Late-Life Alcohol Consumption and 20-Year Mortality

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Background: Growing epidemiological evidence indicates that moderate alcohol consumption is associated with reduced total mortality among middle-aged and older adults. However, the salutary effect of moderate drinking may be overestimated owing to confounding factors. Abstainers may include former problem drinkers with existing health problems and may be atypical compared to drinkers in terms of sociodemographic and social-behavioral factors. The purpose of this study was to examine the association between alcohol consumption and all-cause mortality over 20 years among 1,824 older adults, controlling for a wide range of potential confounding factors associated with abstention.

Methods: The sample at baseline included 1,824 individuals between the ages of 55 and 65. The database at baseline included information on daily alcohol consumption, sociodemographic factors, former problem drinking status, health factors, and social-behavioral factors. Abstention was defined as abstaining from alcohol at baseline. Death across a 20-year follow-up period was confirmed primarily by death certificate.

Results: Controlling only for age and gender, compared to moderate drinkers, abstainers had a more than 2 times increased mortality risk, heavy drinkers had 70% increased risk, and light drinkers had 23% increased risk. A model controlling for former problem drinking status, existing health problems, and key sociodemographic and social-behavioral factors, as well as for age and gender, substantially reduced the mortality effect for abstainers compared to moderate drinkers. However, even after adjusting for all covariates, abstainers and heavy drinkers continued to show increased mortality risks of 51 and 45%, respectively, compared to moderate drinkers.

Conclusions: Findings are consistent with an interpretation that the survival effect for moderate drinking compared to abstention among older adults reflects 2 processes. First, the effect of confounding factors associated with alcohol abstention is considerable. However, even after taking account of traditional and nontraditional covariates, moderate alcohol consumption continued to show a beneficial effect in predicting mortality risk.

Key Words: Alcohol Consumption, Problem Drinking, Mortality, Aging.

ALCOHOL MISUSE HAS been linked to a wide range of medical conditions (Room et al., 2005). Yet growing epidemiological evidence indicates that moderate alcohol consumption is associated with reduced total mortality. Although moderate alcohol consumption is defined somewhat differently across studies, 1 to <3 drinks per day generally encompasses the range within which health benefits have been observed among middle-aged and older adults (Ferreira and Weems, 2008). However, many investigators have expressed concern that the presumed salutary effect of moderate drinking may be overestimated owing to confounding factors associated with alcohol abstention. The purpose of this study was to examine the association between alcohol consumption and all-cause mortality over the course of 20 years among 1,824 older adults, controlling for a wide range of potential confounding factors associated with abstention.

FORMER PROBLEM DRINKING AS A POTENTIAL CONFOUND

An early study by Marmot and colleagues (1981), prospectively examining 10-year mortality in almost 1,500 British men between 20 and 64 years of age, showed a pattern of findings—and problems—replicated in many subsequent studies. The investigators found a U-shaped relationship between baseline alcohol consumption and mortality, with mortality highest among abstainers and individuals consuming 3 or more drinks a day and lowest in moderate drinkers. However, they did not take account of former problem drinking. Thus, a persistent controversy pertaining to the putative salutary health effects of moderate drinking involves a concern that current abstainers may include past heavy or problem drinkers with poor health habits and high prevalence rates of many medical illnesses (Fillmore et al., 2006; Shaper, 1990).

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However, a number of prospective studies that have accounted for former drinking behavior among abstainers have continued to show higher, although attenuated, all-cause mortality among abstainers, as well as heavy drinkers, compared to moderate drinkers (Di Castelnuovo et al., 2006). For example, controlling for former problem drinking, a significant U-shaped relationship between alcohol consumption and all-cause mortality has been found for almost 2,000 U.S. men aged 28 to 82 (moderate drinking indexed annually averaged less than 3 drinks per day; DeLabry et al., 1992) and for more than 85,000 female registered nurses aged 34 to 59 (light-to-moderate drinking encompassed up to slighty more than 2 drinks per day; Fuchs et al., 1995). Similarly, using lifetime abstainers as a reference group, reduced mortality associated with light to moderate alcohol consumption of approximately 1 to 2 drinks per day has been reported for mixed-age samples of U.S. adults (Klatsky et al., 1992; Liao et al., 2000).

NONTRADITIONAL COVARIATES AS POTENTIAL CONFOUNDS

Another, more recent concern is that, compared to drinkers, abstainers may be atypical in many ways that may be associated with health risk (Greenfield et al., 2002). For example, abstainers may differ from drinkers on socioeconomic status (SES) and dietary habits (Rehm et al., 2002). Health behaviors, such as tobacco smoking and physical activity, may also differ between abstainers and drinkers (Gmel et al., 2003). Moreover, few studies have adjusted for social factors, yet abstainers, as well as heavy drinkers, may have fewer social ties and less social support than individuals who drink without misusing alcohol (Heath, 2007; Skog, 1996). Further, potentially important covariates that may be associated with mortality, such as depression and coping deficits, have typically not been included in studies of the alcohol–mortality relationship (Lee et al., 2009).

For example, in a cross-sectional analysis of almost 3,000 Australian adults, Rodgers and colleagues (2000) found that abstainers had lower income, poorer education, and less social support than lower level drinkers consuming up to 14 drinks per week. Similarly, based on a cross-sectional analysis of almost 100,000 U.S. adults, using data from the Behavioral Risk Factor Surveillance System, Naimi and colleagues (2005) demonstrated that abstainers were more likely to have poorer health and lower education and more likely to be unemployed, divorced or widowed, and physically inactive than moderate drinkers who consume < 2 drinks per day.

