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RESEARCH ARTICLE

From Pubs to Scrubs: Alcohol Misuse and Health Care Use

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Objective. To analyze the relationships between alcohol misuse and two types of acute health care use—hospital admissions and emergency room (ER) episodes.
Data Sources/Study Setting. The first (2001/2002) and second (2004/2005) waves of the National Epidemiological Survey of Alcohol and Related Conditions (NESARC).
Study Design. Longitudinal study using a group of adults (18–60 years in Wave 1, $N=23{,}079$). Gender-stratified regression analysis adjusted for a range of covariates associated with health care use. First-difference methods corrected for potential omitted variable bias.
Data Collection. The target population of the NESARC was the civilian noninstitutionalized population aged 18 and older residing in the United States and the District of Columbia. The survey response rate was 81 percent in Wave 1 ($N=43{,}093$) and 65 percent in Wave 2 ($N=34{,}653$).
Principal Findings. Frequent drinking to intoxication was positively associated with hospital admissions for both men and women and increased the likelihood of using ER services for women. Alcohol dependence and/or abuse was related to higher use of ER services for both genders and increased hospitalizations for men.
Conclusions. These findings provide updated and nationally representative estimates of the relationships between alcohol misuse and health care use, and they underscore the potential implications of alcohol misuse on health care expenditures.

Key Words. Alcohol misuse, problem drinking, health care use, first-difference estimation

Alcohol consumption can affect health and health care use in both the short- and long-run. Although some studies show that moderate drinking is protective of health (Thun et al. 1997; Rimm 2000; Rehm, Greenfield, and Rogers 2001; Rehm et al. 2003), the primary public health concern with alcohol consumption is excessive drinking. Empirical studies have shown that alcohol misuse is associated with increased health care use through accidents and injuries in the short run (MacDonald et al. 1999; Vinson, Borges, and

Cherpitel 2003) and morbidity in the long run (Kessler et al. 1996; Thun et al. 1997; Rehm et al. 2003; Grant et al. 2004). In addition, alcohol can be a gateway to other substances, such as illegal drugs, which can also affect health (Kandel, Yamaguchi, and Chen 1992; Botvin et al. 2000). The societal costs of excessive alcohol consumption are substantial according to the latest available U.S. estimate (Harwood 2000), which placed the associated medical consequences at $19 billion in 1998.

Understanding the relationship between alcohol consumption and health care use is important for public policy. First, excessive alcohol consumption may lead to injury or death of the drinker, thereby raising their own health care costs. The most common example is drunk driving, but drinking may also lead to falls, fights, and even defenestration. Second, alcohol consumption can have spillover effects (i.e., externalities) on the health status of others, further raising overall health care costs. These negative externalities can justify public interventions to reduce excessive alcohol consumption on efficiency grounds. Public intervention improves efficiency if individuals who excessively use alcohol decrease their alcohol intake to levels that take into account the external effects their consumption has on others. Third, policy tools are available to curb externalities caused by excessive drinking (Manning et al. 1989). Policy makers could benefit from more and better information on how excessive alcohol consumption affects health care use, which is a major component of the total societal cost of alcohol consumption. To address this need for more and better information, we consider the following research questions: How does alcohol misuse affect the probability of having a hospital admission or emergency department episode? Do omitted variables bias standard regressions?

Research on the direct association between alcohol intake and health care use has been inconsistent (e.g., Haapanen-Niemi et al. 1999; Zarkin et al. 2004). Findings from a survey of enrollees of a large HMO indicated that current drinkers had lower inpatient and outpatient costs than nondrinkers

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and that the heaviest drinkers generated the lowest costs (Armstrong, Midanik, and Klatsky 1998; Rice et al. 2000; Hunkeler et al. 2001). Other studies have highlighted the negative consequences of alcohol use on emergency department episodes and hospitalizations, particularly among heavy or problematic drinkers (e.g., Fleming et al. 2000; Anzai et al. 2005; Cherpitel et al. 2006; French, Gumus, and Turner 2008). Several studies have identified a trend among heavy drinkers of lower use of preventive medical services and higher use of emergency care (e.g., Holroyd et al. 1997; Cryer et al. 1999; Alexandre et al. 2001; Urbanoski 2003; Merrick et al. 2008). Some authors argue that heavy drinkers are also slow to react to medical symptoms and postpone seeking medical care until health problems become serious (Armstrong, Midanik, and Klatsky 1998; Rice et al. 2000; Hunkeler et al. 2001).

The literature on alcohol use and either health or health care is subject to criticism. First, the estimated associations could be revealing a reverse effect whereby those in poor health may decrease their alcohol use. Findings that former drinkers use more health care than lifetime abstainers seem to support this pathway (Rice et al. 2000; Polen et al. 2001). Moreover, lifetime abstainers appear to have more health problems than drinkers (Fillmore et al. 1998). Alternatively, there is evidence that psychiatric disorders may lead to increases in alcohol intake (Gilman 2001). Second, estimates could suffer from omitted variable bias. If alcohol consumption and health status are jointly determined by unobserved factors (such as illegal drug use), then the estimated relationship between alcohol use and health care use will suffer from omitted variables bias. The main objective of this paper is to examine the associations between alcohol misuse and health care use by estimating first-difference models that directly address the problem of omitted variable bias. While reverse causality cannot be ruled out by the estimation of first-difference models, we explore the possibility of reverse causality through a secondary analysis.

