



## Smoking, heavy drinking, and depression among U.S. middle-aged and older adults



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### ABSTRACT

**Objective.** To examine the relationship between smoking, heavy drinking and depression among U.S. middle-aged and older adults.

**Method.** Individual-level data came from 1992–2012 waves of the Health and Retirement Study. Smoking was ascertained from self-reported cigarette smoking status at the time of interview. Heavy drinking was defined as one or more drinks per day on average or four or more drinks on any occasion in the past three months for women, and two or more drinks per day on average or four or more drinks on any occasion in the past three months for men. Depression was defined as scoring three and above on the eight-item Center for Epidemiologic Studies Depression Scale. Cox proportional hazards regressions were performed to examine the relationship between smoking, heavy drinking and depression.

**Results.** Compared to non-smokers, smokers free from depression and heavy drinking at baseline were 20% (95% confidence interval: 12–28%) and 34% (20–50%) more likely to develop depression and engage in heavy drinking during follow-up period, respectively. Compared to non-depressed participants, participants with depression who were nonsmokers and non-heavy drinkers at baseline were 41% (14–74%) and 18% (6–31%) more likely to smoke and engage in heavy drinking during follow-up, respectively. Compared to non-heavy drinkers, heavy drinkers who were nonsmokers at baseline were 60% (26–104%) more likely to smoke during follow-up.

**Conclusion.** Health promotion programs in midlife and older age should be mindful of the associations between smoking, heavy drinking and depression in order to improve intervention effectiveness.

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### Introduction

Depression is a common psychiatric disorder characterized by depressed or sad mood, tiredness, fatigue, disturbed sleep or appetite, and recurrent thoughts of death (Kendler and Gardner, 1998; Marcus et al., 2012). As a major contributor to the global burden of disease, depression consumes considerable medical and social resources and results in substantially reduced quality of life (Ferrari et al., 2013). Compared to their younger counterparts, depressed middle-aged and older adults are more likely to experience loss of interest and cognitive changes, endorse affective and somatic symptoms, and attempt suicide (Fiske et al., 2009). Emerging evidence also relates depression in middle-aged and older adults to other adverse health outcomes like hypertension, cardiovascular disease and functional limitations (Meng et al., 2012; Papakostas, 2009; Xiang and An, 2015a,b).

As two of the leading health risk factors for morbidity and premature mortality in the U.S. and worldwide, smoking and heavy drinking have

been closely linked to depression (Arfken, 2007; Mendelsohn, 2012; Sullivan et al., 2005). Boden and Fergusson (2011) systematically reviewed literature on the relationship between alcohol use disorders and major depression. Meta-analysis reported the presence of either condition to double the odds of the second condition. Park and Romer (2007) systematically reviewed evidence on the relationship between smoking and depression among adolescents. Significant associations between smoking and depression were reported in 47 of 57 reviewed studies. However, validity of findings was compromised as many of the studies did not adjust for confounders or did not use validated instruments to measure depression. Hitsman et al. (2013) systematically reviewed literature on the effect of major depression on smoking cessation. A modest adverse effect from past major depression on abstinence during and after smoking cessation treatment was reported in meta-analysis.

Gender and racial/ethnic differences in smoking, drinking, and depression have been extensively documented (Holmila and Raitasalo, 2005; Perkins et al., 1999; Piccinelli and Wilkinson, 2000), but studies on the differential relationship between these factors across population subgroups remain limited. Husky et al. (2008) assessed gender

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differences in the comorbidity of smoking behavior and major depression, and found female smokers at significantly higher risk of depression than male smokers. Schutte et al. (1997) evaluated gender differences in the relationship between heavy drinking and depression. Heavy drinking predicted depression onset in both genders, but a reciprocal association was found only among men. Castro et al. (2011) examined racial/ethnic differences in the effects of depression on smoking cessation. Depression predicted significantly lower cessation rates for whites and African Americans, but no relationship between depression and smoking cessation was found among Hispanics.