ALCOHOL AND MORTALITY IN OLDER ADULTS

Some evidence based on studies of broad samples across the adult life span tends to support a U-shaped association between alcohol and mortality among older adults with mortality lowest at 1 to 2 drinks per day (e.g., Gmel et al., 2003; Klatsky et al., 1992; Thun et al., 1997). For example, in a 4-year prospective study of over 15,000 adults aged 55 and older, Lee and colleagues (2009) found a U-shaped relationship between alcohol and total mortality with mortality lowest at less than 2 drinks per day. Similarly, Moore and colleagues (2006) found that in adults aged 60 and older both abstainers and "at-risk drinkers" (e.g., those consuming 2 to 3 drinks per day in the context of health comorbidities) had a higher mortality rate than not-at-risk drinkers; however, they noted that the U-shaped association between alcohol and all-cause mortality has been less clear in studies with older adults. However, most studies with older adults have not considered the potential confounding influence of former problem drinking and have not controlled for a broad range of potentially important covariates (Reid et al., 2002).

Mertens and colleagues (1996) examined alcohol consumption and total mortality in a 4-year follow-up of individuals in the present sample. Mertens and her associates considered former problem drinking status and existing health problems, as well as nontraditional factors, including life stressors, social support, and avoidance coping. The 4-year findings showed a U-shaped, prospective relationship between baseline alcohol consumption and mortality, with mortality highest among abstainers and heavy drinkers and lowest in moderate drinkers consuming from 1 to < 3 drinks per day. However, abstainers tended to have more adverse life contexts than did light and moderate drinkers, and abstainers' increased mortality risk was substantially reduced after controlling for life context and coping factors. The current study broadens and extends Mertens and her associates' 4-year follow-up of alcohol and mortality in the present sample to a 20-year follow-up.

PRESENT STUDY

The purpose of this study was to examine alcohol consumption and total mortality among older adults, controlling for a wide range of traditional and nontraditional confounding factors associated with abstention. We examined this issue in a sample of 1,824 adults aged 55 to 65 at baseline followed for 20 years. Although a U-shaped curve between baseline alcohol consumption and all-cause mortality is a common finding, ongoing controversy pertains to concerns that abstainers may include (i) former problem drinkers with existing health problems (Fillmore et al., 2006; Shaper (1990) and (ii) individuals who are atypical compared to drinkers in terms of sociodemographic and social-behavioral factors associated with health risk (Gmel et al., 2003; Heath, 2007; Lee et al., 2009; Rehm et al., 2002; Skog, 1996). These concerns are especially relevant to research with older adults (Reid et al., 2002), where findings on the alcohol–mortality relationship have been less clear (Moore et al., 2006). The present study addresses all of these issues.

Based on previous research on alcohol consumption and total mortality among older adults (Lee et al., 2009; Moore et al., 2006) and 4-year analyses with individuals in the present sample (Mertens et al., 1996), we predicted that baseline alcohol consumption would show a U-shaped relationship

with 20-year total mortality; that is, that both abstainers and heavy drinkers would have a higher mortality rate than moderate drinkers. In addition, extrapolating from research controlling for former problem drinking in broad adult samples (DeLabry et al., 1992; Fuchs et al., 1995) and for a broad range of covariates (though not former problem drinking) in older adults (Lee et al., 2009), we predicted that controlling for former problem drinking status, existing health problems, and key sociodemographic and social-behavioral factors, abstainers would continue to show a higher, though reduced, mortality rate compared to moderate drinkers.

MATERIALS AND METHODS

Sample Selection and Characteristics

The present study is part of a longitudinal project that has examined late-life patterns of alcohol consumption and drinking problems (Mertens et al., 1996; Moos et al., 1991; Schutte et al., 1994, 1998, 2001, 2006) and stress and coping processes (Holahan et al., 1997, 2005) among problem and nonproblem drinkers aged 55 and older.

The sample at baseline included individuals between the ages of 55 and 65 who had had outpatient contact with a health care facility in the previous 3 years. Based on the aims of the parent project, lifetime abstainers were excluded. However, the sample was comparable to similarly aged community samples with respect to health characteristics such as prevalence of chronic illness and hospitalization (for additional information on sample recruitment, see Brennan and Moos, 1990; Moos et al., 1991). Predictive data were obtained from self-report inventories at baseline. Of eligible respondents contacted at baseline, 92% agreed to participate in the survey, and 89% (1,884) of these individuals provided complete data at baseline. The study was approved by the Stanford University Medical School Panel on Human Subjects; after the project was fully explained, participants provided signed informed consent.

To insure consistency in the sample across analyses, the present sample includes 1,824 (97%) baseline participants who provided complete data on the baseline covariates used here. The sample included 682 (37%) women and 1,142 (63%) men. At baseline, the present sample was an average of 61 (SD = 3.15) years of age, and 69% of participants were married. The sample was predominantly Caucasian (91%), with the remainder of the sample African American (3%), Hispanic (2%), Asian American (1%), Native American (1%), and other ethnic backgrounds (2%).

Measures

The database at baseline included information on daily alcohol consumption, sociodemographic factors, former problem drinking status, health factors, and social-behavioral factors. Death across a 20-year follow-up period was confirmed primarily by death certificate. All of the indices were designed for survey research with community samples. The indices have strong psychometric properties and are associated with one another and with psychological adjustment in expected ways. Descriptive and psychometric information on the measures is available in the following sources: (i) Health and Daily Living Form (HDL; Moos et al., 1992) for the measures of daily alcohol consumption, depressive symptoms, smoking status, and physical activity; (ii) an adapted version of the Drinking Problems Index (Finney et al., 1991) for the measure of former problem drinking status; (iii) Life Stressors and Social Resources Inventory (LISRES; Moos and Moos, 1994) for the measures of health problems, number of close friends, and quality of friend support; and (iv) Coping Responses Inventory (CRI; Moos, 1993) for the measure of avoidance coping.

