Relationship of Life-Course Drinking Patterns to Diabetes, Heart Problems, and Hypertension Among Those 40 and Older in the 2005 U.S. National Alcohol Survey*

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ABSTRACT. Objective: The goal of this study was to estimate relationships between life-course drinking patterns and the risks of self-reported diabetes, heart problems, and hypertension. **Method:** Respondents to the 2005 National Alcohol Survey, age 40 and older, reported ever having a doctor or health professional diagnose each of the health-problem outcomes. Retrospective earlier-life drinking patterns were characterized by lifetime abstinence and the frequency of 5+ drinking days (i.e., days on which five or more drinks were consumed) in the respondent's teens, 20s, and 30s. Past-year drinking patterns were measured through intake volume and 5+ days. Potential confounders in the domains of demographics, socioeconomic resources, and other health-risk variables—that is, depression, distress, sense of coherence, body mass index, tobacco use, marijuana use, childhood abuse, and family history of alcohol problems—were controlled through propensity-score matching. **Results:**

After matching, lifetime abstainers were found to be at increased risk of diabetes compared with both lifetime and current moderate drinkers. Exdrinkers were found to be at increased risk of diabetes, heart problems, and hypertension. Higher volume drinkers without monthly 5+ days were found to be at reduced risk of diabetes relative to moderate-volume current drinkers. Heavy-occasion drinkers were found to be at increased risk of hypertension. **Conclusions:** Regular lower quantity alcohol intake may be protective against adult onset of diabetes, but no evidence of protection from heart problems or hypertension was found. Both life course-defined and past year-defined drinking groups exhibit substantial clustering of confounding risk variables, indicating the need for modeling strategies like propensity-score matching. Increased risks among exdrinkers suggest a substantial “sick-quitter” effect. (*J. Stud. Alcohol Drugs*, 71, 515-525, 2010)

THE RELATIONSHIPS BETWEEN alcohol-consumption measures and health outcomes have been studied extensively and include findings of both protective and harmful effects for heart disease and a number of related conditions resulting in the well-known J-shaped curve (Corrao et al., 2004). However, this literature has remained less than conclusive as a result of poor alcohol-intake measurement (Fillmore et al., 2006); rarely including current drinking pattern information (Rehm et al., 2006); a lack of lifetime drinking assessment, including not differentiating former drinkers from lifetime abstainers (Fan et al., 2006; Fillmore et al., 2006); and containing inconsistent and incomplete controls for relevant and correlated confounders (Naimi et al., 2005).

Previous studies have mainly considered average volume and have generally found a J-shaped curve for coronary heart disease (Rehm et al., 2003). However, the pattern of drinking is likely important, with more recent studies finding a reduced risk for higher frequencies of moderate amounts and increased risk from heavy occasions (Breslow and Graubard, 2008; Dorn et al., 2007). Heavy drinking, especially daily drinking and drinking without food, has also been linked to

increased risk of hypertension (Chen et al., 2008; Stewart et al., 2008), an important risk factor for coronary heart disease (Stranges et al., 2004). Alcohol consumption has also been found to be associated with higher levels of high-density lipoprotein cholesterol, seen as a key potential mechanism for any cardioprotective effects (Burr et al., 1986; Djoussé et al., 2004). Moderate drinking has been found to be associated with a decreased risk of type 2 diabetes (Howard et al., 2004), whereas heavy episodic drinking has been associated with an increased risk (Hodge et al., 2006). Moderate alcohol use has also been found to reduce the risk of mortality and morbidity from coronary heart disease among people with diabetes, who have an elevated risk of coronary heart disease (Howard et al., 2004; Valmadrid et al., 1999). Important for the current study, which lacks dietary intake measures, is that a recent study found the protective effect of alcohol on type 2 diabetes was strengthened by the inclusion of dietary-pattern measures (Imamura et al., 2009).

A key issue in this literature has been the “sick-quitter” effect (Shaper et al., 1988). This describes a phenomenon in which individuals who experience health problems, whether caused by alcohol or not, quit drinking because of their health problems and are measured as current abstainers in baseline interviews. This effect has been shown to bias results toward finding a protective effect of current drinking (Gmel et al., 2003). It should be recognized that the term *sick quitter* is misleading, in that the phenomenon, first described by Shaper and colleagues (1988), conceptualizes a downward drift from heavy drinking to moderate drinking

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and then to no drinking or occasional drinking over time under the influence of accumulating health problems and deteriorating health in general (Shaper, 1990). Therefore, even if the difficult task of identifying lifetime abstainers (Rehm et al., 2008) is accomplished, there is still a need to understand the life-course patterns of alcohol use for both current and former drinkers. In particular, it should be recognized that, in a life-course perspective, former drinkers are a type of drinker, not a type of abstainer, which they would be conceptualized as in a current drinking perspective. When ill health leads to quitting drinking, the drinkers who are most at risk for mortality or morbidity outcomes are removed from the pool of current drinkers. Lifetime abstainers cannot similarly select themselves out of this category as their health declines, leading to a bias toward a protective effect of current drinking, even when former drinkers are clearly identified. Life-course drinking patterns may also be particularly important for assessing the effects of heavy drinking (Embersson et al., 2005), because this type of drinking exhibits less stability over time than more moderate patterns (Kerr et al., 2002).

The present study uses two different approaches to estimating the effects of alcohol on health outcomes. First, retrospectively assessed earlier life drinking patterns are compared using propensity-score matched groups to predict accumulated heart disease-related health outcomes (Hudson et al., 2005). Second, groups defined by current drinking patterns are compared using propensity-score models, where earlier life drinking patterns are included with the control variables. The 2005 U.S. National Alcohol Survey includes questions on whether a health professional has ever diagnosed heart problems, diabetes, or hypertension and a detailed assessment of current drinking and heavy drinking during the respondent's teens, 20s, and 30s. Using National Alcohol Survey data in this study, respondents age 40 and older can, therefore, be classified by their drinking patterns up to this age as well as by their current drinking. The 2005 National Alcohol Survey also includes a variety of demographic, socioeconomic resource, and other health-related risk-factor measures. These important confounders are highly clustered and are not balanced across earlier life drinking groups. Propensity-score matching procedures are used to construct comparable groups by both earlier life and current drinking patterns for analyses of the three health outcomes and to remove individuals with clusters of confounding variables that are highly dissimilar to the control group. This step is essential in enabling valid estimates of alcohol's effects.

Method

Data

The 2005 National Alcohol Survey, conducted in 2005 and 2006 by DataStat Inc., is a national household computer-

assisted telephone-interview survey of persons age 18 and older. Data were collected from 6,919 respondents using list-assisted random digit dialing with a sampling frame of all 50 states and the District of Columbia. The design oversamples African Americans, Hispanics, and low-population states, and the American Association for Public Opinion Research (2000) Cooperation Rate 3 was 56%. Examining self-reported health conditions as the main outcomes, the current study focused on people at middle age and older, and the analysis was restricted to individuals age 40 and older ($N = 4,316$). Of this sample, 78 people were excluded from the analysis because they were missing information on earlier life heavy drinking, and 155 people were excluded because of missing data on variables required for constructing the propensity score. This resulted in an available sample size of 4,083.