Using data from a nationally representative longitudinal survey, this study added a new data point to the literature by examining the relationship between smoking, heavy drinking and depression among U.S. middle-aged and older adults. As previous systematic reviews and meta-analyses documented effects that went in both directions and the underlining causal relationships remain unclear (Boden and Fergusson, 2011; Park and Romer, 2007; Sullivan et al., 2005), we hypothesized and empirically tested bidirectional associations between smoking, heavy drinking, and depression in which the presence of any one condition predicted future onset of the other two conditions. Survival models were performed to estimate the associations between smoking, heavy drinking, and depression, and potential population heterogeneities in the associations across gender and race/ethnicity were examined in subgroup analysis based on stratified samples.

## Methods

### Study participants

Individual-level data came from the Health and Retirement Study (HRS), an ongoing longitudinal study that surveys a representative sample of U.S. community-dwelling adults 50 years of age and above since 1992. Follow-up interviews are conducted every other year, with an overall response rate over 80% across waves. The HRS collects rich information including income, employment, assets, pension plans, health insurance, disability, physical health and functioning, cognitive functioning, and health care expenditures. Survey design, questionnaires, and other details about the HRS can be found on its web portal (<http://hrsonline.isr.umich.edu/>). This study used the HRS cross-sectional (RAND HRS enhanced fat files) and longitudinal (RAND HRS dataset version N) datasets constructed by the RAND Corporation, which cleaned and compiled the HRS data from 1992, 1993, 1994, 1995, 1996, 1998, 2000, 2002, 2004, 2006, 2008, 2010, and 2012 waves (<http://hrsonline.isr.umich.edu/modules/meta/rand/>). It included the original HRS cohort (born between 1931 and 1941) entering in 1992, the Asset and Health Dynamics Among the Oldest Old (AHEAD) cohort (born before 1924) entering in 1993, the Children of Depression (CODA) cohort (born between 1924 and 1930) and the War Baby (WB) cohort (born between 1942 and 1947) both entering in 1998, the Early Baby Boomer (EBB) cohort (born between 1948 and 1953) entering in 2004, and the Mid Baby Boomer (MBB) cohort (born between 1954 and 1959) entering in 2010. The HRS was approved by the University of Michigan Human Subjects Review Committee, and this study used de-identified publicly available HRS data and therefore did not require additional human subjects review.

The sampling unit in the HRS is household. A married household was considered age eligible as long as one spouse in the household was age eligible (e.g., 50 years of age and above). Therefore, it is possible that both spouses in a household were interviewed but only one of them met the age criterion whereas the other spouse did not. We restricted the study samples to HRS participants born during 1900–1953 (50 years of age and above in 1992) and free from depression, heavy drinking, or smoking at their first interview (i.e., baseline), respectively. Participants were excluded from the analyses on the basis of age ineligibility, presence of a specific condition (depressed, heavy drinking, or smoking) at the baseline, and/or missing covariates.

### Current depression, heavy drinking, and smoking status

Depressive symptoms were measured by the eight-item CES-D, a shortened version of the 20-item CES-D (Kohout et al., 1993). Participants were asked whether (“yes” or “no”) they felt depressed, felt that everything was an effort, slept restlessly, could not get going, felt sad, felt lonely, enjoyed life, and were happy in the past week. The two positive items (i.e., “enjoyed life” and “was

happy”) are reverse-coded, so that a higher score indicates a more depressed mood. The eight-item CES-D total score, ranging from zero to eight, sums up the presence of (coded as one) or absence (coded as zero) from each of the eight feelings. Melchior et al. (1993) reported that the eight-item and 20-item CES-D scales were highly correlated ( $r = 0.93$ ) and had comparable discriminant validity. A cut-off score of three has been suggested by previous validation studies to indicate clinically relevant depressive symptoms (Turvey et al., 1999). This cut-off score has a sensitivity of 0.71 and a specificity of 0.79 to predict major depressive episodes. A participant was classified as having a depression onset in a survey wave if one scored three or above on the eight-item CES-D in that wave.

Heavy drinking was defined in accordance with the 2010 Dietary Guidelines for Americans (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010) as one or more drink per day on average or four or more drinks on any occasion in the past three months for women, and two or more drinks per day on average or four or more drinks on any occasion in the past three months for men.