Baseline Alcohol Consumption. Average daily ethanol consumption was assessed with a quantity-frequency index using items adapted from the Health and Daily Living Form (HDL; Moos et al., 1992). Quantity of alcohol consumption was assessed by items that measured amounts of wine, beer, and hard liquor participants had consumed on the days they drank in the last month. Responses to these items were then converted to reflect the ethanol content of the beverages consumed. Frequency of alcohol consumption was assessed by responses to questions asking how often per week (never, less than once, once or twice, 3 to 4 times, nearly every day) participants had consumed beer, wine, and hard liquor in the last month. From this information, a composite quantity-frequency value was calculated to provide an overall index of participants' average daily ethanol consumption.

There is support for the validity of self-report measures of alcohol consumption for mixed-age and older adults (Babor et al., 1987; Stacy et al., 1985; Tucker et al., 1991; Werch, 1989). Based on the approximation that in the United States 5 oz of wine, 12 oz of beer, and 1 shot (1.5 oz) of hard liquor contain an average of 0.6 oz (approximately 14 g) of pure, 100% alcohol (NIAAA, 2007), we defined 4 categories of average daily alcohol consumption at baseline: (1) abstainer (0 g); (2) light, defined as consuming up to less than 1 drink/d (consuming more than 0 g but less than 14 g/d); (3) moderate, defined as consuming between 1 to less than 3 drinks per day (14 g to <42 g/d); and (4) heavy, defined as drinking 3 or more drinks per day (42 g/d or more). This categorization is similar to that used in prior studies (Camacho et al., 1987; DeLabry et al., 1992; Di Castelnuovo et al., 2006; Ferreira and Weems, 2008; Mertens et al., 1996) and resulted in a total of 345 (19%) abstainers, 595 (32%) light drinkers, 560 (31%) moderate drinkers, and 324 (18%) heavy drinkers.

Sociodemographic Factors. In addition to age and gender (female = 0, male = 1), 2 sociodemographic factors were assessed: SES and marital status. At baseline, respondents were asked to report their total annual family income and years of education. We indexed SES as the average of participant's family income and years of education, using standard scores for both measures to equate their scales. For 61 cases for whom family income was not available, we used years of education alone (r between family income and years of education for participants for whom both measures were available = 0.42, n = 1,763, $p < 0.01$). Marital status was assessed by a dichotomous index (not married = 0; married = 1).

Former Problem Drinking Status. Respondents were classified as former problem drinkers using information from an adapted version of the Drinking Problems Index (Finney et al., 1991). Following Mertens and colleagues (1996), we defined former problem drinkers as those who, according to 5 specific DPI items, had had no drinking problems during the 2 years immediately prior to baseline but had experienced one or more drinking problems at some point prior to that (nonformer problem drinker = 0, former problem drinker = 1). Examples of the items are as follows: had a drink in the morning, had a relative or friend worry or complain about your drinking, and had your drinking create problems between you and a relative or friend.

Health Factors. Following Mertens and colleagues (1996), health problems at baseline were indexed as a count of 9 self-reported physician-diagnosed medical conditions experienced in the past 12 months (cancer, diabetes, heart problems, stroke, high blood pressure, anemia, bronchitis, kidney problems, and ulcers) and 7 physical ailments experienced in the past 12 months (pain in the heart or tightness or heaviness in the chest, trouble breathing or shortness of breath, constant coughing or frequent heavy chest colds, frequent cramps in the leg, swollen ankles, getting very tired in a short time, and trouble climbing stairs or getting outdoors).

Social-Behavioral Factors. Social-behavioral factors encompassed obesity, smoking, physical activity, depressive symptoms, coping, and quantitative and qualitative measures of social support.

Each respondent's body mass index (BMI) was calculated based on reported height and weight at baseline. BMI was calculated as (weight in pounds ×703)/height in inches squared. *Obesity* was operationalized as a BMI of 30 or more (score = 1) versus a BMI of less than 30 (score = 0) (Ogden et al., 2006).

Smoking Status. Current cigarette smoking at baseline was operationalized as smoking one or more cigarettes per day (nonsmoker = 0, smoker = 1).

Physical Activity. Following Harris and colleagues (2006), the level of physical activity at baseline was indexed by summing 4 items asking participants whether or not (no = 0; yes = 1) during the last month they engaged in: (i) swimming or tennis with friends; (ii) swimming or tennis with family; (iii) long hikes or walks with friends; and (iv) long hikes or walks with family. Summing items, the total score ranged from zero (no activity) to 4 (high activity).

Depressive Symptoms. Depressive symptoms at baseline were tapped by an index of 18 symptoms experienced during the previous month, derived from the Research Diagnostic Criteria (Spitzer et al., 1978). Depressive symptoms included 7 items that tap mood-related symptoms (e.g., feeling depressed (sad or blue); feeling guilty, worthless, or down on yourself; feeling negative or pessimistic) and 11 items that tap behavioral manifestations of depression (e.g., loss of energy, fatigue, tiredness; loss of interest or pleasure in your usual activities; crying). Responses were reported on a 5-point scale reflecting how frequently symptoms were experienced, from *never* (0) to *often* (4). The depressive symptoms score is the sum of responses across the 18 items (Cronbach's $\alpha = 0.92$ at baseline).

Avoidance Coping. Avoidance coping was measured at baseline with the CRI (Moos, 1993). Respondents were asked to identify the "most important problem or stressful situation" they had experienced in the past 12 months and to rate how frequently they had engaged in each of a variety of coping responses to deal with it, using a 4-point scale ranging from *not at all* (0) to *fairly often* (3). Avoidance coping included 6 items that tap cognitive attempts to avoid thinking realistically about the problem (e.g., "Did you try to deny how serious the problem really was?" and "Did you try not to think about the problem?") and 6 items that tap behavioral attempts to reduce tension by expressing negative feelings rather than dealing directly with the problem (e.g., "Did you take it out on other people when you felt angry or depressed?" and "Did you yell or shout to let off steam?"). The avoidance coping score is the sum of responses across the 12 items (Cronbach's $\alpha = 0.74$).

Number of Close Friends. Number of close friends was indexed at baseline based on respondents' response to an item that asked: "How many close friends do you have, people you feel at ease with and can talk to about personal matters?" Responses were coded from 0 to 4 or more.