Measures

Earlier life heavy drinking exposures were categorized into five groups: (a) lifetime abstainers; (b) those never reporting 5+ drinks in a day at least monthly in their teens, 20s, or 30s (never heavy); (c) those reporting 5+ drinks in a day monthly in their teens, 20s, or 30s but never 5+ weekly (less heavy); (d) those reporting 5+ drinks in a day at least weekly in their teens or 20s but not for the 30s (young heavy); and (e) those reporting 5+ drinks in a day at least weekly in their 30s (heavy 30s). Individuals were classified into the five categories based on whether they had consumed any alcoholic beverages during their entire lifetime and a series of three questions asking the frequency of consuming five or more drinks on one occasion during one's teens, 20s, and 30s, with options ranging from "nearly every day," "three or four times a week," "one or two times a week," "one to three times a month" to "once a year" and "never." Current drinking status was elicited from the monthly alcohol volume and the frequency of drinking five or more drinks during the last 12 months. Alcohol volume was calculated from beverage-specific graduated frequency questions (Greenfield, 2000) and adjusted for estimated drink alcohol content by beverage type and context using data from methodological studies of drink alcohol content for both home (Kerr et al., 2005, 2009) and on-premise (Kerr et al., 2008) drinks. Individuals were classified into six current drinking groups: (a) lifetime abstainers, (b) exdrinkers, (c) average volume of less than 2 drinks per month (occasional), (d) average volume of 2 to less than 30 drinks per month and never 5+ monthly (moderate volume), (e) average volume of 30 or more drinks per month and never 5+ monthly (higher volume), and (f) 5+ at least monthly (heavy occasion).

Three health condition measures were examined as outcomes: (a) any heart or coronary problem, (b) diabetes, and (c) hypertension, also called high blood pressure. The three health conditions were asked about in a series of ques-

tions phrased as “Have you ever been told by a doctor or other health professional that you had (*condition*)?” Potential confounders were divided into three groups: demographic characteristics, socioeconomic resources, and health-related risk factors. Table 1 lists the 25 variables that were used to construct the propensity score used as the balancing factor between the matched groups for the earlier life drinking exposure categories. These variables plus the earlier life drinking exposure groups were used to construct the propensity scores for the current drinking exposure groups.

Eight demographic variables were considered as potential predictors of earlier life heavy drinking status, with categories shown in Table 1. Four variables were used to characterize each individual's socioeconomic resources: educational attainment, past-year income, lifetime homelessness, and current health insurance type. The 2005 U.S. federal poverty guidelines, incorporating household size, were used to classify the household income of respondents into three categories plus a “missing” category for those who did not answer.

Altogether we selected 13 additional variables as potential health-risk confounders, including all available variables potentially related to heart problems, such as sense of coherence (Wainwright et al., 2008), depression (Kuper et al., 2009), and childhood abuse (Dong et al., 2004). Tobacco smoking was described by years of smoking and the mean number of cigarettes per year. Because only the year of last smoking was available for smokers, the age at onset of smoking was assumed to be 15 in calculating years of use. An indicator for any lifetime marijuana use was included. Body mass index was a continuous measure created using an individual's self-reported weight and height. Three measures of depression were included: a short eight-item version of the Center for Epidemiology Studies–Depression scale, with values ranging from 0 to 24; a current depression measure, based on whether the respondent had 2 consecutive weeks or more during which she or he felt sad, blue, or depressed during the past year; and a chronic-depression measure, based on a question asking whether the respondent had 2 years or more in their lifetime when she or he felt depressed or sad most days. Distress was assessed by a question on how much distress the respondent is currently experiencing, with four options from *none* to *a great deal* (range: 0–3). The Sense of Coherence scale (Midanik and Zabkiewicz, 2009) was based on four questions asking how often individuals (a) felt they were being treated unfairly, (b) were in a situation in which they did not know what to do, (c) felt bad things always happened to them, and (d) felt that things in daily life have little meaning. Two dichotomous variables regarding childhood abuse were based on questions asking separately whether the respondent was hit with something or beaten up (physical abuse) and whether the respondent was forced to have sex against her or his will (sexual abuse) during childhood and adolescence. Alcoholism in the parents and grandparents was

elicited from questions asking whether the respondent's biological father or mother and grandfather or grandmother had been a problem drinker, regardless of whether the respondent had lived with them.

Analyses

Introduced by Rosenbaum and Rubin (1983), propensity score–based methods help to adjust for selection bias caused by confounding variables associated with both the exposure and outcome. Given a propensity score, normally the predicted probability of binary category or multicategory treatment/exposure, it was shown the conditional distribution of confounders is independent from the treatment/exposure assignment (Rosenbaum and Rubin, 1983). The propensity-score adjustment is thus sufficient to remove bias resulting from all observed covariates. Rubin (1973) has shown that if the variance-covariance matrices of covariates in treatment and control groups are unequal, then adjustment on a propensity-score matched sample is more robust and relies less on the model's extrapolation than model-based adjustment on a random sample (Rosenbaum and Rubin, 1983). The propensity-score method is particularly useful when there are a large number of covariates in the model, as is the case here.

All covariate measures for the drinking exposure groups are listed in Table 1 and Table 2, which also show the proportions or mean values across the earlier life and current drinking exposure groups and report an overall *F* test of differences in the means. All available confounders that were potentially related to disease outcomes were used in constructing the propensity scores. These included some covariates that were strongly related to the exposure but may be only weakly related to the outcomes, as the literature suggests that any covariates related to the exposure should not be excluded unless they are known a priori to be unrelated to the outcome (Brookhart et al., 2006). To construct the propensity scores for earlier life drinking exposures, multiple logistic regression models were estimated for each of the four group comparisons. These models included 38 covariates representing the 25 demographic and health-risk measures (some measures were represented by multiple indicator variables). These covariates, together with the earlier life drinking exposure indicators (excluding lifetime abstainers) were then used to create propensity-score models for the current drinking exposure measures. Following a method suggested by Rubin (1997), in the case of earlier life drinking exposure matching, propensity scores were created separately for four pairwise comparisons predicting lifetime abstainer, less-heavy drinker, young heavy drinker, and heavy-in-30s drinker, with the never-heavy group as the reference. The selection of never heavy as the reference group was based on this group having the largest sample size ($n = 1,876$) compared with the other four groups (n s from 433

TABLE 1. Prevalence and means across earlier life heavy drinking pattern categories, before propensity-score matching