METHODOLOGY

Conceptual Framework

In his seminal work, Grossman (1972) argued that individuals do not care about health care per se, but care about health. Grossman highlighted several features that distinguish the demand for health from the neoclassical demand of other consumption goods. First, consumers gain utility from healthy days and invest in health as part of human capital. Second, consumers are endowed with an initial health stock that depreciates over time, but that can be increased through investment. Third, health investments stem from a household production function that uses health care and other health inputs. The demand for health care is a derived demand for an input in the production of health.

We are interested in the effect of alcohol misuse on acute health care use. The standard assumption is that alcohol misuse affects health care demand through increased health problems (injuries, cancer, or mental problems). Under this framework, the demand for health care would be given by

$$HC = f(H(A, X), X) \tag{1}$$

where HC is acute health care services (emergency room [ER] visits and hospitalizations in our empirical model), H denotes health problems, A refers to alcohol misuse, and X captures individual sociodemographic characteristics that affect the consumption of health care both directly and indirectly. We expect alcohol misuse to increase health problems and thus lead to a higher demand for health care services.

Some authors have hypothesized that consumers who misuse alcohol may shun preventive or ambulatory health care to avoid scrutiny over their alcohol consumption (Armstrong, Midanik, and Klatsky 1998; Rice et al. 2000; Hunkeler et al. 2001). These consumers may not seek medical attention until health problems become acute and urgent care is needed. As a consequence, they are more likely to show up at the emergency department or be admitted to a hospital. The demand function above can be modified slightly to reflect this additional pathway:

$$HC = f(H(A, X), A, X) \tag{2}$$

In equation (2), $H(A, X)$ captures not only the higher risks of accidents, injuries, and morbidity associated with alcohol misuse but also the detrimental effects on health from delaying care. Moreover, given a particular health profile, individuals who misuse alcohol may be willing to substitute acute care for more predictable and less costly preventive/ambulatory care to avoid scrutiny. This substitution effect is captured by the second A in equation (2).

Rather than estimating equation (2), which is empirically daunting without imposing strong assumptions, we estimate the following reduced-form health care demand equation:

$$HC = f(A, X) \tag{3}$$

Reduced-form estimates identify the full association between alcohol misuse and health care use, but they cannot separate out the direct effect of alcohol on health, the effects resulting from delayed care, or the substitution between preventive and acute services. Structural-equation estimation is necessary to independently identify these effects. Unfortunately, like other related studies in the literature, data limitations do not allow us to distinguish between these alternative mechanisms.

Equation (3) intentionally excludes measures of health status and health-related behaviors (such as illegal drug use). If we adjusted for health status and chronic conditions, we would not be able to capture the full effect of alcohol misuse on health care demand. Such a specification would only be able to show evidence of a substitution effect between health care modalities, an effect we expect to be relatively minor.

Despite the conceptual appeal of reduced-form estimation, it still presents statistical challenges. First, alcohol use may be significantly correlated with important omitted variables (e.g., risk aversion, addictive tendencies, stress) that are also correlated with health care use. Failure to adjust for these important but unmeasured features will result in inconsistent coefficients due to omitted variable bias. Second, reverse causality from health status to alcohol misuse is also a possibility. Individuals in poor health may decrease their alcohol use. Likewise, some mental health problems may lead to increases in the intake of alcohol. Failure to control for health status before the decision to consume alcohol may result in an inability to prove causality. Finally, many studies have shown that men and women have different consumption patterns and effects from alcohol (e.g., Hupkens, Knibbe, and Drop 1993; Robbins and Martin 1993; Wilsnack et al. 2000). We therefore follow the medical literature and estimate separate equations for men and women (e.g., Doll 1998; Cherpitel 1999; Haapanen-Niemi et al. 1999).

Empirical Approach

We used pooled cross-sectional (linear probability) OLS and first-differencing techniques to estimate the association between alcohol misuse and health care use:

$$HC_{it} = \beta_0 + \beta_a A_{it} + X_{it}'\beta_x + c_i + \varepsilon_{it} \tag{4}$$

where HC_{it} is one of two measures of health care use (ER use or hospitalizations) for individual i in Wave t, A_{it} a measure of alcohol misuse, X_{it} a set of enabling and predisposing characteristics determining health care access (Andersen 1995), c_i an unobserved individual effect assumed constant over time, and ε_{it} an error term uncorrelated with A_{it} and X_{it}. β_0, β_a, and β_x are reduced-form parameters to estimate.