Quality of Friend Support. Quality of friend support was indexed at baseline as the sum of 6 items tapping the quality of support from friends. For example, respondents were asked: "Can you count on your friends to help you when you need it?" and "Do you confide in any of your friends?" Responses were scored on a 5-point scale, ranging from *never* (0) to *often* (4) (Cronbach's $\alpha = 0.88$).

Mortality. The outcome variable was death (surviving = 0, death = 1) during the 20-year follow-up. A total of 937 (51%) of the 1,824 participants died during the 20-year follow-up. The fact of death was confirmed by death certificate for 860 cases (92%), by another official source (primarily the Social Security Death Index) for 66 cases (7%), and verbally by telephone by an individual at the participant's former residence (primarily the spouse) for 11 cases (1%).

Analytic Plan. Primary analyses are organized in 3 sets. First, we conducted tests to identify potential baseline covariates. We examined each covariate as a predictor of 20-year mortality in logistic regression analyses, and we examined the association between baseline alcohol group membership and each covariate, using analyses of variance (ANOVA) for continuous variables and chi-square analyses for categorical variables. Next, we examined the association between baseline alcohol group membership and mortality risk across the 20-year follow-up period in 2 sets of Cox proportional hazards regression analyses. Initially, we examined a model controlling only for age and gender. Then, we examined a model controlling for eleven additional covarites—former problem drinking status, existing health problems, and key sociodemographic and social-behavioral factors—as well as for age and gender.

Because very little is know about gender differences in older adults' use of alcohol and its consequences, we also explored the potential role of gender as a moderator of the relationships between predictive factors and 20-year mortality. Following guidelines for subgroup analyses (Wang et al., 2007), we (i) examined the interaction of each covariate with gender in the logistic regression analyses predicting 20-year mortality; (ii) retained significant interactions in the full Cox proportional hazards model; and (iii) examined the interaction of alcohol group membership with gender in both the initial and full Cox proportional hazards models. We mean-centered variables that were multiplied to create each interaction term and retained these mean-centered variables in the respective models.

RESULTS

Analyses of Excluded Participants

Among the full sample of 1,884 baseline participants, we compared participants who provided sufficient data to be included in the present analyses ($n = 1{,}824$) with those who did not provide sufficient data ($n = 60$). Most missing data occurred for the avoidance coping variable ($n = 44$), with the remainder of missing data scattered across the remaining covariates (n varies from 1 to 5). Compared to excluded participants, those included in the analyses did not differ significantly on gender, age, alcohol group membership, or 20-year mortality.

Descriptive Information on Sample Mortality

The mortality rate was highest among baseline abstainers (239 of 345 or 69%) and baseline heavy drinkers (195 of 324 or 60%) and lowest among baseline light drinkers (271 of 595 or 46%) and baseline moderate drinkers (232 of 560 or 41%).

Tests of Potential of Covariates

Based on concerns about potential confounding factors related to abstainers, we examined eleven additional baseline covariates for possible inclusion in a final model. The covariates encompassed former problem drinker status, health

Table 1. Results of Logistic Regression Analyses for Each Baseline Covariate Examined Separately as a Predictor of 20-Year Mortality (N = 1,824)

Covariate	OR	95% CI
SES[a]	0.52**	0.47, 0.59
Marital status[b] (No = 0, Yes = 1)	0.66**	0.54, 0.81
Former problem drinker[b] (No = 0, Yes = 1)	1.40**	1.12, 1.73
Health problems	1.39**	1.33, 1.46
Obesity[b] (No = 0, Yes = 1)	1.82**	1.33, 2.49
Smoking status[b] (No = 0, Yes = 1)	2.99**	2.38, 3.75
Physical activity	0.77**	0.70, 0.85
Depressive symptoms	1.27**	1.15, 1.39
Avoidance coping	1.17**	1.07, 1.29
Number of close friends	0.87**	0.81, 0.93
Quality of friend support	0.83**	0.76, 0.91

SES, socioeconomic status.
[a]Standardized scale.
[b]Binary variable coded 0–1.
**$p < 0.01$.

factors, sociodemographic factors, and social-behavioral factors. First, we examined each covariate as a predictor of 20-year mortality in separate logistic regression analyses. All eleven covariates significantly predicted mortality (see Table 1). We then added the interaction between gender and each covariate to each predictive model. Two interactions were statistically significant ($p < 0.05$)—gender × marital status (OR = 0.56, $p < 0.01$, 95% CI = 0.37, 0.85) and gender × avoidance coping (OR = 0.97, $p < 0.05$, 95% CI = 0.94, 0.999). The association between being unmarried and higher mortality was stronger for men than women, while the positive association between avoidance coping and mortality was stronger for women than men. In each case, the main effect for the respective covariate remained significant ($p < 0.01$) with the interaction term in the model.

Next, we examined the association between baseline alcohol group membership and each covariate. Continuous variables were examined in separate 1-factor analyses of variance (ANOVA). Categorical variables were examined in separate chi-square analyses crossed with the level of daily alcohol consumption. Baseline alcohol group membership was significantly ($p < 0.01$) associated with all eleven covariates. Based on these results, all eleven covariates were retained in a final Cox proportional hazards regression model, along with the interaction terms for gender × marital status and gender × avoidance coping.

Table 2 shows means for each covariate by alcohol group membership along with results of the overall ANOVA and chi-square analyses. In post hoc Duncan analyses with continuous variables, abstainers were significantly ($p < 0.01$) higher than moderate drinkers on health problems, depressive symptoms, and avoidance coping, and significantly lower than moderate drinkers on SES, number of close friends, quality of friend support, and physical activity. In follow-up chi-square analyses with categorical variables, abstainers were significantly ($p < 0.01$) more likely to have had prior drinking problems, to be obese, and to smoke cigarettes than were moderate drinkers and significantly less likely to be married than moderate drinkers.