Variable	Lifetime abstainers (<i>n</i> = 638)	Never heavy ^a (<i>n</i> = 1,876)	Less heavy ^b (<i>n</i> = 626)	Young heavy ^c (<i>n</i> = 433)	Heavy 30s ^d (<i>n</i> = 510)	<i>F</i>
Demographics						
Gender male, %	26.8	33.5	59.6	66.1	76.1	147.12***
Age, <i>M</i>	59.1	58.5	53.6	51.5	54.9	56.65***
Ethnicity						
White and other, %	52.5	70.0	82.3	79.7	70.0	40.98***
Hispanic, %	26.8	12.5	11.0	11.8	14.5	23.33***
Black, %	20.7	17.3	6.7	8.5	15.5	18.27***
Married, %	55.3	57.7	64.4	69.1	59.8	7.01***
Employment						
Employed, %	41.2	55.3	69.6	70.2	53.5	36.4***
Unemployed, %	16.1	10.2	9.9	14.3	22.2	15.85***
Retired, %	30.7	29.4	18.1	13.6	22.4	19.88***
Homemaker, %	11.9	5.0	2.4	1.8	2.0	23.65***
Religion						
Protestant, %	54.2	50.6	42.8	45.0	40.4	8.87***
Catholic, %	24.0	26.0	30.0	27.7	30.6	2.56*
Other religion, %	16.1	14.6	12.3	14.1	13.3	1.08
No religion, %	5.6	8.8	14.9	13.2	15.7	13.17***
Region						
Northeast, %	13.5	19.2	21.6	18.7	20.4	4.03**
Midwest, %	16.6	25.9	28.1	27.5	26.7	7.56***
South, %	48.9	37.6	28.0	35.6	32.0	17.01***
Mountain, %	8.9	7.1	11.7	9.7	8.2	3.37**
Pacific, %	12.1	10.1	10.7	8.5	12.7	1.56
Born in United States, %	73.8	88.0	90.4	92.6	88.0	29.69***
Socioeconomic resources						
Education						
<High school graduate, %	25.7	9.5	7.5	10.6	15.7	35.07***
High school graduate, %	35.0	27.8	27.5	27.9	30.6	3.45**
Some college, %	20.1	23.8	24.1	29.1	28.8	4.39**
College graduate, %	19.3	38.9	40.9	32.3	24.9	29.48***
Family income, past year						
Below poverty, %	25.7	10.9	7.5	9.5	15.1	31.13***
1×-2× poverty, %	20.7	16.6	13.1	13.9	17.4	3.99**
2× poverty, %	33.9	57.7	71.1	69.3	60.8	58.14***
Missing, %	19.7	14.8	8.3	7.4	6.7	18.86***
Homelessness ever lifetime, %	7.1	5.1	6.9	11.3	17.6	25.54***
Health insurance						
No coverage, %	16.8	9.1	10.2	12.0	14.1	8.21***
Public, %	39.5	33.3	22.0	18.5	34.3	21.44***
Private, %	39.2	53.5	64.7	66.1	48.2	30.13***
Health-related risk factors						
Years of smoking, <i>M</i>	8.1	13.8	18.8	19.2	26.7	96.64***
No. of cigarettes when smoking, <i>M</i>	3.2	6.6	10.5	12.3	16.7	114.04***
Marijuana use ever, lifetime, %	6.4	20.4	44.6	52.4	48.0	144.61***
BMI, <i>M</i>	28.1	27.2	27.6	28.3	28.2	7.65***
CES-D scale, <i>M</i>	3.94	3.42	3.42	3.73	4.89	15.45***
Current depression, %	17.7	15.6	15.3	16.2	23.1	4.54**
Chronic depression, %	20.2	16.4	16.6	21.5	30.2	13.42***
Distress, <i>M</i>	1.07	1.22	1.23	1.36	1.31	7.57***
Sense of coherence, <i>M</i>	4.18	4.27	4.25	4.20	4.10	7.38***
Childhood physical abuse, %	13.3	17.5	28.4	33.0	35.1	37.55***
Childhood sexual abuse, %	5.3	7.4	8.3	11.1	12.7	6.80***
Alcoholism in parent, %	16.1	19.3	22.0	24.7	35.5	19.61***
Alcoholism in grandparent, %	4.4	7.3	12.1	13.2	14.3	14.41***

Notes: BMI = body mass index; CES-D = Center for Epidemiology Studies–Depression scale. ^aNever heavy = never 5+ monthly or more during teens/20s/30s; ^bless heavy = 5+ monthly but not weekly during teens/20s/30s; ^cyoung heavy = 5+ weekly or more during teens/20s, but not 30s; ^dheavy 30s = 5+ weekly or more during 30s.

p* < .05; *p* < .01; ****p* < .001.

to 638), thus providing the largest pool for matching. Furthermore, this group can be considered as a proxy for lifetime moderate drinking in comparison with lifetime abstainers and three types of heavy drinkers. Likewise, in the exposure matching for current drinking, moderate volume drinkers ($n = 1,194$) were used as the reference group in the pairwise comparisons with groups of lifetime abstainers, exdrinkers, occasional, higher volume, and heavy-occasion drinkers.

Once the propensity scores were created for each comparison, we matched the control group (never heavy or moderate) to each of the other drinking exposure groups. The logit form of the estimated probability was used to match the exposed and nonexposed groups, following suggestions in the literature (D'Agostino, 1998; Rosenbaum and Rubin, 1985). The propensity-score matching was implemented in Stata 10 (StataCorp LP, College Station, TX) with the user-written command PSMATCH2 (Leuven and Sianesi, 2003). Several methods of matching were carried out and the one generating the best matching (nearest available one-to-one matching within the caliper) was chosen. Following this matching approach, we randomly ordered the exposed and nonexposed groups and defined a common support region as 0.1 of the predicted probability. The caliper width used here, equivalent to 5%-10% of the standard deviation of the probability for the combined groups, is more conservative than the usual 20% recommendation (Rosenbaum and Rubin, 1985). The case in the nonexposed group with the closest propensity score was then selected to match with each case in the exposed group. Three alternative matching procedures (one-to-one and one-to-two matching with replacement and Mahalanobis-metric matching) were also used for sensitivity analyses.

After propensity-score matching, the balancing of all covariates was evaluated by both pairwise t tests and standardized-difference methods. Because t tests before and after matching cannot be compared directly as a result of the change in sample size, standardized differences—the percentage of absolute difference in sample means divided by the pooled before-matching standard deviation—have been recommended as a better measure in assessing balance (Austin, 2008; D'Agostino, 1998). The effect of earlier life and current drinking exposures were examined separately for each pair of comparisons, given that the effect estimate is free from confounding from covariates fully balanced by propensity-score matching. The effects were evaluated by both differences in means between matched exposure and control groups, as well as the odds ratios (ORs) from conditional logistic regressions. The ORs were primarily used to evaluate effect sizes of drinking exposures. The group means for comparison groups are also presented to show the change in outcome rates for specific exposure groups before and after matching, which cannot be inferred from ORs.

Results

Table 1 lists all potential confounding variables used to construct the propensity score and their distribution (proportion and mean) across the five groups of the earlier life heavy drinking measure, namely lifetime abstainers ($n = 638$), never-heavy ($n = 1,876$) drinkers, less-heavy drinkers ($n = 626$), young heavy drinkers ($n = 433$), and heavy-30s drinkers ($n = 510$). One-way analysis-of-variance tests were performed on each covariate across the five groups, with F statistics shown in the last column. None of the included variables was found to be balanced across all groups. Two general patterns can be seen across the drinking pattern groups: (a) a U-shaped pattern, where more favorable risk-factor values are seen in the middle groups, and (b) an increasing pattern, where the least favorable risk-factor values are seen in the heavy drinking groups. Examples of the U-shaped relationship indicating higher health-risk profiles among lifetime abstainers and weekly heavy drinkers include age, educational attainment, income, homelessness, health insurance coverage, body mass index, depression, and sense of coherence. Examples of the increasing pattern, where lifetime abstainers have the best profiles and frequent heavy drinkers the most risky, include tobacco and marijuana use, distress, childhood abuse, and family alcoholism.