Smoking was assessed by the question “Do you smoke cigarettes now?” A participant was classified as a smoker in a survey wave if he or she answered yes in that wave.

Among 24,759 participants who did not have depression at their baseline interview, 27.38% of them had one or more depression onset during the follow-up period; among 27,331 participants who did not engage in heavy drinking at their baseline interview, 7.41% had heavy drinking during follow-up; and among 24,669 participants who did not smoke at their baseline interview, 2.02% smoked during follow-up.

### Covariates

We controlled both wave-invariant and wave-variant individual characteristics in the regression analyses. Wave-invariant covariates include gender, race/ethnicity (non-Hispanic white, non-Hispanic African American, non-Hispanic other race or multi-race, and Hispanic), education (education less than high school, high school, college, and education higher than college), birth cohort (HRS, AHEAD, CODA, WB, EBB, and MBB), and history of psychiatric problem (ever versus never diagnosed with psychiatric problem), smoking (ever versus never smoked in one's life), and drinking (ever versus never drank in one's life) reported at the baseline interview. Wave-variant covariates include age in years, marital status (married or living with partner, and unmarried, divorced, separated, or widowed), household net wealth (divided into four quartiles based on the wealth distribution in each survey wave), diagnosis of a chronic condition (hypertension, diabetes, heart disease, stroke, lung disease, arthritis, and cancer), residential census region (Midwest, Northeast, South, and West), and body weight status. Body mass index (BMI) was calculated from self-reported height and weight. Body weight status was classified into four categories—underweight ( $BMI < 18.5 \text{ kg/m}^2$ ), normal weight ( $18.5 \text{ kg/m}^2 \leq BMI < 25 \text{ kg/m}^2$ ), overweight ( $25 \text{ kg/m}^2 \leq BMI < 30 \text{ kg/m}^2$ ), and obesity ( $BMI \geq 30 \text{ kg/m}^2$ ).

### Statistical analyses

Descriptive statistics, weighted by the HRS baseline sampling weights, are reported separately for the three study samples that were free from depression, heavy drinking, or smoking at the baseline interview, respectively.

Cox proportional hazards regressions were performed to examine the relationship between depression, heavy drinking, and smoking. The regression to estimate the impact of heavy drinking and smoking on depression was performed on the participants who were non-depressed at the baseline interview, and the two key independent variables were their current heavy drinking and smoking status. Similarly, the regression to estimate the impact of depression and smoking on heavy drinking was performed on the participants who did not engage in heavy drinking at the baseline interview, and the two key independent variables were their current depression and smoking status. The regression to estimate the impact of depression and heavy drinking on smoking was performed on the participants who did not smoke at the baseline interview, and the two key independent variables were their current depression and heavy drinking status. In these regressions, a participant was considered a “survivor” till a specific condition (depression, heavy drinking, or smoking) was reported, if ever. Participants who died or were lost during follow-up without ever reporting a specific condition were censored at the last wave when they were interviewed. Participants who were alive and remained free from a specific condition by 2012 were censored at the last wave of the study. Multiple “failures”, namely more than one occurrence of a specific condition

(e.g., depression recovery and relapse), were accounted for in regression estimation. In subgroup analysis, separate regressions were performed on the study samples stratified by gender and race/ethnicity.

All statistical analyses were conducted using Stata 14.0 SE version (StataCorp, College Station, TX).

## Results

Table 1 reports descriptive statistics of the three study samples free from depression, heavy drinking, or smoking at the baseline interview, respectively. Among the participants free from depression at the