Because alcohol use may be correlated with important unmeasured variables likely to be associated with health care use, OLS is likely to produce inconsistent estimates of β_a. We took advantage of NESARC's panel structure to estimate β_a using a first-difference model:

$$(HC_{i2} - HC_{i1}) = \beta_a(A_{i2} - A_{i1}) + (X_{i2} - X_{i1})'\beta_x + \varepsilon_{it} \tag{5}$$

This first-difference equation eliminates time-invariant unobserved individual heterogeneity c_i from equation (4), thus improving consistency relative to OLS. We estimated equation (5) using linear probability models rather than logit fixed effects techniques because linear probability estimation allowed us to incorporate NESARC sample weights, to cluster standard errors around primary sample units, and to estimate marginal effects. We ran separate regressions for men and women.

Alcohol misuse is most likely to affect the use of health care services through changes in health status. The effect could also work through other channels, however, such as changes in employment status and health insurance. To acknowledge these possible mediating effects, we estimated three specifications of equation (5): a parsimonious specification considering just the unadjusted effect of changes in alcohol misuse on variations in health care use; a richer specification that adjusts for changes in enabling and predisposing characteristics (i.e., marital status, household composition, household equivalent income, education, health insurance, occupational status, region, urbanity, and time of interview); and a final augmented specification that also controls for between-wave variation in self-reported measures of health status, indicators for several health conditions, body mass index, and other risky health behaviors such as smoking and illegal drug use. These alternative specifications explore the role of individual observable characteristics and health conditions as possible mediating effects.

The econometric approach used in this paper addresses biases due to time-invariant omitted variables. First differencing, however, will not completely remove omitted variables bias if there are unmeasured changes in health conditions over time that simultaneously affect the demands for alcohol and health care. Such would be the case for individuals who curtail alcohol use because of a newly diagnosed disease, or individuals who respond to a mental health crisis by increasing their alcohol consumption. Another problem first-differencing does not rule out is reverse causality. To explore the sensitivity of our main results to reverse causality, we conducted a secondary analysis considering only a subsample of individuals less likely to have experienced negative health shocks between Waves 1 and 2 (i.e., those reporting good or better health in both waves). Other sensitivity analyses included testing for nonlinear and asymmetric effects of changes in alcohol misuse on health care variation between waves.

DATA

We analyzed data from Waves 1 and 2 of the NESARC. NESARC is a longitudinal survey of a representative sample of the U.S. population conducted by the Bureau of the Census on behalf of the National Institute on Alcohol Abuse and Alcoholism (Grant et al. 2003). The first round of interviews was fielded between August 2001 and May 2002, and the second was conducted between August 2004 and August 2005. In Wave 1, 43,093 individuals were interviewed face to face through computer-assisted personal interviewing. Of these, 34,653 were reinterviewed in Wave 2. NESARC targeted the civilian noninstitutionalized population aged 18 and older residing in the United States. The survey team made a special effort to contact persons who live in boarding houses, nontransient hotels and motels, shelters, facilities for housing workers, college quarters, and group homes. These persons are more likely than the general population to misuse alcohol. The overall survey response rate was 81 percent in Wave 1 and 65 percent in Wave 2 (the response rate of Wave 1 respondents in Wave 2 was 80 percent).

After excluding individuals who did not respond in Wave 2, women who were currently or had been pregnant within the past year in either wave, respondents not aged 18 – 60 in Wave 1, and respondents who did not provide valid responses to items of interest, the final analysis sample included 23,079 individuals (see Table S1 in Appendix). We selected the age of 60 as the cutoff age in Wave 1 because the levels of alcohol consumption that constitute alcohol misuse are lower for elderly individuals. For an analysis of the association between health care use and alcohol use among the elderly, see Balsa et al. (2008).

Measures

Health Care Use. We analyzed two health care use variables: any hospital admission and any emergency department episode, each measured over the past year. We constructed dichotomous measures from the counts reported in the surveys due to the overabundance of zeros and extreme outliers for a small number of observations.

Alcohol Misuse

We constructed two dichotomous indicators and one continuous measure of alcohol misuse. The first measure indicates heavy drinking. NIAAA recommends no more than two drinks per day for men and one drink per day for women and older people. One drink equals one 12-ounce bottle of beer or wine cooler, one 5-ounce glass of wine, or 1.5 ounces of 80-proof distilled spirits. Respondents were asked the average frequency (number of days) and intensity (drinks per episode) of alcohol use in the past 12 months. From the estimated average daily intake of alcohol we coded an indicator of heavy drinking as 1 if respondents exceeded the NIAAA recommendation. Abstainers and all other drinkers were coded as 0. The second measure indicated a diagnosis of alcohol abuse or dependence during the past year based on the diagnostic criteria suggested in the DSM-IV by the American Psychiatric Association (1994). All individuals screening positive for alcohol abuse or dependence were coded as 1, and all other individuals with nonmissing responses (including abstainers) were coded as 0. Finally, we constructed a measure of the number of days the respondent reported drinking to intoxication in the past year. Response categories ranged from "never in the last year" to "every day." The number of days drinking to intoxication was coded as the midpoint of the reported category. Abstainers were coded as 0.