Using the never-heavy group as a reference, individuals from the other four groups were separately matched, one to one, to the reference group using the constructed propensity score. This resulted in matched pairs of lifetime abstainers ($n = 569$), less-heavy drinkers ($n = 564$), young heavy drinkers ($n = 374$), and heavy-30s drinkers ($n = 361$). No significant difference was observed for any comparison using t tests. In addition, the standardized difference was generated for comparisons between all covariates of each pair to examine the effectiveness of balancing through propensity-score matching. After matching, the standardized difference on most covariates was within 5% of the pooled standard deviation of the combined comparison groups. All covariates in the four comparisons had a standardized difference within 10%, except for one item, childhood sexual abuse, between the heavy-30s and never-heavy groups, where the standardized difference was 11% (results not shown). The importance of the propensity-score matching procedure can also be seen by comparison of those included in the matched groups with those who could not be matched. In the lifetime-abstainer group, those not matched ($n = 69$) included a high proportion of foreign-born Hispanic women and those who had low incomes, low education levels, high rates of current depression, and low rates of tobacco and marijuana use. Conversely, the unmatched heavy-30s group ($n = 149$) included a high proportion of unemployed men; heavy tobacco use; and high rates of marijuana use, depression, distress, childhood abuse, and family alcohol problems. These unmatched individuals can be seen as having clustered health risk fac-

TABLE 2. Prevalence and means across current drinking pattern categories, before propensity-score matching

Variable	Ex-drinkers ^a (<i>n</i> = 986)	Occasional ^b (<i>n</i> = 552)	Moderate volume ^c (<i>n</i> = 1,194)	Higher volume ^d (<i>n</i> = 480)	Heavy occasion ^e (<i>n</i> = 233)	<i>F</i> ^f
Demographics						
Gender male, %	46.7	33.5	46.3	61.7	78.1	58.53***
Age, <i>M</i>	58.2	56.4	54.9	58.2	50.3	31.38***
Ethnicity						
White and other, %	61.3	76.6	78.9	81.5	74.2	46.06***
Hispanic, %	16.1	10.7	11.1	9.2	14.6	21.95***
Black, %	22.6	12.7	10.0	9.4	11.2	20.76***
Married, %	55.7	61.2	62.3	63.3	66.1	4.46***
Employment						
Employed, %	46.9	60.5	66.2	62.1	71.7	36.49***
Unemployed, %	19.2	11.1	8.7	7.5	16.3	15.28***
Retired, %	29.7	22.5	21.5	28.8	11.6	11.66***
Homemaker, %	4.3	6.0	3.6	1.7	0.4	19.07***
Religion						
Protestant, %	53.0	50.7	44.5	41.5	36.9	9.54***
Catholic, %	20.8	29.5	30.8	29.2	32.6	7.60***
Other religion, %	17.4	12.7	12.2	13.1	12.0	3.34**
No religion, %	8.7	7.1	12.5	16.3	18.5	12.88***
Region						
Northeast, %	16.4	20.7	21.1	24.2	15.9	6.29***
Midwest, %	24.2	30.3	28.1	21.0	31.8	9.69***
South, %	40.6	31.5	32.2	35.0	30.9	13.77***
Mountain, %	7.9	9.6	8.2	9.2	7.7	0.41
Pacific, %	10.9	8.0	10.5	10.6	13.7	1.58
Born in United States, %	87.1	89.7	89.5	91.7	87.6	23.52***
Socioeconomic resources						
Education						
<High school graduate, %	18.8	7.6	6.3	4.4	12.4	46.04***
High school graduate, %	33.7	32.8	24.4	18.8	32.6	12.84***
Some college, %	24.9	25.9	25.3	24.2	27.0	1.75
College graduate, %	22.6	33.7	44.1	52.7	27.9	53.64***
Family income						
Below poverty, %	18.6	10.1	7.3	4.6	9.4	39.39***
1×-2× poverty, %	22.9	16.3	11.6	11.9	13.3	13.64***
2× poverty, %	47.2	60.0	69.1	74.2	68.7	70.01***
Missing, %	11.4	13.6	12.0	9.4	8.6	7.93***
Homelessness ever lifetime, %	11.6	6.0	5.7	6.3	13.7	8.54***
Health insurance						
No coverage, %	13.2	8.2	9.0	7.3	17.6	10.21***
Public, %	38.1	29.5	24.0	32.3	16.3	19.69***
Private, %	44.4	58.2	63.5	57.7	63.1	31.08***
Health-related risk factors						
Years of smoking, <i>M</i>	17.8	16.0	15.3	19.1	24.6	41.79***
No. of cigarettes when smoking, <i>M</i>	9.9	8.9	8.4	10.3	13.4	34.31***
Marijuana use ever lifetime, %	24.4	29.2	35.5	39.4	50.6	58.15***
BMI, <i>M</i>	28.1	27.9	27.4	26.2	27.8	9.05***
CES-D scale, <i>M</i>	4.17	3.56	3.20	3.52	4.66	10.22***
Current depression, %	20.2	17.2	15.2	11.9	18.9	3.97**
Chronic depression, %	25.3	17.2	16.2	15.6	20.2	7.20***
Distress, <i>M</i>	1.28	1.27	1.23	1.25	1.25	4.45***
Sense of coherence, <i>M</i>	4.17	4.21	4.28	4.30	4.15	5.60***
Childhood physical abuse, %	21.0	23.7	24.1	24.8	35.6	11.96***
Childhood sexual abuse, %	10.1	10.1	8.3	6.0	8.6	3.52**
Alcoholism in parent, %	25.2	22.5	20.9	19.8	30.5	6.14***
Alcoholism in grandparent, %	9.3	10.9	10.6	8.3	10.7	4.71***
Earlier life heavy drinking pattern						
Never heavy	62.2	68.5	54.0	45.2	9.9	73.37***
Less heavy	8.4	14.9	22.4	29.0	23.2	31.93***
Young heavy	11.2	10.1	14.8	10.2	17.6	4.53**
Heavy 30s	18.3	6.5	8.7	15.6	49.4	80.63***

Notes: BMI = body mass index; CES-D = Center for Epidemiology Studies–Depression scale. ^aExdrinker = no alcohol during last 12 months; ^boccasional = average volume less than 2 drinks per month; ^cmoderate volume = average volume of two to less than 30 drinks per month and never 5+ monthly; ^dhigher volume = average volume of 30 or more drinks per month and never 5+ monthly. ^eheavy occasion = 5+ at least monthly; ^f*F* tests were performed across the 5 categories shown in Table 2, plus the group of lifetime abstainers (shown in Table 1). The exceptions are the variables of earlier life heavy drinking (the last four rows), in which the *F* tests were performed across the five categories shown in Table 2 without lifetime abstainers.

p* < .01; *p* < .001.

tors that are scarce or not found in the never-heavy reference group, such that it would be impossible to differentiate the effects of drinking pattern on the outcome measures.