**Table 1**  
Health Retirement Study baseline participant characteristics (95% confidence interval).

Variable	Sample with no depression at baseline	Sample with no heavy drinking at baseline	Sample with no smoking at baseline
Number of participants at baseline	24,759	27,331	24,669
Current depression status (%)			
Depressed	/	22.09 (21.44, 22.73)	19.06 (18.42, 19.70)
Nondepressed	/	77.91 (77.27, 78.56)	80.94 (80.30, 81.58)
Current heavy drinking status (%)			
Heavy drinking	18.18 (17.50, 18.86)	/	14.88 (14.24, 15.52)
No heavy drinking	81.82 (81.14, 82.50)	/	85.12 (84.48, 85.76)
Current smoking status (%)			
Smoking	17.95 (17.30, 18.60)	17.73 (17.11, 18.34)	/
Nonsmoking	82.05 (81.40, 82.70)	82.27 (81.66, 82.89)	/
History of psychiatric problem (%)			
Ever diagnosed with psychiatric problem	8.79 (8.30, 9.28)	13.56 (13.00, 14.12)	11.79 (11.23, 12.34)
Never diagnosed with psychiatric problem	91.21 (90.72, 91.70)	86.44 (85.88, 87.00)	88.21 (87.66, 88.77)
History of drinking (%)			
Ever drank in one's life	65.77 (65.00, 66.53)	55.36 (54.59, 56.13)	62.52 (61.74, 63.30)
Never drank in one's life	34.23 (33.47, 35.00)	44.64 (43.87, 45.41)	37.48 (36.70, 38.26)
History of smoking (%)			
Ever smoked in one's life	56.86 (56.04, 57.68)	54.67 (53.89, 55.45)	46.40 (45.57, 47.22)
Never smoked in one's life	43.14 (42.32, 43.96)	45.33 (44.55, 46.11)	53.60 (52.78, 54.43)
Gender (%)			
Male	51.03 (50.20, 51.85)	43.62 (42.84, 44.41)	47.66 (46.84, 48.49)
Female	48.97 (48.15, 49.80)	56.38 (55.59, 57.16)	52.34 (51.51, 53.16)
Age			
Age in years	60.46 (60.31, 60.61)	60.96 (60.82, 61.10)	61.23 (61.08, 61.39)
Race/ethnicity (%)			
Non-Hispanic white	79.89 (79.27, 80.51)	76.85 (76.22, 77.48)	78.29 (77.65, 78.93)
Non-Hispanic African American	10.25 (9.82, 10.67)	11.83 (11.40, 12.26)	10.27 (9.85, 10.68)
Non-Hispanic other race/multi-race	3.02 (2.72, 3.32)	3.44 (3.13, 3.75)	3.22 (2.90, 3.53)
Hispanic	6.84 (6.44, 7.25)	7.88 (7.47, 8.30)	8.23 (7.79, 8.67)
Marital status (%)			
Married or living with partner	70.32 (69.56, 71.07)	65.77 (65.03, 66.51)	68.31 (67.55, 69.07)
Unmarried/divorced/separated/widowed	29.68 (28.93, 30.44)	34.23 (33.49, 34.97)	31.69 (30.93, 32.45)
Education (%)			
Less than high school	16.60 (16.05, 17.14)	21.31 (20.72, 21.89)	18.06 (17.50, 18.62)
High school	51.28 (50.45, 52.10)	50.62 (49.84, 51.41)	49.06 (48.24, 49.88)