Initial Predictive Model Controlling for Age and Gender

We examined the association between the 4 groups as identified by their baseline daily alcohol consumption and mortality risk across the 20-year follow-up period in an initial Cox proportional hazards regression analysis, controlling only for age and gender. Alcohol group membership was dummy-coded, with moderate drinkers as the reference group. The 4 alcohol consumption groups did not differ on age [ANOVA, $F(3, 1{,}820) = 0.49$, $p = 0.69$]. However, the groups did differ on gender [$\chi^2(3, N = 1{,}824) = 66.94$, $p < 0.01$], with men more represented among heavy drinkers (77%) and

Table 2. Means, Standard Deviations (in Parentheses), and Individual Group Contrasts for Baseline Covariates by Alcohol Consumption Group Membership. Results of Overall F and Chi-Square Tests Are Shown in the Last Column (N = 1,824)

	Baseline alcohol consumption groups				
Covariate	Abstainer	Light	Moderate	Heavy	Overall test[a]
SES[b]	−0.38[c] (0.76)	0.06 (0.85)	0.20 (0.81)	−0.01 (0.84)	$F = 37.39$**
Marital status[d] (No = 0, Yes = 1)	0.57[c] (0.50)	0.68 (0.47)	0.77 (0.42)	0.68 (0.47)	$\chi^2 = 37.00$**
Former problem drinker[d] (No = 0, Yes = 1)	0.66[c] (0.48)	0.28 (0.45)	0.07 (0.26)	0.01 (0.08)	$\chi^2 = 519.00$**
Health problems	3.66[c] (2.95)	2.57 (2.52)	2.00 (2.24)	2.38 (2.39)	$F = 32.11$**
Obesity[d] (No = 0, Yes = 1)	0.15[c] (0.36)	0.11 (0.31)	0.07 (0.25)	0.10 (0.31)	$\chi^2 = 28.79$**
Smoking status[d] (No = 0, Yes = 1)	0.32[c] (0.47)	0.19 (0.39)	0.20 (0.40)	0.38 (0.49)	$\chi^2 = 58.61$**
Physical activity	0.70[c] (0.91)	1.22 (1.23)	1.27 (1.19)	1.04 (1.16)	$F = 20.90$**
Depressive symptoms	25.94[c] (15.21)	20.85 (13.20)	18.32 (12.31)	20.26 (13.59)	$F = 23.42$**
Avoidance coping	5.77[c] (3.21)	4.95 (2.96)	4.76 (3.13)	5.31 (3.27)	$F = 8.45$**
Number of close friends	2.55[c] (1.45)	2.84 (1.28)	2.94 (1.28)	2.85 (1.30)	$F = 6.58$**
Quality of friend support	15.93[c] (5.60)	16.86 (4.67)	17.07 (4.54)	16.75 (4.71)	$F = 4.28$**

SES, socioeconomic status.
[a]df for F = 3, 120; df for χ^2 = 3.
[b]Standardized scale.
[c]Differs significantly ($p < 0.01$) from moderate drinkers.
[d]Binary variable coded 0–1.
**$p < 0.01$.

Table 3. Results of a Cox Proportional Hazards Regression Analysis Predicting 20-Year Mortality Risk From Alcohol Consumption Group Membership[a] at Baseline in an Initial Model Controlling for Age and Gender (N = 1,824)

Covariate	Hazard ratio	95% CI
Age (Years)	1.07**	1.04, 1.09
Gender (Female = 0, Male = 1)	1.53**	1.33, 1.77
Abstainers	2.22**	1.85, 2.66
Heavy drinkers	1.70**	1.40, 2.06
Light drinkers	1.23*	1.03, 1.47

[a]Baseline alcohol group membership was dummy-coded, with moderate drinkers as the reference group.
*$p < 0.05$, **$p < 0.01$.

abstainers (71%) compared to light drinkers (52%) and moderate drinkers (60%).

Results of the Cox proportional hazards regression analysis are shown in Table 3. Hazard ratios were examined with the Wald test and control for the other covariates in the model. Age and male gender were positively related to mortality risk. Compared to moderate drinkers, all 3 of the other alcohol consumption groups had increased 20-year mortality risk. Abstainers had a more than 2 times increased risk, heavy drinkers had 70% increased risk, and light drinkers had 23% increased risk. Including interactions between gender and alcohol group membership did not significantly improve model fit [$\chi^2(3, N = 1{,}824) = 0.48$, $p = 0.92$]. That is, the association between alcohol group membership and mortality risk did not differ for women and men.

Figure 1 plots cumulative hazard across the 20-year follow-up by baseline alcohol group membership for the initial model. The y-axis depicts model-predicted total accumulated risk (equal to the negative log of the survival probability). The figure shows the total accumulated risk of mortality for an individual in each alcohol group from baseline until the respective time point across the 20 years (Singer and Willet, 2003). The plot shows that accumulated mortality risk is consistently greatest for abstainers, lowest for moderate and light drinkers, and intermediate for heavy drinkers.

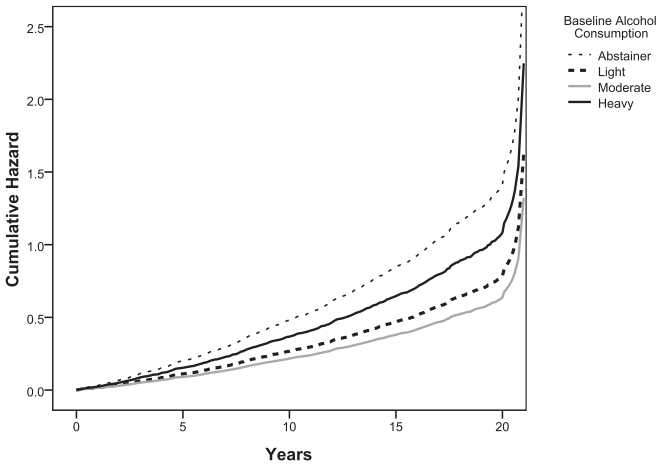

Fig. 1. Cumulative hazard of mortality across 20 years by baseline alcohol consumption group membership for an initial model controlling for age and gender.