Proportions and means for the variables used in estimating propensity scores for the current drinking groups are presented in Table 2. Note that although the distribution of covariates was not shown for lifetime abstainers (see Table 1), the group was included in the *F* test of cross-group differences in means. Most of these covariates are found to differ significantly across the current drinking groups, indicating the importance of the propensity-score matching approach. Many variables show similar U-shaped and increasing patterns to those seen in Table 1, although some patterns are less pronounced and the strong relationships with childhood abuse and family alcohol problems seen in the earlier life groups are not found in the current drinking groups. As might be expected, the earlier life heavy drinking variables are not balanced across the current drinking groups. Exdrinkers are found to have high rates of never 5+ monthly but also of 5+ weekly in their 30s. Only 9.9%

of current heavy-occasion drinkers did not report monthly heavy drinking in at least one of the earlier decades, and about half of them were weekly heavy drinkers in their 30s, indicating a long-term pattern of frequent heavy drinking. The propensity-score matching resulted in matched pairs of lifetime abstainers (*n* = 388), exdrinkers (*n* = 677), occasional drinkers (*n* = 547), high-volume drinkers (*n* = 467), and heavy-occasion drinkers (*n* = 187), using moderate-volume drinkers as the reference group. No significant difference was observed for any comparison using *t* tests, and the standardized difference on most covariates was within 5% of the pooled standard deviation of the combined comparison groups. All covariates in the five comparisons had a standardized difference within 10%, except for Black race and having no religion between the heavy-occasion and moderate groups (standardized difference = 12% and 16%, respectively, results not shown).

After determining that propensity-score matching performed very well in balancing the potential confounders between the comparison groups, the effect of earlier life heavy

TABLE 3. Effects of earlier life heavy drinking on health conditions, before and after propensity-score matching

	Lifetime abstainer vs. never heavy	Less heavy vs. never heavy	Young heavy vs. never heavy	Heavy 30s vs. never heavy
<i>n</i> of matched pairs	569	564	374	361
Heart problem				
Before matching				
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.157 (0.014)	0.133 (0.014)	0.134 (0.016)	0.184 (0.017)*
Control group, ^b <i>M</i> (<i>SE</i>)	0.148 (0.008)	0.148 (0.008)	0.148 (0.008)	0.148 (0.008)
Difference, <i>M</i>	0.009 (0.016)	-0.016 (0.016)	-0.014 (0.019)	0.036 (0.018)*
Odds ratio [95% CI]	1.07 [0.83, 1.37]	0.88 [0.67, 1.14]	0.89 [0.66, 1.21]	1.30 [1.00, 1.68]*
After matching				
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.151 (0.015)	0.138 (0.015)	0.136 (0.018)	0.169 (0.020)
Control group, ^b <i>M</i> (<i>SE</i>)	0.183 (0.016)	0.142 (0.015)	0.155 (0.019)	0.180 (0.020)
Difference, <i>M</i>	-0.032 (0.022)	-0.004 (0.021)	-0.019 (0.025)	-0.011 (0.029)
Odds ratio [95% CI]	0.80 [0.58, 1.09]	0.97 [0.70, 1.35]	0.85 [0.56, 1.30]	0.93 [0.64, 1.35]
Diabetes				
Before matching				
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.216 (0.016)	0.086 (0.011)	0.122 (0.016)	0.147 (0.016)
Control group, ^b <i>M</i> (<i>SE</i>)	0.117 (0.007)	0.117 (0.007)	0.117 (0.007)	0.117 (0.007)
Difference, <i>M</i>	0.100 (0.018)***	-0.030 (0.014)*	0.006 (0.017)	0.030 (0.017)
Odds ratio [95% CI]	2.09 [1.65, 2.64]***	0.71 [0.52, 0.98]*	1.06 [0.77, 1.45]	1.30 [0.98, 1.73]
After matching				
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.211 (0.017)	0.089 (0.012)	0.126 (0.017)	0.133 (0.018)
Control group, ^b <i>M</i> (<i>SE</i>)	0.148 (0.015)	0.115 (0.013)	0.112 (0.016)	0.139 (0.018)
Difference, <i>M</i>	0.063 (0.023)**	-0.027 (0.018)	0.013 (0.024)	-0.006 (0.025)
Odds ratio [95% CI]	1.54 [1.13, 2.09]**	0.76 [0.52, 1.11]	1.13 [0.73, 1.74]	0.95 [0.62, 1.47]
Hypertension				
Before matching				
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.456 (0.020)	0.327 (0.019)	0.314 (0.022)	0.459 (0.022)
Control group, ^b <i>M</i> (<i>SE</i>)	0.409 (0.011)	0.409 (0.011)	0.409 (0.011)	0.409 (0.011)
Difference, <i>M</i>	0.047 (0.023)*	-0.081 (0.022)***	-0.095 (0.026)***	0.050 (0.025)*
Odds ratio [95% CI]	1.21 [1.01, 1.45]*	0.70 [0.58, 0.85]***	0.66 [0.52, 0.83]***	1.23 [1.01, 1.49]*
After matching				
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.450 (0.021)	0.344 (0.020)	0.318 (0.024)	0.446 (0.026)
Control group, ^b <i>M</i> (<i>SE</i>)	0.473 (0.021)	0.333 (0.020)	0.329 (0.024)	0.421 (0.026)
Difference, <i>M</i>	-0.023 (0.029)	0.011 (0.029)	-0.011 (0.033)	0.025 (0.035)
Odds ratio [95% CI]	0.91 [0.71, 1.15]	1.04 [0.82, 1.32]	0.95 [0.69, 1.30]	1.12 [0.82, 1.53]

^aExposure groups for the four comparisons are lifetime abstainers, less heavy, young heavy, and heavy 30s, respectively; ^bcontrol group is never heavy for all four comparisons.

p* < .05; *p* < .01; ****p* < .001.

TABLE 4. Effects of current drinking on health conditions, before and after propensity-score matching