College	21.78 (21.06, 22.51)	19.14 (18.47, 19.81)	22.20 (21.46, 22.94)
Higher than college	10.34 (9.80, 10.88)	8.93 (8.44, 9.42)	10.68 (10.13, 11.23)
Household wealth (%)			
Lowest income quartile	20.52 (19.86, 21.18)	26.02 (25.33, 26.71)	21.31 (20.65, 21.98)
Mid-low income quartile	24.93 (24.22, 25.65)	25.79 (25.10, 26.48)	24.72 (24.01, 25.42)
Mid-high income quartile	26.72 (25.99, 27.45)	24.79 (24.11, 25.47)	26.37 (25.63, 27.10)
Highest-high income quartile	27.83 (27.09, 28.57)	23.40 (22.74, 24.07)	27.61 (26.86, 28.35)
Body weight status (%)			
Underweight (BMI < 18.5 kg/m <sup>2</sup> )	1.33 (1.15, 1.51)	1.44 (1.26, 1.62)	1.12 (0.97, 1.28)
Normal weight (18.5 kg/m <sup>2</sup> ≤ BMI < 25 kg/m <sup>2</sup> )	32.05 (31.29, 32.81)	31.56 (30.84, 32.28)	29.70 (28.96, 30.44)
Overweight (25 kg/m <sup>2</sup> ≤ BMI < 30 kg/m <sup>2</sup> )	40.18 (39.37, 40.98)	37.76 (37.01, 38.52)	39.43 (38.62, 40.23)
Obese (BMI ≥ 30 kg/m <sup>2</sup> )	26.45 (25.70, 27.19)	29.23 (28.50, 29.96)	29.75 (28.98, 30.52)
Chronic condition (%)			
Hypertension	40.47 (39.67, 41.27)	43.01 (42.24, 43.79)	44.07 (43.26, 44.88)
Diabetes	11.77 (11.25, 12.29)	14.54 (13.99, 15.09)	14.06 (13.49, 14.62)
Heart disease	15.26 (14.70, 15.82)	17.41 (16.84, 17.97)	17.38 (16.80, 17.97)
Stroke	3.86 (3.57, 4.15)	4.68 (4.36, 4.99)	4.35 (4.05, 4.66)
Lung disease	5.95 (5.57, 6.32)	7.85 (7.44, 8.26)	6.07 (5.70, 6.44)
Arthritis	37.78 (37.00, 38.56)	37.91 (37.16, 38.66)	41.43 (40.63, 42.23)
Cancer	7.99 (7.57, 8.42)	8.73 (8.30, 9.16)	8.76 (8.32, 9.20)
Residential census region (%)			
Northeast	18.49 (17.85, 19.14)	17.95 (17.34, 18.55)	18.50 (17.85, 19.14)
Midwest	25.67 (24.95, 26.39)	24.84 (24.17, 25.52)	24.47 (23.77, 25.17)
South	35.69 (34.90, 36.48)	38.00 (37.24, 38.76)	36.35 (35.55, 37.14)
West	20.15 (19.49, 20.80)	19.21 (18.59, 19.83)	20.69 (20.02, 21.36)
Study cohort (%)			
Mid Baby Boomer (born 1954–1959)	18.92 (18.13, 19.70)	16.81 (16.09, 17.53)	18.57 (17.80, 19.35)
Early Baby Boomer (born 1948–1953)	19.35 (18.63, 20.07)	18.34 (17.66, 19.02)	19.51 (18.78, 20.23)
War Baby (born 1942–1947)	14.47 (13.83, 15.10)	14.30 (13.68, 14.92)	14.02 (13.38, 14.65)
HRS cohort (born 1931–1941)	24.17 (23.58, 24.75)	24.28 (23.72, 24.84)	22.09 (21.53, 22.65)
Children of Depression (born 1924–1930)	7.19 (6.85, 7.53)	7.80 (7.45, 8.14)	7.71 (7.36, 8.06)
AHEAD cohort (born before 1924)	15.91 (15.42, 16.41)	18.47 (17.97, 18.96)	18.10 (17.58, 18.62)

