deviations are reported in parentheses for continuous variables. Although almost all variables reveal highly significant differences in median values (Kruskal-Wallis (1952) rank-sum tests) across the drinking groups, the differences are sometimes very small in magnitude.

¹ Heavy alcohol use is defined as a man who consumed, on average over the past 30 days, more than 2 drinks per day or a man who consumed 5 or more drinks in one drinking session.

² The cost of living adjusted average price (in dollars) of a six-pack of Heineken beer in 12-ounce containers.

³ Household equivalent income was calculated using the Luxembourg income study measure of equivalent income: household income/(household size)².

Table 2
Tests of Instrument Reliability and Independent Equations for Heavy Alcohol Use

	Routine physical exam ¹	Flu vaccine ¹	Always wear seatbelt ¹
Men	(n=90,296)	(n=90,992)	N=(89,981)
<i>F</i> -test of instrument strength ²	13.22 ***	13.22 ***	13.22 ***
χ^2 -test for exclusion restrictions (<i>p</i> -value) ³	0.755	0.001 ***	0.678
Coefficient estimate for rho	0.223 (0.107)	0.104 (0.214)	-0.037 (0.341)
χ^2 -test for independent equations (<i>p</i> -value)	0.044 **	0.630	0.913
Recommended estimation method	RBVP	Probit	Probit
Women	(n=142,704)	(n=143,985)	(n= 142,660)
<i>F</i> -test of instrument strength ²	18.39 ***	18.39 ***	18.39 ***
χ^2 -test for exclusion restrictions (<i>p</i> -value) ³	0.225	0.318	0.602
Coefficient estimate for rho	-0.017 (0.130)	0.179 (0.107)	0.092 (0.135)
χ^2 -test for independent equations (<i>p</i> -value)	0.895	0.101	0.500
Recommended estimation method	Probit	Probit	Probit

Note: All specifications control for the full set of explanatory variables listed in Table 1.

¹ Instrumental variables include residents living in dry areas, population per licensed alcohol outlet, and cost of living adjusted price of beer.

² *F* statistic for the explanatory power of the instruments in the first stage linear probability models reported.

³ Just identified models were estimated following Rashad and Kaestner (2004). The tests were performed with each instrument selected as the excluded instrument. The most conservative results (i.e., smallest *p*-values from each set of tests) are reported.

RBVP = recursive bivariate probit model.

* Statistically significant, $p \leq 0.10$;

** Statistically significant, $p \leq 0.05$;

*** Statistically significant, $p \leq 0.01$.

Table 3
Effects of Heavy Alcohol Use¹ on Health Promotion Activities

	Routine physical exam	Flu vaccine	Always wear seatbelt
Men	(n=90,296)	(n=90,992)	(n=89,981)
<i>Baseline proportions</i>	0.587	0.280	0.733
<i>Probit estimation</i>	-0.041*** (0.008)	-0.029*** (0.007)	-0.064*** (0.006)
<i>OLS</i>	-0.037*** (0.007)	-0.029*** (0.007)	-0.064*** (0.007)
<i>Recursive bivariate probit estimation</i>	-0.191*** (0.071)	-0.078 (0.099)	-0.044 (0.180)
<i>2SLS</i>	-0.197 (0.217)	-0.510*** (0.177)	0.008 (0.424)
Women	(n=142,704)	(n=143,985)	(n=142,660)
<i>Baseline proportions</i>	0.708	0.314	0.844
<i>Probit estimation</i>	-0.017** (0.008)	-0.039*** (0.006)	-0.030*** (0.006)
<i>OLS</i>	-0.016** (0.008)	-0.036*** (0.005)	-0.032*** (0.006)
<i>Recursive bivariate probit estimation</i>	-0.006 (0.086)	-0.126*** (0.047)	-0.071 (0.067)
<i>2SLS</i>	-0.324 (0.455)	-0.509 (0.468)	-0.055 (0.470)

Note: Estimates are marginal effects and cluster-corrected standard errors are in parentheses.

¹ Heavy alcohol use is defined as a man (woman) who consumed, on average over the past 30 days, more than 2 (1) drinks per day or a man (woman) who consumed 5 (4) or more drinks in one drinking session.

* Statistically significant, $p \leq 0.10$;

** Statistically significant, $p \leq 0.05$;

*** Statistically significant, $p \leq 0.01$.