Full Predictive Model Controlling for All Covariates

Finally, we examined the association between alcohol group membership and mortality risk across the 20-year follow-up in a Cox proportional hazards regression analysis controlling for age and gender, all eleven additional covarites indexed at baseline, and the interaction terms for gender × marital status and gender × avoidance coping. One covariate, physical activity, did not meet the proportional hazards assumption that the hazards ratio for any 2 observations remains constant over time. Preliminary tests indicated that the strength of baseline physical activity in predicting mortality risk decreased over time. Thus, following convention (Singer and Willet, 2003, pp. 562–570), an interaction term reflecting the physical activity × time interaction was included as a correction in the model.

We used a hierarchical strategy, with sets of covariates proposed as potential confounds related to abstainers entered in successive blocks. Consistent with the initial model, age and gender were entered at step 1. Reflecting concerns that abstainers may be atypical sociodemographically, sociodemographic factors (SES, marital status, and gender × marital status) were entered at step 2. Consistent with objections that abstainers may include former problem drinkers with high prevalence rates of medical illness, former problem drinking status and health problems were entered at steps 3 and 4, respectively. Reflecting concerns that abstainers may be atypical in terms of social and behavioral factors, social-behavioral factors (obesity, smoking status, physical activity, physical activity × time interaction, depressive symptoms, avoidance coping, gender × avoidance coping, number of close friends, and quality of friend support) were entered at step 5. Alcohol group membership, dummy-coded with moderate drinkers as the reference group, was entered at step 6.

Results for each set of predictors at each step of entry into the model are presented in Table 4. Change in the -2 log likelihood statistic for the set of variables entered at each step was examined with a chi-square test, and controls for variables entered at all prior steps. Hazard ratios for individual covariates were examined with the Wald test and control for variables entered at all prior steps, as well as for other covariates entered at the respective step. Each block of covariates added a significant ($p < 0.01$) increment in predicting mortality risk. At the last step, after accounting for all other covariates, alcohol group membership added a significant ($p < 0.01$) additional increment in predicting mortality risk.

After adjusting for the effects of age and gender, all eleven additional covariates, and the gender–marital status and gender–avoidance coping interactions, abstainers and heavy drinkers continued to show increased mortality risks of 49 and 42%, respectively, compared to moderate drinkers. However, after adjusting for all covariates, the slightly higher relative risk for light drinkers (12%) compared to moderate

Table 4. Results of a Cox Proportional-Hazards Regression Analysis at Each Step Predicting 20-Year Mortality Risk From Alcohol Consumption Group Membership at Baseline in a Model Controlling for All Baseline Covariates (N = 1,824). Each Step Controls for Variables Entered at All Prior Steps

		−2 LL change at step		Individual covariates	
Step	Covariates by predictor set	df	χ^2	Hazard ratio	95% CI
1	Age and gender	2	87.55**		
	Age			1.06**	1.04, 1.08
	Gender[b] (Female = 0, Male = 1)			1.65**	1.43, 1.90
2	Sociodemographic factors	3	132.51**		
	SES[a]			0.68**	0.63, 0.74
	Marital status[b] (No = 0, Yes = 1)			0.86*	0.74, 0.99
	Gender × Marital status			0.63**	0.47, 0.84
3	Former problem drinker[b] (No = 0, Yes = 1)	1	6.14*	1.21*	1.04, 1.39
4	Health problems	1	158.25**	1.17**	1.14, 1.20
5	Social-behavioral factors	9	69.75**		
	Obesity[b] (No = 0, Yes = 1)			1.00	0.82, 1.22
	Smoking status[b] (No = 0, Yes = 1)			1.63**	1.41, 1.89
	Physical activity			0.84**	0.74, 0.96
	Physical activity × Time			1.02*	1.004, 1.03
	Depressive symptoms			1.00	0.99, 1.00
	Avoidance coping			1.00	0.98, 1.00
	Gender × Avoidance coping			0.96**	0.93, 0.98
	# Close friends			0.97	0.92, 1.03
	Quality of support			1.00	0.98, 1.02
6	Alcohol consumption group	3	20.99**		
	Abstainers			1.49**	1.20, 1.84
	Heavy drinkers			1.42**	1.17, 1.73
	Light drinkers			1.12	0.94, 1.35

SES, socioeconomic status.
[a]Standardized scale.
[b]Binary variable coded 0–1.
*$p < 0.05$, **$p < 0.01$.

drinkers was no longer significant.[1] These population estimates are close to relative increments in 20-year mortality in the present sample of 68% for abstainers, 46% for heavy drinkers, and 12% for light drinkers in comparison with moderate drinkers, based on the descriptive information on sample mortality described earlier. As in the initial model, including interactions between gender and alcohol group membership did not significantly improve model fit [$\chi^2(3, N = 1{,}824) = 3.27$, $p = 0.35$]. Comparing Tables 1 and 4 shows that relative mortality risk for abstainers drops by 33% (from 2.22 to 1.49) and approaches that of heavy drinkers. For heavy drinkers and light drinkers, relative mortality risk drops more modestly by 16% (1.70 to 1.42) and 9% (1.23 to 1.12), respectively.[2]

Figure 2 plots cumulative hazard across the 20-year follow-up by baseline alcohol group membership for the final model controlling for all covariates. Comparing Figs. 1 and 2 demonstrates the effect of including the additional covariates on cumulative hazard for each group. Compared to the initial model, accumulated risk for abstainers and heavy drinkers is much more similar in the full model after controlling for all covariates. However, even after adjusting for all covariates, accumulated risk for abstainers and heavy drinkers remains consistently higher across 20 years than that for light and moderate drinkers.