Descriptive Statistics

Almost 8 percent of men in our sample were admitted to the hospital and over 19 percent visited an emergency department when considering averages across Waves 1 and 2 (see Table 1). Among women, the prevalence of health care use was slightly higher: 9.6 percent were admitted to the hospital and nearly 22 percent reported an emergency department episode. Both hospitalizations and ER episodes increased between the baseline and follow-up waves.

Among men, 8.9 percent were heavy drinkers in the pooled sample and 15.4 percent met the clinical diagnosis for abuse or dependence during the past year. Among women in the pooled Wave 1/Wave 2 sample, 6.2 percent were heavy drinkers and 6.4 percent screened positive for alcohol abuse or dependence. Rates of heavy drinking were similar in Waves 1 and 2, and Wave 2 showed a decrease in the average number of days with episodes of intoxication relative to Wave 1. On the other hand, rates of alcohol abuse or dependence were higher in Wave 2 when compared with Wave 1.

Our preferred specifications adjusted for a number of enabling and predisposing characteristics. Many of the trends observed in these character-

Table 1: Mean Values for All Analysis Variables

	Men (N= 10,879)		Women (N= 12,220)		
Variable	*Average w1 & w2*	*Difference w2 – w1*	*Average w1 & w2*	*Difference w2 – w1*	*Difference Men – Women (in Levels)*
Demographics					
Age	38.923		40.270		***
White	0.589		0.538		***
African American	0.160		0.221		***
Hispanic	0.201		0.194		*
Other race	0.050		0.047		*
Health care use (past year)					
Any hospitalization (%)	0.077	0.027***	0.096	0.020***	***
Any ER (%)	0.192	0.020***	0.216	0.028***	
Alcohol use (past year)					
Heavy drinking (%)	0.089	– 0.001	0.062	0.002	***
Alcohol abuse and/or dependence (%)	0.154	0.025***	0.064	0.008***	***
Days drinking to intoxication (10's)	0.822	– 0.086**	0.328	– 0.055**	***
Enabling and predisposing characteristics					
Married (%)	0.585	0.034***	0.527	0.012***	***
Divorced (%)	0.139	0.005***	0.208	0.011***	***
Widowed (%)	0.008	0.001**	0.035	0.005***	***
Single (%)	0.268	– 0.040***	0.230	– 0.027***	***
Number of children in household	0.749	– 0.134***	0.855	– 0.240***	***
Household equivalent income ($1,000)	15.796	– 0.890***	12.689	– 0.125	***
Household income imputed	0.076	– 0.035***	0.077	– 0.026***	
Less than high school (%)	0.127	– 0.007***	0.122	– 0.008***	
High school completed (%)	0.271	– 0.015***	0.267	– 0.020***	
Some post secondary education (%)	0.320	0.009***	0.348	0.011***	***

continued

Table 1. *Continued*

	Men (N= 10,879)		*Women (N= 12,220)*		
Variable	*Average w1 & w2*	*Difference w2 − w1*	*Average w1 & w2*	*Difference w2 − w1*	*Difference Men − Women (in Levels)*
College degree (%)	0.148	0.000	0.132	0.001	***
Graduate education (%)	0.135	0.013***	0.131	0.015***	
Private insurance (%)	0.720	0.018***	0.694	0.018***	***
Medicaid (%)	0.041	0.008***	0.085	0.007***	***
Medicare (%)	0.039	0.007***	0.047	0.010***	***
Military insurance (%)	0.040	0.004***	0.024	0.004***	***
Death in the family (%)	0.303	0.019***	0.330	0.008*	***
Worked past 12 months (%)	0.917	−0.020***	0.812	−0.020***	***
Currently employed (%)	0.843	−0.004	0.731	−0.011***	***
Currently unemployed (%)	0.043	−0.002	0.042	0.003	
Out of the labor force (%)	0.115	0.007***	0.229	0.009**	***
Disabled (%)	0.037	0.007***	0.048	0.012***	***
Retired (%)	0.041	0.024***	0.038	0.024***	***
In school (%)	0.067	−0.028***	0.076	−0.022***	***
Homemaker (%)	0.005	−0.001	0.140	−0.011***	***
Other activities (%)	0.017	−0.004***	0.024	0.001	***
Rural (%)	0.174	−0.026***	0.171	−0.022***	
Northeast (%)	0.179	−0.006	0.178	−0.011**	
Midwest (%)	0.206	−0.037***	0.200	−0.025***	**
South (%)	0.370	0.026***	0.378	0.002	
West (%)	0.245	0.017***	0.244	0.034***	
Year of interview	2002	3.064***	2002	3.043***	***
Interviewed in summer (%)	0.505	−0.179***	0.512	−0.139***	**
Interviewed in fall (%)	0.152	0.121***	0.138	0.102**	***