Notes: Statistics were weighted by HRS baseline sampling weights. 95% confidence intervals are in parentheses.

baseline, 18.18% of them engaged in heavy drinking and 17.95% smoked at the baseline; among the participants who did not engage in heavy drinking at the baseline, 22.09% of them had depression and 17.73% smoked at the baseline; and among the participants who did not smoke at the baseline, 19.06% of them had depression and 14.88% engaged in heavy drinking at the baseline.

Table 2 reports the adjusted hazard ratios (AHRs) for depression, heavy drinking, and smoking estimated in Cox proportional hazards regressions among the three study samples that were free from depression, heavy drinking, and smoking at the baseline, respectively. Depression predicted future smoking among baseline nonsmokers, and smoking predicted future depression onset among baseline non-depressed participants. Specifically, compared to their non-depressed counterparts, participants who were depressed were 41% (AHR = 1.41, 95% confidence interval [CI] = 1.14–1.74) more likely to smoke during the study follow-up period; and compared to nonsmokers, smokers were 20% (AHR = 1.20, 95% CI = 1.12–1.28) more likely to develop depression during follow-up. Heavy drinking predicted future smoking among baseline nonsmokers, and smoking predicted future engagement in heavy drinking among baseline non-heavy drinkers. Specifically, compared to non-heavy drinkers, heavy drinkers were 60% (AHR = 1.60, 95% CI = 1.26–2.04) more likely to smoke during the study follow-up period; and compared to nonsmokers, smokers were 34% (AHR = 1.34, 95% CI = 1.20–1.50) more likely to engage in heavy drinking during follow-up. Depression predicted future engagement in heavy drinking among baseline non-heavy drinkers. Compared to their non-depressed counterparts, participants who were depressed were 18% (AHR = 1.18, 95% CI = 1.06–1.31) more likely to engage in heavy drinking during the study follow-up period. In contrast, the effect of heavy drinking on future depression onset among baseline non-depressed participants was statistically nonsignificant (AHR = 1.05, 95% CI = 0.98–1.13) at  $P < 0.05$ .

Ever diagnosed with psychiatric problem, ever smoking in one's life, and ever drinking in one's life reported at baseline strongly predicted future depression onset, smoking, and heavy drinking among baseline non-depressed participants, non-heavy drinkers, and nonsmokers, respectively. In addition, ever smoking in one's life time reported at baseline predicted future depression onset and heavy drinking among baseline non-depressed participants and non-heavy drinkers, respectively.

Table 3 reports results from subgroup analysis. The relationship between depression, heavy drinking and smoking to some extent differed across gender and race/ethnicity. In contrast to their male counterparts, depression was not a statistically significant predictor of future smoking or heavy drinking among baseline non-smokers and non-heavy drinkers, respectively; and heavy drinking was not a significant predictor of future smoking among baseline non-smokers in female middle-aged and older adults. A bidirectional association between depression and smoking was identified among whites and Hispanics but no relationship between the two was found in African Americans. A bidirectional association between smoking and heavy drinking was found among African Americans and Hispanics, but heavy drinking did not predict future smoking in whites. A bidirectional association between heavy drinking and depression was identified among African Americans, but heavy drinking did not predict future depression in whites, and no relationship was found between the two among Hispanics.

## Discussion

This study examined the relationship between smoking, heavy drinking and depression among U.S. middle-aged and older adults using data from a nationally representative longitudinal survey. Bidirectional associations were found between smoking and depression and between smoking and heavy drinking. Depression predicted future engagement in heavy drinking among baseline non-heavy drinkers but not vice versa. Previous systematic reviews criticized the lack of

adequate control for potential confounders in the existing literature (Park and Romer, 2007; Sullivan et al., 2005), but that is unlikely to explain the null finding here. Survival models without controlling for any of the covariates estimated a rather small but statistically significant inverse bidirectional association between heavy drinking and depression. The estimated negative effect of heavy drinking on depression onset became positive but statistically nonsignificant after controlling for covariates, whereas the estimated negative effect of depression on future heavy drinking became positive and statistically significant. One plausible explanation is that the measure on heavy drinking in the HRS did not distinguish habitual drinkers from people with more severe alcohol abuse problems such as alcohol use disorders, which was found to increase the risk of mental disorders (Boden and Fergusson, 2011). While the CAGE (Ewing, 1984)—a four-question screening instrument for alcohol dependence was administered in a few waves in the HRS, it was asked during participants' baseline interview only, so that we were unable to model incidence of alcohol dependence during the follow-up period.

The relationship between smoking and depression has been extensively documented, but mostly in cross-sectional studies, which confines the conclusions regarding causality and directionality (Mendelsohn, 2012; Ünsal and Tözün, 2014; Wiesbeck et al., 2008). One exception is Boden et al. (2010), which examined the longitudinal relationship between smoking and depression by collecting data on nicotine dependence and depressive symptoms in early adulthood (at 18, 21 and 25 years of age) from a birth cohort of approximately 1000 New Zealand residents. Nicotine dependence was found to predict future depression onset. In contrast, mixed findings were reported regarding the impact of depression on subsequent smoking cessation (Doyle et al., 2014). Some epidemiological and clinical studies found a significant depression effect on the likelihood of smoking cessation whereas others did not reveal such an association (Berlin et al., 2009). The underlining biological mechanism linking smoking with depression is not well understood. There is some preliminary evidence of a shared etiology between heavy smoking and dysthymia, whereas no shared vulnerability with heavy smoking was found for major depression (Dierker et al., 2002).