	LT abstainer vs. moderate volume	Exdrinkers vs. moderate volume	Occasional vs. moderate volume	Higher volume vs. moderate volume	Heavy occasion vs. moderate volume
<i>n</i> of matched pairs	388	677	547	467	187
Heart problem					
Before matching					
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.157 (0.014)	0.224 (0.013)	0.123 (0.014)	0.150 (0.016)	0.103 (0.020)
Control group, ^b <i>M</i> (<i>SE</i>)	0.107 (0.009)	0.107 (0.009)	0.107 (0.009)	0.107 (0.009)	0.107 (0.009)
Difference, <i>M</i>	0.050 (0.017)**	0.117 (0.016)***	0.016 (0.017)	0.043 (0.019)*	-0.004 (0.022)
Odds ratio [95% CI]	1.55 [1.17, 2.05]**	2.41 [1.90, 3.05]***	1.17 [0.86, 1.60]	1.47 [1.08, 2.00]*	0.96 [0.60, 1.52]
After matching					
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.137 (0.017)	0.188 (0.015)	0.122 (0.014)	0.148 (0.016)	0.096 (0.022)
Control group, ^b <i>M</i> (<i>SE</i>)	0.126 (0.017)	0.129 (0.013)	0.119 (0.014)	0.113 (0.015)	0.134 (0.025)
Difference, <i>M</i>	0.010 (0.025)	0.059 (0.020)**	0.004 (0.020)	0.034 (0.021)	-0.037 (0.032)
Odds ratio [95% CI]	1.09 [0.72, 1.64]	1.56 [1.16, 2.11]**	1.03 [0.72, 1.47]	1.38 [0.93, 2.05]	0.68 [0.35, 1.31]
Diabetes					
Before matching					
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.216 (0.016)	0.193 (0.013)	0.107 (0.013)	0.054 (0.010)	0.069 (0.017)
Control group, ^b <i>M</i> (<i>SE</i>)	0.092 (0.008)	0.092 (0.008)	0.092 (0.008)	0.092 (0.008)	0.092 (0.008)
Difference, <i>M</i>	0.124 (0.018)***	0.101 (0.015)***	0.015 (0.016)	-0.038 (0.013)*	-0.023 (0.019)
Odds ratio [95% CI]	2.72 [2.07, 3.57]***	2.35 [1.83, 3.03]***	1.18 [0.84, 1.65]	0.56 [0.36, 0.88]*	0.73 [0.42, 1.25]
After matching					
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.186 (0.020)	0.164 (0.014)	0.108 (0.013)	0.056 (0.011)	0.075 (0.019)
Control group, ^b <i>M</i> (<i>SE</i>)	0.106 (0.016)	0.123 (0.013)	0.101 (0.013)	0.092 (0.013)	0.118 (0.024)
Difference, <i>M</i>	0.080 (0.025)**	0.041 (0.019)*	0.007 (0.019)	-0.036 (0.016)*	-0.043 (0.031)
Odds ratio [95% CI]	1.97 [1.29, 3.01]**	1.39 [1.03, 1.89]*	1.08 [0.74, 1.59]	0.55 [0.32, 0.94]*	0.62 [0.31, 1.24]
Hypertension					
Before matching					
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.456 (0.020)	0.481 (0.016)	0.411 (0.021)	0.356 (0.022)	0.339 (0.031)
Control group, ^b <i>M</i> (<i>SE</i>)	0.327 (0.014)	0.327 (0.014)	0.327 (0.014)	0.327 (0.014)	0.327 (0.014)
Difference, <i>M</i>	0.129 (0.024)***	0.153 (0.021)***	0.084 (0.025)**	0.029 (0.026)	0.012 (0.034)
Odds ratio [95% CI]	1.72 [1.41, 2.10]***	1.90 [1.60, 2.26]***	1.43 [1.16, 1.77]**	1.14 [0.91, 1.42]	1.05 [0.78, 1.42]
After matching					
Exposure group, ^a <i>M</i> (<i>SE</i>)	0.381 (0.025)	0.428 (0.019)	0.411 (0.021)	0.349 (0.022)	0.374 (0.035)
Control group, ^b <i>M</i> (<i>SE</i>)	0.399 (0.025)	0.366 (0.019)	0.378 (0.021)	0.328 (0.022)	0.273 (0.033)
Difference, <i>M</i>	-0.018 (0.034)	0.062 (0.026)*	0.033 (0.030)	0.021 (0.031)	0.102 (0.046)*
Odds ratio [95% CI]	0.92 [0.68, 1.24]	1.32 [1.05, 1.65]*	1.15 [0.90, 1.46]	1.10 [0.84, 1.45]	1.66 [1.04, 2.62]*

Notes: LT = lifetime. ^aExposure groups for the five comparisons are lifetime abstainers, exdrinkers, occasional, higher volume and heavy occasion, respectively; ^bcontrol group is moderate volume for all five comparisons

p* < .05; *p* < .01; ****p* < .001.

drinking on the three health condition outcomes was examined before and after propensity-score matching, as shown in Table 3. Using the original (unmatched) groups, lifetime abstainers were found to be at increased risk for diabetes and hypertension; the less-heavy group was found to be at reduced risk for diabetes and hypertension; the young heavy group was found to be at reduced risk for hypertension; and the heavy-30s group was found to be at increased risk for heart problems and hypertension. After matching, only one of these effects remained significant: the increased risk for diabetes among lifetime abstainers, which was reduced in magnitude to an OR of 1.54. Elevated risks for heart problems, hypertension, and high cholesterol for heavy-30s drinkers and for hypertension for lifetime abstainers were no longer found. The reduced risks for hypertension in the less-heavy and young heavy groups were also not seen after matching. Although the reduced risk of diabetes in the less-heavy group was no longer significant after matching, the estimated OR remained low at 0.76. Group mean rates are

presented to illustrate the effects of matching. For example, the original mean rates of diabetes were 21.6% and 11.7% for lifetime abstainers and never-heavy groups, respectively. After matching, the diabetes rate was basically unchanged for lifetime abstainers at 21.1%, whereas it moderately increased to 14.8% for the never-heavy group.

The effects of current drinking pattern on each health condition, controlling for the earlier life heavy drinking and all covariates used to construct the propensity score, are presented in Table 4. Models were estimated within each matched-pair comparison group. Before matching, lifetime abstainers and exdrinkers were found to be at increased risk for heart problems, diabetes, and hypertension; occasional drinkers were found to be at increased risk for hypertension; high-volume drinkers were found to be at increased risk for heart problems but reduced risk for diabetes; and heavy-occasion drinkers were not seen to differ in risks from moderate drinkers. After matching, the exdrinkers remained at increased risk for all three health problems, although the

ORs were reduced compared with the unmatched groups. The increased risk among lifetime abstainers for heart problems and hypertension was no longer observed; however, diabetes risk remained significantly elevated. The lowest diabetes risks after matching were seen for the high-volume and heavy-occasion groups, with a significantly reduced OR of 0.55 in the high-volume group. A significantly elevated risk for hypertension in the heavy-occasion group was found after matching, although not before matching.

Two types of sensitivity analysis were performed to test the robustness of the findings. First, covariates with standardized differences larger than 10% between the matched groups were entered as control variables in the conditional logistic regressions. The results were substantially the same as those presented. Second, results obtained under the three alternative matching methods were also similar to the presented effects generated from the best matching method.

Discussion

Research on the health effects of alcohol has not commonly incorporated life-course drinking patterns and typically focuses on contemporaneous correlations between alcohol-consumption measures and health outcomes or relationships between a single measure of baseline current drinking and a prospective follow-up of outcomes years later. Our study has begun to address the issue of incorporating life-course measures into the analyses of alcohol-related health outcomes by using a retrospective cross-sectional cohort design in a general population representative sample of the U.S. population. Further, propensity-score matching procedures with a wide range of demographic, socioeconomic, and health-risk-factor variables were used to address the difficult issue of confounding risk factors clustering within alcohol-consumption-defined groups.

These analyses have confirmed previous findings of a protective effect of moderate alcohol use on diabetes risk in both the lifetime and current drinking groups. Further, the pattern of effects on diabetes risk across the current drinking groups is consistent with a protective effect of regular alcohol intake, because the highest risk is seen for the lifetime-abstainer group, an elevated but lower risk is seen for exdrinkers, no effect is found for occasional drinkers, and a reduced risk is found for those drinking 30 or more drinks per month compared with those drinking fewer than 30 drinks. Our results add to the existing literature, which has supported a protective effect of alcohol but has not included studies controlling for lifetime drinking patterns, strengthening the case for a causal relationship.

Our findings are contrary to many previous studies on heart problems in general, and coronary heart disease risk specifically, where protective effects of moderate drinking have often been found. A major difference between the present study and previous analyses is the inclusion of

former drinkers in the life-course drinking groups in this study instead of including them in the abstention group or in their own separate group. Our analyses of current drinking groups clearly show exdrinkers to be at elevated risk for diabetes, hypertension, and heart problems; therefore, their inclusion in an abstainer group would have strongly affected the results. The elevated risk of heart problems found for exdrinkers, but not lifetime abstainers in either model, suggests that the sick-quitter bias is substantial. Because diabetes is a known risk factor for heart disease (Valmadrid et al., 1999), a protective effect on heart problems might also be expected; however, there may be additional effects of alcohol counteracting protection against diabetes, or there could be protection against heart disease mortality but not morbidity. We hope that this perspective on life-course drinking classification will be considered in the design of future studies so that causal relationships between alcohol consumption and heart problems can be clearly established or rejected.