continued

Table 1. *Continued*

	Men (N= 10,879)		Women (N= 12,220)		
Variable	*Average w1 & w2*	*Difference w2 − w1*	*Average w1 & w2*	*Difference w2 − w1*	*Difference Men − Women (in Levels)*
Interviewed in winter (%)	0.018	0.028***	0.015	0.011***	**
Interviewed in spring (%)	0.325	0.029***	0.334	0.026***	**
Health endowment					
SF12 norm based physical disability scale	52.490	− 0.519***	51.286	− 0.845***	***
SF12 norm based mental disability scale	52.823	− 0.945***	50.532	− 1.148***	***
Major depression past year (%)	0.058	− 0.008***	0.115	− 0.010***	***
BMI	27.776	0.667***	27.544	0.865***	***
Self-perceived health (1 = max/5 = min)	2.166	0.137***	2.300	0.124***	***
Hypertension (%)	0.163	0.059***	0.181	0.057***	***
Gastritis (%)	0.030	0.002	0.053	0.000	***
Arthritis (%)	0.102	0.028***	0.170	0.046***	***
Heart problems (%)	0.050	0.009***	0.069	0.011***	***
Other health-related behaviors					
Smoker (%)	0.330	− 0.040***	0.232	− 0.023***	***
Any drug use (%)	0.095	0.016***	0.058	0.005**	***

Sample includes men and women aged 18–60 years in Wave 1 who completed a follow up interview in Wave 2 (excludes pregnant women). *T*- and *z*-tests were conducted to examine the statistical significance of differences between waves and between men and women.

***Difference statistically significant at 1%.

**Difference statistically significant at 5%.

*Difference statistically significant at 10%.

BMI, body mass index; ER, emergency room.

istics between Wave 1 and 2 were concordant with the aging of the NESARC population. The proportion of married, divorced, and widowed individuals increased from Wave 1 to Wave 2 and the number of children in households decreased. The sample population became slightly more educated, and there was an increase in the proportion of people out of the labor force, disabled, and retired. Average household income was lower and unemployment was higher in 2003–2004 relative to 2000–2001. There were statistically significant differences between men and women for most of the analysis variables.

First-difference effects are identified solely by individuals changing drinking status across waves. Table 2 shows that the number of men becoming heavy drinkers or weekly drinkers to intoxication in Wave 2 was not significantly different from the number of men who decreased these measures of alcohol use. On the other hand, the number of men with a new diagnosis of alcohol abuse or dependence in Wave 2 (N= 1,010) was higher than the number recovering from these conditions (N= 730). Among women, the flow of those becoming alcohol misusers in Wave 2 was in the same range as the flow of those reverting patterns of alcohol misuse. The men and women who became heavy drinkers, became alcohol dependent, or began drinking to intoxication weekly in Wave 2 experienced the highest increases in hospital-

Table 2: Changes in Health Care Use by Changes in Drinking Categories from Wave 1 to Wave 2

	Men (N= 10,879)			*Women (N= 12,200)*		
	N	*Any Hospital*	*Any ER*	*N*	*Any Hospital*	*Any ER*
Heavy drinking						
From 0 to 0	9,389	0.030	0.023	11,023	0.019	0.027
From 0 to 1	514	0.033	– 0.002	433	0.060	0.074
From 1 to 0	530	– 0.019	0.013	403	0.022	– 0.005
From 1 to 1	446	0.016	– 0.007	341	– 0.015	0.047
Alcohol abuse and/or dependence						
From 0 to 0	8,334	0.030	0.028	10,915	0.020	0.030
From 0 to 1	1,010	0.039	0.045	552	0.020	0.029
From 1 to 0	738	0.011	– 0.039	450	0.011	– 0.027
From 1 to 1	797	– 0.003	– 0.034	283	0.028	0.060
Weekly drinking to intoxication						
From 0 to 0	9,938	0.029	0.025	11,821	0.020	0.027
From 0 to 1	377	0.029	– 0.056	166	0.120	0.175
From 1 to 0	416	0.005	– 0.005	190	– 0.079	0.000
From 1 to 1	148	– 0.047	– 0.068	23	0.043	0.043

ER, emergency room.

izations between Waves 1 and 2. For women, shifts into any of these categories were associated with the highest rates of ER use. For men, highest ER use was evident among those with a new diagnosis of alcohol abuse or dependence, but not among individuals shifting into heavy drinking.

Results

For comparison, we start by presenting results from pooled OLS linear probability models, which do not control for potential omitted variable bias (equation [4]). Each cell in Table 3 reports the effect of a particular alcohol misuse measure on one of two indicators of acute health care use. The first three columns depict results for men and show the value of the estimated coefficients and standard errors given different sets of adjustors. We first estimated parsimonious versions of our benchmark OLS model without any controls (Column [1]); we then added controls for regional, interview, individual, and family characteristics (Column [2]); and finally controlled for health status and health-related behaviors (Column [3]). Columns (4)–(6) show results for women adjusting subsequently for the same nested sets of controls. In these regressions, standard errors are clustered at the individual level to control for heteroskedasticity. Estimates in Columns (2) and (5) are bolded to highlight our preferred specification. Results from the pooled OLS model showed no robust associations between heavy drinking and use of acute health care. There was some evidence of a positive effect of heavy drinking on ER services for women, but only at a 10 percent significance level. Having a diagnosis of alcohol abuse or dependence, on the other hand, increased the likelihood of using ER services both for men and women, but it was not related to hospitalizations. Frequency of drinking to intoxication predicted increases both in the likelihood of being hospitalized and in the use of ER services.