The bidirectional association between smoking and heavy drinking found in the present study is in accordance with existing literature. The concurrent association between smoking and drinking has been widely observed (De Leon et al., 2007; Faeh et al., 2006; Reed et al., 2007; Weitzman and Chen, 2005). Findings from prospective, longitudinal studies have supported the notion that smoking has a long-term effect on later alcohol consumption and vice versa (Morgen et al., 2008; Jackson et al., 2003; Jensen et al., 2003). In a Danish representative sample of young women, daily smoking at baseline predicted increased risk of becoming a heavy drinker eight years later (Morgen et al., 2008). Data from a nationally representative sample of U.S. adults reported that consuming five or more drinks in one occasion during the past month reduced the odds of smoking cessation, and this negative effect on smoking cessation appeared stronger among older adults (Dawson, 2000). Several pathways have been proposed to explain the co-occurrence of smoking and alcohol, including shared genetic predispositions (Koopmans et al., 1997), personality characteristics such as impulsivity and sensation-seeking (Bien and Burge, 1990), behavior mechanisms such as self-medication (Little, 2000), and social influences (Room, 2004).

There was some preliminary evidence on the population heterogeneities in the relationships between depression, heavy drinking and smoking. However, it is far from clear why the relationships differed and whether the results could be replicated in different samples or settings. Future studies need to confirm these differences and elucidate the underlying pathways.

A few limitations of this study should be noted. Modeling results based on data from prospective observational studies should be interpreted as correlations rather than causations. CES-D measures



**Table 2**

Adjusted hazard ratios for depression, heavy drinking, and smoking estimated in Cox proportional hazards regressions (95% confidence interval).