Additional Analysis

Because our definition of moderate alcohol consumption exceeded the 1 to 2 drinks per day used in some studies with older adults (e.g., Gmel et al., 2003; Klatsky et al., 1992; Thun et al., 1997), we conducted an additional analysis to examine the potential mortality effect of contrasting levels of alcohol consumption within the moderate drinker group. Specifically, we contrasted moderate drinkers who consumed up to 2 drinks per day (from 14 to 28 g of alcohol, score = 0, n = 345) with moderate drinkers who consumed from more than 2 drinks per day to < 3 drinks per day (from more than 28 to less than 42 g of alcohol, score = 1, n = 215) on mortality risk across the 20-year follow-up period in a Cox proportional hazards regression analysis, controlling for all covariates in the full predictive

[1]Other individual covariates that retained statistical significance ($p < 0.05$) at the last step were: age (OR = 1.06, 95% CI = 1.04, 1.08), gender (OR = 1.43, 95% CI = 1.22, 1.67), SES (OR = 0.83, 95% CI = 0.76, 0.90), health problems (OR = 1.17, 95% CI = 1.14, 1.20), smoking status (OR = 1.59, 95% CI = 1.37, 1.84), physical activity (OR = 0.85, 95% CI = 0.75, 0.97), physical activity × time (OR = 1.02, 95% CI = 1.003, 1.03), gender × marital status (OR = 0.61, 95% CI = 0.46, 0.82), and gender × avoidance coping (OR = 0.96, 95% CI = 0.94, 0.98).

[2]We also explored interactions between former problem drinking status and alcohol group membership, as well as between former problem drinking status and the other covariates. There were no significant ($p < 0.05$) interactions between former problem drinking status and alcohol group membership or between former problem drinking status and the other covariates.

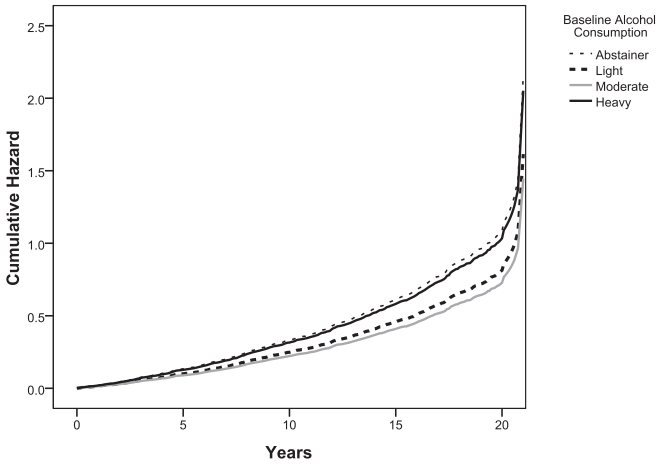

Fig. 2. Cumulative hazard of mortality across 20 years by baseline alcohol consumption group membership for a model controlling for all covariates.

model. Moderate drinkers who consumed up to 2 drinks per day were nearly identical in 20-year mortality risk with moderate drinkers who consumed from more than 2 to <3 drinks per day (OR = 0.97, p = 0.80, 95% CI = 0.74, 1.26).

DISCUSSION

This study examined alcohol consumption and total mortality among 1,824 older adults followed for 20 years, controlling for a wide range of traditional and nontraditional confounding factors associated with abstention. In an initial model, controlling only for age and gender, baseline alcohol consumption group showed a U-shaped relationship with total mortality. A model controlling for former problem drinking status, existing health problems, and key sociodemographic and social-behavioral factors substantially reduced the mortality effect for abstainers compared to moderate drinkers. However, even after adjusting for all covariates, abstainers and heavy drinkers continued to show increased mortality risk compared to moderate drinkers. Unique strengths of this study are its focus on alcohol and mortality in a large sample of older adults, its prospective design across a 20-year follow-up period, and its ability to control for a wide range of traditional and nontraditional confounding factors associated with abstention.

Consistent with previous research on alcohol consumption and total mortality among older adults (Klatsky et al., 1992; Lee et al., 2009; Moore et al., 2006) and 4-year analyses with individuals in the present sample (Mertens et al., 1996), in an initial Cox proportional hazards regression analysis controlling only for age and gender, baseline alcohol consumption showed a U-shaped relationship with mortality risk across the 20-year follow-up period. Compared to moderate drinkers, abstainers had a more than 2 times increased mortality risk, heavy drinkers had 70% increased risk, and light drinkers had 23% increased risk.

Ongoing controversy pertaining to the relatively high mortality risk among abstainers in previous research concerns the possibility that abstainers may include former problem drinkers with many health problems (Fillmore et al., 2006; Shaper (1990) and individuals who are atypical in terms of sociodemographic and social-behavioral factors that may be associated with health risk (Gmel et al., 2003; Heath, 2007; Lee et al., 2009; Rehm et al., 2002; Skog, 1996). Based on these concerns, we predicted that controlling for former problem drinking status, existing health problems, and key sociodemographic and social-behavioral factors, abstainers would continue to show a higher, though reduced, mortality rate compared to moderate drinkers.

In fact, in tests of potential covariates, we found among these older adults that at baseline, abstainers were significantly more likely to have had prior drinking problems, to be obese, and to smoke cigarettes than moderate drinkers and significantly higher than moderate drinkers on health problems, depressive symptoms, and avoidance coping. Moreover, at baseline, abstainers were significantly lower than moderate drinkers on SES, physical activity, number of close friends, and quality of friend support and significantly less likely to be married than moderate drinkers. Moreover, all of these covariates significantly predicted mortality. We found only 2 gender interactions associated with increased mortality (the effect for being unmarried was relatively stronger for men and the effect for avoidance coping was relatively stronger for women). However, including these interactions in the full model affected the model only slightly. Moreover, the association between alcohol group membership and mortality risk did not vary by gender.