Table 4 reports first-difference estimates (equation [5]) with the same nested specifications as in Table 3. We first describe results in our preferred (bolded) specification and then comment on the comparisons between specifications. Overall, the results from the first-difference models were very similar to the pooled OLS results. Again, becoming a heavy drinker was not robustly related to any of the health care measures analyzed, although at a $p<.10$, heavy drinking was positively associated with female hospitalizations. Men meeting the criteria for alcohol abuse or dependence were 3.1 percentage points more likely than other men to use ER services ($p<.05$) and 1.7 percentage points more likely to be hospitalized ($p<.10$). These effects represented increases of

Table 3: Pooled OLS (Linear Probability) Effects of Alcohol Misuse on Hospitalizations and ER Use. Alternative Specifications Adjusting Subsequently for Nested Sets of Controls

	Men (N= 21,748)			*Women (N= 24,386)*		
	Unadjusted Pooled OLS Effect (1)	*+ SES, Family, Region (2)*	*+ Health, Health Behaviors (3)*	*Unadjusted Pooled OLS Effect (4)*	*+ SES, Family, Region (5)*	*+ Health, Health Behaviors (6)*
Dependent variable: any hospitalization						
Heavy drinking	0.013*	**0.010**	0.005	0.012	**0.015**	0.011
	(0.008)	**(0.008)**	(0.008)	(0.010)	**(0.010)**	(0.009)
Alcohol abuse and/or dependence	0.010	**0.011***	0.002	0.007	**0.011**	– 0.003
	(0.006)	**(0.006)**	(0.006)	(0.009)	**(0.009)**	(0.009)
Days drinking to intoxication (10s)	0.002***	**0.002*****	0.001**	0.003***	**0.003*****	0.002**
	(0.001)	**(0.001)**	(0.001)	(0.001)	**(0.001)**	(0.001)
Dependent variable: any ER use						
Heavy drinking	0.016	**0.007**	– 0.012	0.026*	**0.026***	0.010
	(0.013)	**(0.012)**	(0.012)	(0.015)	**(0.014)**	(0.014)
Alcohol abuse and/or dependence	0.036***	**0.033*****	0.011	0.048***	**0.045*****	0.013
	(0.010)	**(0.010)**	(0.010)	(0.015)	**(0.014)**	(0.014)
Days drinking to intoxication (10s)	0.002**	**0.002***	0.000	0.004**	**0.004****	0.002*
	(0.001)	**(0.001)**	(0.001)	(0.002)	**(0.002)**	(0.001)

Standard errors in parentheses. Columns (1) and (4) report unadjusted pooled OLS effects, columns (2) and (5) adjust regressions by enabling and predisposing characteristics as listed in Table 1, and columns (3) and (6) adjust in addition for health status and health-related behaviors other than alcohol.

***Significant at 1%.

**Significant at 5%.

*Significant at 10%.

Bolded estimates denote preferred specification.

ER, emergency room.

Table 4: First Difference Linear Probability Effects of Alcohol Misuse on Hospitalizations and ER Use. Alternative Specifications Adjusting Subsequently for Nested Sets of Controls

	Men (N= 10,879)			*Women (N= 12,200)*		
	Unadjusted First-Difference Effect (1)	*+ SES, Family, Region (2)*	*+ Health, Health Behaviors (3)*	*Unadjusted First-Difference Effect (4)*	*+ SES, Family, Region (5)*	*+ Health, Health Behaviors (6)*
Dependent variable: any hospitalization						
Heavy drinking	0.021	**0.019**	0.014	0.031*	**0.030***	0.023
	(0.013)	**(0.013)**	(0.012)	(0.018)	**(0.018)**	(0.018)
Alcohol abuse and/or dependence	0.017*	**0.017***	0.009	0.002	**0.002**	−0.003
	(0.010)	**(0.009)**	(0.009)	(0.015)	**(0.014)**	(0.013)
Days drinking to intoxication	0.002***	**0.003*****	0.002***	0.004***	**0.004*****	0.004***
	(0.001)	**(0.001)**	(0.001)	(0.001)	**(0.001)**	(0.001)
Dependent variable: any ER use						
Heavy drinking	−0.016	**−0.018**	−0.026	0.032	**0.031**	0.017
	(0.019)	**(0.019)**	(0.018)	(0.023)	**(0.024)**	(0.024)
Alcohol abuse and/or dependence	0.032**	**0.031****	0.021	0.034*	**0.034***	0.022
	(0.015)	**(0.015)**	(0.015)	(0.020)	**(0.020)**	(0.021)
Days drinking to intoxication	0.000	**0.000**	−0.000	0.005**	**0.004****	0.004**
	(0.001)	**(0.001)**	(0.001)	(0.002)	**(0.002)**	(0.002)

Standard errors in parentheses. Columns (1) and (4) report unadjusted first difference effects, columns (2) and (5) adjust regressions by enabling and predisposing characteristics as listed in Table 1, and columns (3) and (6) adjust in addition for health status and health-related behaviors other than alcohol.