The finding of increased hypertension risk among current drinkers who drink five or more drinks in a day at least monthly is consistent with previous studies. It was interesting to observe that the significant risk emerged only after matching. This may have been because the heavy-occasion group had a much lower average age than other groups before matching. No significant effects on hypertension were found in the lifetime drinking groups, which may indicate that consistent long-term heavy drinking is responsible.

Our study has a number of limitations that must be considered in the interpretation of the findings presented. First, the health-outcome measures are based on self-reports of a doctor or other health professional's diagnosis and are, therefore, subject to misunderstandings and omissions by the respondents. There are also likely to be selection effects in terms of seeking medical attention, particularly for hypertension and diabetes, because these may have not yet resulted in serious symptoms in less severe cases. In the United States, based on studies with both diagnostic tests and the same type of questions used in the National Alcohol Survey, it is estimated that about one third of individuals with diabetes (Norris et al., 2008) and about 30% of individuals with hypertension (Cutler et al., 2008) are undiagnosed. We do not have complete information on the timing of health-outcome diagnoses in relation to specific drinking patterns. Specificity of timing will be improved by questions on drinking patterns in the years before and after these events to be included in the 2009-2010 National Alcohol Survey. The study does not include a number of important risk factors for these conditions, such as diet and nutrition assessments, exercise, measured height and weight, body-mass-index history, lifetime drug use other than marijuana, or any physical diagnostic tests. The recent finding—that including diet measures in models of diabetes risk biased results toward a smaller protective effect (Imamura et al., 2009)—suggests that including dietary measures would not have eliminated our findings

regarding diabetes. Although alcohol-consumption patterns are assessed through multiple and detailed questions in the 2005 National Alcohol Survey, the lifetime measures used in the analyses are retrospective and may, therefore, be subject to recall bias downward (Caldwell et al., 2006; Lemmens et al., 1997; Rehm et al., 2008; Russell et al., 1997), leading to some degree of misclassification. Because of sample-size limitations, we are not able to estimate separate models by gender or race/ethnicity group. Differential relationships across these groups should be addressed in future studies.

Identifying and isolating the causal effects of alcohol-use patterns on heart disease, diabetes, hypertension, and other health outcomes remains a challenge, and new studies with diverse methodologies are needed to advance understanding. Our work calls attention to issues with life-course drinking-pattern classification, particularly the categorization of former drinkers, and to the need for attention to clustered confounding risk factors through propensity score-based procedures, such as matching. Taking these issues into account, we did not find evidence of a protective effect of lifetime moderate drinking on heart problems or hypertension, nor did we find evidence of increased risk for heart problems among lifetime heavy drinkers, although previous findings of increasing risk for hypertension from heavy-occasion drinking were replicated. Our results did confirm previous findings of a protective effect of lifetime moderate drinking and current more-frequent drinking on diabetes risk, strengthening the case for a causal relationship. Diabetes is a serious health condition and a major risk factor for mortality in general, as well as coronary heart disease, blindness, and other complications (Howard et al., 2004). If moderate alcohol use is further confirmed as a preventative factor, then this should be considered along with other risks and benefits in determining recommended alcohol-consumption limits (Dawson, 2000; Dufour, 2001).

References

- American Association for Public Opinion Research. (2000). *Standard definitions: Final dispositions of case codes and outcome rates for surveys*. Ann Arbor, MI: Author.
- Austin, P. C. (2008). A critical appraisal of propensity-score matching in the medical literature between 1996 and 2003. *Statistics in Medicine*, 27, 2037-2049.
- Breslow, R. A., & Graubard, B. I. (2008). Prospective study of alcohol consumption in the United States: Quantity, frequency, and cause-specific mortality. *Alcoholism: Clinical and Experimental Research*, 32, 1-9.
- Brookhart, M. A., Schneeweiss, S., Rothman, K. J., Glynn, R. J., Avorn, J., & Sturmer, T. (2006). Variable selection for propensity score models. *American Journal of Epidemiology*, 163, 1149-1156.
- Burr, M. L., Fehily, A. M., Butland, B. K., Bolton, C. H., & Eastham, R. D. (1986). Alcohol and high-density-lipoprotein cholesterol: A randomized controlled trial. *British Journal of Nutrition*, 56, 81-86.
- Caldwell, T. M., Rogers, B., Power, C., Clark, C. L., & Stansfeld, S. A. (2006). Drinking histories of self-identified lifetime abstainers and occasional drinkers: Findings from the 1958 British Birth Cohort Study. *Alcohol and Alcoholism*, 41, 650-654.
- Chen, L., Smith, G. D., Harbord, R. M., & Lewis, S. J. (2008). Alcohol intake and blood pressure: A systematic review implementing a Mendelian randomization approach. *PLoS Medicine*, 5 (3), e52.
- Corrao, G., Bagnardi, V., Zambon, A., & La Vecchia, C. (2004). A meta-analysis of alcohol consumption and the risk of 15 diseases. *Preventive Medicine*, 38, 613-619.
- Cutler, J. A., Sorlie, P. D., Wolz, M., Thom, T., Fields, L. E., & Roccella, E. J. (2008). Trends in hypertension prevalence, awareness, treatment, and control rates in United States adults between 1988-1994 and 1999-2004. *Hypertension*, 52, 818-827.
- D'Agostino, R. B., Jr. (1998). Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group. *Statistics in Medicine*, 17, 2265-2281.
- Dawson, D. A. (2000). US low-risk drinking guidelines: Examination of four alternatives. *Alcoholism: Clinical and Experimental Research*, 24, 1820-1829.
- Djoussé, L., Arnett, D. K., Eckfeldt, J. H., Province, M. A., Singer, M. R., & Ellison, R. C. (2004). Alcohol consumption and metabolic syndrome: Does the type of beverage matter? *Obesity Research*, 12, 1375-1385.
- Dong, M., Giles, W. H., Felitti, V. J., Dube, S. R., Williams, J. E., Chapman, D. P., & Anda, R. F. (2004). Insights into causal pathways for ischemic heart disease: Adverse childhood experiences study. *Circulation*, 110, 1761-1766.
- Dorn, J. M., Hovey, K., Williams, B. A., Freudenheim, J. L., Russell, M., Nochajski, T. H., & Trevisan, M. (2007). Alcohol drinking pattern and non-fatal myocardial infarction in women. *Addiction*, 102, 730-739.
- Dufour, M. C. (2001). If you drink alcoholic beverages, do so in moderation: What does this mean? *Journal of Nutrition*, 131 (Suppl. No. 1), 552S-561S.
- Embersson, J. R., Shaper, A. G., Wannamethee, S. G., Morris, R. W., & Whincup, P. H. (2005). Alcohol intake in middle age and risk of cardiovascular disease and mortality: Accounting for intake variation over time. *American Journal of Epidemiology*, 161, 856-863.
- Fan, A. Z., Russell, M., Dorn, J., Freudenheim, J. L., Nochajski, T., Hovey, K., & Trevisan, M. (2006). Lifetime alcohol drinking pattern is related to the prevalence of metabolic syndrome: The Western New York Health Study (WNYHS). *European Journal of Epidemiology*, 21, 129-138.
- Fillmore, K. M., Kerr, W. C., Stockwell, T., Chikritzhs, T., & Bostrom, A. (2006). Moderate alcohol use and reduced mortality risk: Systematic error in prospective studies. *Addiction Research and Theory*, 14, 101-132.
- Gmel, G., Gütjahr, E., & Rehm, J. (2003). How stable is the risk curve between alcohol and all-cause mortality and what factors influence the shape? A precision-weighted hierarchical meta-analysis. *European Journal of Epidemiology*, 18, 631-642.
- Greenfield, T. K. (2000). Ways of measuring drinking patterns and the difference they make: Experience with graduated frequencies. *Journal of Substance Abuse*, 12, 33-49.
- Hodge, A. M., English, D. R., O'Dea, K., & Giles, G. G. (2006). Alcohol intake, consumption pattern and beverage type, and the risk of Type 2 diabetes. *Diabetic Medicine*, 23, 690-697.
- Howard, A. A., Arnstern, J. H., & Gourevitch, M. N. (2004). Effect of alcohol consumption on diabetes mellitus: A systematic review. *Annals of Internal Medicine*, 140, 211-219, E221-E224.
- Hudson, J. I., Pope, H. G., Jr., & Glynn, R. J. (2005). The cross-sectional cohort study: An underutilized design. *Epidemiology*, 16, 355-359.
- Imamura, F., Lichtenstein, A. H., Dallal, G. E., Meigs, J. B., & Jacques, P. F. (2009). Confounding by dietary patterns of the inverse association between alcohol consumption and type 2 diabetes risk. *American Journal of Epidemiology*, 170, 37-45.
- Kerr, W. C., Fillmore, K. M., & Bostrom, A. (2002). Stability of alcohol consumption over time: Evidence from three longitudinal surveys from the United States. *Journal of Studies on Alcohol*, 63, 325-333.
- Kerr, W. C., Greenfield, T. K., Tujague, J., & Brown, S. (2005). A drink is a