Controlling for age and gender, all eleven additional covariates, and the gender–marital status and gender–avoidance coping interactions in the Cox proportional hazards regression analysis reduced the 20-year mortality risk for abstainers compared to moderate drinkers. After including all covariates, the relative mortality risk for abstainers compared to moderate drinkers dropped by close to one-third and approached that of heavy drinkers. However, even after adjusting for all covariates, abstainers and heavy drinkers continued to show increased mortality risks of 49 and 42%, respectively, compared to moderate drinkers. After adjusting for all covariates, the relative risk for light drinkers compared to moderate drinkers was no longer significant.

According to previous work, the apparent health-protective effects of moderate alcohol consumption compared to abstention may be related to reductions in cardiovascular illness (Corrao et al., 2004). Plausible mechanisms include the role of alcohol in increasing high-density lipoprotein cholesterol, fibrinolysis, endothelial function, and antioxidant effects and in reducing plasma viscosity, fibrinogen concentration, platelet aggregation, and inflammation (Kloner and Rexkall, 2007; Rehm et al., 2003). In contrast, the adverse health effects of high compared to moderate alcohol consumption appear primarily because of noncardiovascular illnesses. Alcohol misuse

is associated with several cancers (oral cavity, esophagus, and larynx), cirrhosis of the liver, chronic pancreatitis, and hypertension, as well as with injuries (Corrao et al., 2004). Importantly, any health-protective effects of alcohol appear to be limited to *regular* moderate drinking. Heavy episodic drinking—even when average consumption remains moderate—is associated with increased cardiovascular risk (Rehm et al., 2003; Room et al., 2005).

Our findings are consistent with those of other investigators (Klatsky et al., 1992; Lee et al., 2009; Moore et al., 2006) who have reported a U-shaped association between alcohol and mortality among older adults after controlling for many, though not all, of these confounding factors. However, conclusions about alcohol and health in older adults also need to consider broader quality of life and safety concerns involving cognitive function, falls, and alcohol use problems that may be associated with moderate alcohol consumption. In the case of cognitive function, moderate alcohol consumption of 1 to 2 drinks per day does not appear to increase the risk of cognitive impairment or decline in older adults (Lang et al., 2007a; Stampfer et al., 2005) and may even be associated with improved cognitive function in older individuals (Espeland et al., 2005; Lang et al., 2007b). Findings pertaining to falls from the Cardiovascular Health Study indicate that moderate alcohol consumption (14 or more drinks per week) predicts increased falls in older adults (Mukamal et al., 2003). In regard to alcohol use problems, alcohol consumption among older adults in excess of 2 drinks per day or 7 drinks per week is associated with an elevated risk of alcohol use problems among both women and men (Moos et al., 2004, 2009).

In addition, several limitations should be kept in mind in interpreting the present findings. Most important, as with other research on alcohol and mortality in humans, these are not experimental findings. Although we controlled for a wide range of traditional and nontraditional confounding factors associated with abstention, there may be other important confounding factors that remained uncontrolled. Also, measurement error may have reduced the degree of control achieved in those factors we did index. In addition, although mortality was indexed objectively, our measures of alcohol consumption and of confounding factors were based on self-report. Although there is support for the validity of self-report measures of alcohol consumption for mixed-age and older adults (Babor et al., 1987; Stacy et al., 1985; Tucker et al., 1991; Werch, 1989), future research would be strengthened by including objective indices or collateral information on alcohol consumption and confounding factors. Further, consistent with most previous research, our analyses were limited to baseline alcohol consumption. Future research is needed to examine the health effects of changing patterns of alcohol consumption during the aging years. Moreover, as Reid and colleagues (2002) pointed out, studying the alcohol-mortality relationship in older adults is subject to a biasing survival effect in that the most vulnerable individuals may have died before baseline assessment.

A further limitation is that we were not able to examine lifetime abstention because the parent project of which this study was a part excluded lifetime abstainers. However, we did control for both former problem drinking status and existing health problems at baseline, factors that are central to the concern that the apparent health benefits of moderate drinking reflect a downward drift of medically ill drinkers into nondrinking (or occasional drinking) categories (Fillmore et al., 2006; Shaper, 1990). Moreover, Rehm and colleagues (2008) have questioned the appropriateness of lifetime abstainers as a comparison group in alcohol epidemiology, because of unreliability in reporting lifetime abstention and interpretive problems associated with the small number of lifetime abstainers in most samples. Similarly, Fillmore and colleagues (2006) observed that among over fifty studies in their meta-analysis examining alcohol consumption and mortality, only a small fraction of studies used complete lifetime abstainers as the comparison group. Finally, our study design and measures of alcohol consumption limited our ability to consider the effects of heavy episodic drinking, number of years of abstention, or reasons for abstention, all of which remain important issues for future research.

In addition, several cautions should be emphasized in interpreting the present findings. Even among moderate drinkers, higher levels of alcohol consumption and heavy episodic drinking may adversely affect safety and quality of life. Consuming more than 2 drinks per day has been associated with increased falls (Mukamal et al., 2003), a higher risk of alcohol use problems (Moos et al., 2004, 2009), and potential adverse interactions with medications (Moore et al., 2006) in older adults. Further, heavy episodic drinking is associated with increased cardiovascular risk even when overall consumption is moderate (Rehm et al., 2003; Room et al., 2005). Finally, we indexed daily alcohol consumption at baseline. It is likely that alcohol consumption declined over time, particularly among individuals who were close to the upper limit of moderate drinking (Brennan et al., 2010; Kerr et al., 2004; Moore et al., 2005).

Overall, our findings are consistent with an interpretation that an important part of the survival effect for moderate drinking compared to abstention among older adults is explained by the effect of confounding factors associated with alcohol abstention. Current abstainers in this sample included many former problem drinkers, individuals with more health problems, and individuals characterized by both sociodemographic and social-behavioral factors associated with higher mortality. However, even after taking account of all of these traditional and nontraditional covariates, moderate alcohol consumption continued to show a significant, though attenuated, association with lower mortality risk.

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