***Significant at 1%.

**Significant at 5%.

*Significant at 10%.

Bolded estimates denote preferred specification.

ER, emergency room.

16 and 22 percent, respectively, relative to the mean. Alcohol abuse or dependence among women was associated with an increase of 3.4 percentage points in the use of ER services ($p<.10$), a 16 percent increase relative to the mean. Finally, the number of days drinking to intoxication had a strong statistical influence on the likelihood of hospitalizations for men and women ($p<.01$), and on the likelihood of using ER services among women ($p<.05$). Increasing the frequency of alcohol intoxication by 10 days per year raised the probability of being hospitalized by 0.3 and 0.4 percentage points for men and women, respectively (in both cases a 4 percent increase relative to the mean), and was associated with a 0.4 percentage point increase in the probability of using ER services for women (a 2 percent increase in terms of the mean).

The similarity between coefficients in Columns (1) and (2) and in Columns (4) and (5) of Table 4 reveals that the effects of alcohol misuse on ER use and hospitalizations were not mediated by enabling and predisposing characteristics. The effects of drinking to intoxication on ER visits and hospitalizations were also robust to the inclusion of health controls (compare Columns [2] and [3], and Columns [5] and [6]). However, all estimates of the effect of alcohol abuse or dependence lost statistical significance and became smaller in magnitude after adjusting for health and health behaviors. If alcohol misuse affects the demand for health care through increased disease severity, it seems reasonable to exclude health status from the regressions in order to assess the full effect of alcohol misuse on health services use. On the other hand, individuals in poor health may be less likely to misuse alcohol and more likely to demand health care. In this latter case, failure to control for health endowment and health behaviors will result in spurious estimates of the effect of alcohol use on health care demand. The key is whether health status precedes the diagnosis of alcohol abuse or dependence or if it is a consequence of this condition. Unfortunately, neither pooled OLS nor first difference models can completely address this issue. But reverse causality from health to alcohol use is likely to be smaller in a first-difference model than in a pooled OLS specification because first-differencing purges coefficients from unobserved measures of health status that remain constant over time.

Sensitivity Analysis

We performed a number of sensitivity checks to examine the robustness of our findings. First, we explored the presence of nonlinearities in the effects of frequency of drinking to intoxication by categorizing individuals into several excluding categories: never drank to intoxication in the past year; drank to intoxication at least once a month but less than once a week; drank to intoxication exactly once a week; and drank to intoxication 2 or more days per week. We ran a first-differencing model analyzing the effects of the three latter categories on acute health care use. Results are reported in Appendix Table S2 under the same format as Table 4. For men, drinking to intoxication twice a week or more was associated with a 5.3 percentage point increase (68 percent) in the likelihood of any hospitalization ($p<.01$) and drinking monthly to intoxication raised the likelihood of using ER, but at a lower level of statistical significance ($p<.10$). In the case of women, drinking to intoxication at least once a week was strongly associated, both statistically and economically, with hospitalization events ($p<.01$) and with use of the ER ($p<.05$). Drinking to intoxication once a week increased hospitalizations by 13.2 percentage points (138 percent) among women. Interestingly, in the case of women, drinking to intoxication on a monthly basis was associated with a *decrease* in the use of ER services of 6 percentage points. Recall that the comparison group includes nonheavy drinkers and abstainers, and the literature has identified some beneficial effects of moderate drinking (Simons et al. 1996; Thun et al. 1997; Doll 1998; Klatsky 1999; Rimm 2000; Rehm, Greenfield, and Rogers 2001; Rehm et al. 2003; Malinski et al. 2004). Thus, it is possible that the beneficial effects of occasional drinking, even though it is drinking to intoxication, exceed the harmful effects stemming from the intoxicating episodes.

Second, to examine the potential for reverse causality, we reran equation (5) using only those individuals who self-reported to be in good health or better in both waves. The idea was to remove observations in which negative health status change may have led to alcohol misuse change while controlling for enabling and predisposing characteristics. Imposing this condition, the analysis subsamples decreased to 7,570 men and 8,530 women. Results are reported in column 2 of Appendix Tables S3 (men) and A4 (women). To make comparisons simple, the first column in these tables redisplays results from the preferred specification in our first-difference models (Table 4). Drinking to intoxication continued to be significantly associated with any hospitalizations for both genders ($p<.05$), but not with ER use. As in Table 4, a diagnosis of alcohol abuse or dependence increased the likelihood of using ER services for both genders ($p<.05$) and was associated with higher rates of hospitalizations among men ($p<.10$). In addition, heavy drinking increased the probability of using the ER among women.