- drink? Variation in the alcohol content of beer, wine, and spirits drinks in a U.S. methodological sample. *Alcoholism: Clinical and Experimental Research*, 29, 2015-2021.
- Kerr, W. C., Patterson, D., & Greenfield, T. K. (2009). Differences in the measured alcohol content of drinks between black, white and Hispanic men and women in a US national sample. *Addiction*, 104, 1503-1511.
- Kerr, W. C., Patterson, D., Koenen, M. A., & Greenfield, T. K. (2008). Alcohol content variation of bar and restaurant drinks in Northern California. *Alcoholism: Clinical and Experimental Research*, 32, 1623-1629.
- Kuper, H., Nicholson, A., Kivimaki, M., Aitsi-Selmi, A., Cavalleri, G., Deanfield, J. E., ... Hemingway, H. (2009). Evaluating the causal relevance of diverse risk markers: Horizontal systematic review. *BMJ*, 339, b4265.
- Lemmens, P. H., Volovics, L., & Haan, Y. D. (1997). Measurement of lifetime exposure to alcohol: Data quality of a self-administered questionnaire and impact on risk assessment. *Contemporary Drug Problems*, 24, 581-601.
- Leuven, E., & Sianesi, B. (2003). PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing (Statistical Software Components, S432001). Chestnut Hill, MA: Department of Economics, Boston College. Retrieved from <http://ideas.repec.org/c/boc/bocode/s432001.html>
- Midanik, L. T., & Zabkiewicz, D. (2009). Indicators of sense of coherence and alcohol-related problems: The 2000 U.S. National Alcohol Survey. *Substance Use and Misuse*, 44, 357-373.
- Naimi, T. S., Brown, D. W., Brewer, R. D., Giles, W. H., Mensah, G., Serdula, M. K., ... Stroup, D. F. (2005). Cardiovascular risk factors and confounders among nondrinking and moderate-drinking U.S. adults. *American Journal of Preventive Medicine*, 28, 369-373.
- Norris, S. L., Kansagara, D., Bougatsos, C., & Rongwei, F. (2008). Screening adults for type 2 diabetes: A review of the evidence for the U.S. Preventive Services Task Force. *Annals of Internal Medicine*, 148, 855-868.
- Rehm, J., Greenfield, T. K., & Kerr, W. C. (2006). Patterns of drinking and mortality from different diseases: An overview. *Contemporary Drug Problems*, 33, 205-235.
- Rehm, J., Irving, H., Ye, Y., Kerr, W. C., Bond, J., & Greenfield, T. K. (2008). Are lifetime abstainers the best control group in alcohol epidemiology? On the stability and validity of reported lifetime abstention. *American Journal of Epidemiology*, 168, 866-871.
- Rhem, J., Semplos, C. T., & Trevisan, M. (2003). Average volume of alcohol consumption, patterns of drinking and risk of coronary heart disease: A review. *Journal of Cardiovascular Risk*, 10, 15-20.
- Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika*, 70, 41-55.
- Rosenbaum, P. R., & Rubin, D. B. (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *American Statistician*, 39, 33-38.
- Rubin, D. B. (1973). The use of matched sampling and regression adjustment to remove bias in observational studies. *Biometrics*, 29, 185-203.
- Rubin, D. B. (1997). Estimating causal effects from large data sets using propensity scores. *Annals of Internal Medicine*, 127 (5, Part 2), 757-763.
- Russell, M., Marshall, J. R., Trevisan, M., Freudenheim, J. L., Chan, A. W. K., Markovic, N., ... Priore, R. L. (1997). Test-retest reliability of the Cognitive Lifetime Drinking History. *American Journal of Epidemiology*, 146, 975-982.
- Shaper, A. G. (1990). Alcohol and mortality: A review of prospective studies. *British Journal of Addiction*, 85, 837-847.
- Shaper, A. G., Wannamethee, G., & Walker, M. (1988). Alcohol and mortality in British men: Explaining the U-shaped curve. *Lancet*, 2, 1267-1273.
- Stewart, S. H., Latham, P. K., Miller, P. M., Randall, P., & Anton, R. F. (2008). Blood pressure reduction during treatment for alcohol dependence: Results from the Combining Medications and Behavioral Interventions for Alcoholism (COMBINE) study. *Addiction*, 103, 1622-1628.
- Stranges, S., Wu, T., Dorn, J. M., Freudenheim, J. L., Muti, P., Farinero, E., ... Trevisan, M. (2004). Relationship of alcohol drinking pattern to risk of hypertension: A population-based study. *Hypertension*, 44, 813-819.
- Valmadrid, C. T., Klein, R., Moss, S. E., Klein, B. E. K., & Cruickshanks, K. J. (1999). Alcohol intake and the risk of coronary heart disease mortality in persons with older-onset diabetes mellitus. *Journal of the American Medical Association*, 282, 239-246.
- Wainwright, N. W. J., Surtees, P. G., Welch, A. A., Luben, R. N., Khaw, K.-T., & Bingham, S. A. (2008). Sense of coherence, lifestyle choices and mortality. *Journal of Epidemiology and Community Health*, 62, 829-831.