Third, we examined whether the effects of increases and decreases in alcohol misuse on changes in health care use were of similar magnitude. For this purpose, we interacted the change score for each of our alcohol misuse measures with a dummy variable indicating whether the change was positive or negative. Results, available upon request, did not display evidence of asymmetric effects, although statistical power was a concern in some specifications.

Finally, we investigated whether the estimated association between alcohol abuse and/or dependence and the outcome variables could be structurally connected due to the way alcohol abuse and dependence were defined. We identified four questions in the NESARC instrument for DSM-IV alcohol abuse and dependence that could lead to a possible spurious correlation between problem drinking and health care use: "Ever continue to drink even though causing health problems . . .," "Ever continue to drink despite prior blackout . . .," "Ever in situations that increased chances of getting hurt while drinking or after drinking . . .," and "Ever get into a physical fight when or right after drinking . . ." Each of these situations could lead to an emergency room or hospitalization episode. However, for individuals with equally serious drinking problems, those experiencing the outcome of a hospital admission might end up being categorized as abusers/alcohol dependent, while those not seeking care might not. To assess the potential sensitivity of our results to this problem, we redefined alcohol abuse and/or dependence excluding the items potentially associated to a hospital admission or an emergency department episode. The difference in the diagnoses of alcohol abuse and/or dependence with and without the health-related items was of 0.006 in Wave 1 and 0.005 in Wave 2 (around 0.5 and 0.4 percent of the Wave 1 and Wave 2 prevalence, respectively). We repeated the analysis using the modified abuse/dependence measure as the main explanatory variable, and our core estimates remained robust to this alternative specification.

Discussion

This study uses longitudinal data from a large and nationally representative survey to examine the effects of alcohol misuse on two relatively common, easily understood, and expensive health care measures: inpatient hospital admissions and emergency department episodes. Potential omitted variable bias is addressed in the analysis through the use of first-differencing estimation techniques. Our estimates improve upon those in prior studies, which are based primarily on bivariate relationships and conventional multivariate regression techniques that fail to address the potential endogeneity of alcohol use. In addition, many of the published studies have analyzed samples that are not nationally representative of the adult population in the United States (Holroyd et al. 1997; Cherpitel 1999; Anzai et al. 2005; French, Gumus, and Turner 2008).

Overall, our findings showed evidence of a positive association between alcohol misuse (measured either by drinking to intoxication or by having a diagnosis of alcohol abuse or dependence) and use of acute health care services. Our strongest result, which was robust to adjustments for health status and behaviors, highlighted the significant consequences that drinking to intoxication has on the use of inpatient health care (both for men and women). We also found strong evidence that having a condition of alcohol abuse or dependence raises the probability of an ER episode (for men and women) and a hospital stay (for men only).

Counter to our expectations, we did not find any major differences between pooled OLS estimates and first-difference estimates, suggesting that omitted variables bias is not an important concern after controlling for a set of enabling and predisposing characteristics. We also did not find stark differences in results for men and women. The effects of alcohol abuse or dependence on hospitalizations and use of ER services were more robust for men than for women, but the weaker findings for women could be the result of lower statistical power (e.g., half as many women had an alcohol abuse or dependence diagnosis as did men). Drinking to intoxication had a positive and statistically significant effect on the use of inpatient care both for women and men, but the effects were stronger for women. In addition, drinking to intoxication increased the likelihood of ER use for women, but not for men.

Like most empirical studies with secondary data, this research is not without limitations or simplifying assumptions. First, measures of alcohol consumption and health care use 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. Heavy drinkers can under-report health care use to avoid scrutiny of their problematic drinking or those more likely to experience consequences related to drinking could under-report their alcohol use. Even if there is no correlation between misreports in alcohol and health care use measures, classical measurement error can bias coefficients toward zero (Greene 2003). Second, our methodology addresses possible biases due to unobservable time invariant heterogeneity. However, first-difference models are not able to account for any time varying heterogeneity, so this could be a potential source of remaining bias in our estimates. Moreover, first-difference models cannot address potential reverse causality running from health status to alcohol misuse. We empirically examined this issue (at least partially) via alternative samples and specifications and did not find evidence of reverse causality.

In summary, the present paper provides updated and statistically rigorous estimates of the relationships between alcohol misuse, hospitalizations, and emergency department episodes. Building on previous research, the findings offer further justification for investment in alcohol treatment and prevention, both for men and women. Health care providers, employers, and policy makers should consider the health care costs of alcohol misuse when designing alcohol policies and programs.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.
Table S1: Sample Definition.

Table S2: First Difference Effects of Frequency of Drinking to Intoxication on Hospitalizations and ER Use. Alternative Specifications Adjusting Subsequently for Nested Sets of Controls.

Table S3: Sensitivity Analyses for Men. All Specifications Adjust for Enabling and Predisposing Characteristics But Not for Health and Health Behaviors.

Table S4: Sensitivity Analyses for Women. All Specifications Adjust for Enabling and Predisposing Characteristics But Not for Health and Health Behaviors.