Variable	Depression	Heavy drinking	Smoking
<b>Study sample</b>			
Baseline characteristics	No depression	No heavy drinking	No smoking
Number of participants at baseline	24,759	27,331	24,669
Number of observations	97,817	124,419	111,598
<b>Current depression status</b>			
Depressed	/	1.18 (1.06, 1.31)	1.41 (1.14, 1.74)
Nondepressed (reference)	/	1.00	1.00
<b>Current heavy drinking status</b>			
Heavy drinking	1.05 (0.98, 1.13)	/	1.60 (1.26, 2.04)
No heavy drinking (reference)	1.00	/	1.00
<b>Current smoking status</b>			
Smoking	1.20 (1.12, 1.28)	1.34 (1.20, 1.50)	/
Nonsmoking (reference)	1.00	1.00	/
<b>History of psychiatric problem</b>			
Ever diagnosed with psychiatric problem	1.54 (1.44, 1.65)	0.98 (0.85, 1.12)	1.16 (0.90, 1.49)
Never diagnosed with psychiatric problem (reference)	1.00	1.00	1.00
<b>History of drinking</b>			
Ever drank in one's life	0.99 (0.95, 1.04)	6.10 (5.34, 6.97)	0.94 (0.76, 1.15)
Never drank in one's life (reference)	1.00	1.00	1.00
<b>History of smoking</b>			
Ever smoked in one's life	1.08 (1.02, 1.13)	1.49 (1.35, 1.64)	25.73 (16.86, 39.26)
Never smoked in one's life (reference)	1.00	1.00	1.00
<b>Gender</b>			
Male	0.76 (0.72, 0.80)	1.88 (1.72, 2.05)	1.05 (0.87, 1.28)
Female (reference)	1.00	1.00	1.00
<b>Age</b>			
Age in years	0.99 (0.99, 1.00)	0.96 (0.95, 0.97)	0.94 (0.92, 0.96)
<b>Race/ethnicity</b>			
Non-Hispanic white (reference)	1.00	1.00	1.00
Non-Hispanic African American	1.00 (0.94, 1.06)	1.16 (1.03, 1.31)	1.38 (1.07, 1.78)
Non-Hispanic other race/multi-race	1.07 (0.92, 1.24)	0.87 (0.66, 1.17)	1.50 (0.90, 2.52)
Hispanic	1.33 (1.22, 1.44)	1.44 (1.24, 1.66)	1.68 (1.26, 2.24)
<b>Marital status</b>			
Married or living with partner	0.72 (0.68, 0.76)	0.87 (0.78, 0.95)	0.63 (0.52, 0.77)
Unmarried/divorced/separated/widowed (reference)	1.00	1.00	1.00
<b>Education</b>			
Less than high school (reference)	1.00	1.00	1.00
High school	0.84 (0.79, 0.88)	0.88 (0.78, 0.99)	1.06 (0.84, 1.34)
College	0.74 (0.68, 0.80)	0.97 (0.84, 1.12)	0.77 (0.56, 1.07)
Higher than college	0.67 (0.60, 0.74)	0.90 (0.76, 1.07)	0.62 (0.40, 0.98)
<b>Household wealth</b>			
Lowest income quartile (reference)	1.00	1.00	1.00
Mid-low income quartile	0.92 (0.87, 0.98)	0.97 (0.86, 1.11)	1.02 (0.81, 1.28)
Mid-high income quartile	0.86 (0.80, 0.92)	1.19 (1.04, 1.35)	0.78 (0.60, 1.02)
Highest-high income quartile	0.74 (0.68, 0.79)	1.37 (1.20, 1.58)	0.63 (0.46, 0.85)
<b>Body weight status</b>			
Underweight	1.05 (0.91, 1.22)	0.75 (0.50, 1.13)	1.05 (0.50, 2.24)
Normal weight (reference)	1.00	1.00	1.00
Overweight	0.96 (0.91, 1.01)	0.87 (0.79, 0.96)	0.65 (0.53, 0.80)
Obese	1.06 (1.00, 1.13)	0.77 (0.69, 0.87)	0.40 (0.31, 0.52)
<b>Chronic condition</b>			
Hypertension	1.13 (1.08, 1.18)	1.06 (0.97, 1.16)	0.86 (0.71, 1.05)
Diabetes	1.15 (1.09, 1.22)	0.69 (0.61, 0.79)	0.83 (0.64, 1.08)
Heart disease	1.25 (1.19, 1.32)	0.80 (0.71, 0.90)	1.18 (0.95, 1.47)
Stroke	1.16 (1.07, 1.25)	0.88 (0.73, 1.05)	1.16 (0.82, 1.64)
Lung disease	1.49 (1.40, 1.60)	0.89 (0.76, 1.04)	1.19 (0.87, 1.61)
Arthritis	1.36 (1.30, 1.43)	1.02 (0.93, 1.11)	1.07 (0.88, 1.30)
Cancer	1.15 (1.08, 1.22)	0.98 (0.86, 1.12)	0.73 (0.53, 1.01)
<b>Residential census region</b>			
Northeast (reference)	1.00	1.00	1.00
Midwest	0.95 (0.89, 1.02)	0.86 (0.76, 0.98)	0.99 (0.74, 1.32)
South	1.01 (0.95, 1.08)	0.91 (0.81, 1.03)	1.00 (0.77, 1.29)
West	0.95 (0.89, 1.03)	0.97 (0.86, 1.11)	1.01 (0.76, 1.34)
<b>Study cohort</b>			
Mid Baby Boomer (born 1954–1959) (reference)	1.00	1.00	1.00
Early Baby Boomer (born 1948–1953)	1.10 (0.98, 1.25)	1.34 (1.11, 1.61)	1.00 (0.67, 1.48)
War Baby (born 1942–1947)	0.79 (0.69, 0.91)	1.12 (0.89, 1.40)	0.63 (0.38, 1.05)
HRS cohort (born 1931–1941)	0.88 (0.76, 1.02)	1.09 (0.85, 1.40)	0.40 (0.22, 0.73)
Children of Depression (born 1924–1930)	0.85 (0.70, 1.02)	1.01 (0.70, 1.46)	0.58 (0.26, 1.31)
AHEAD cohort (born before 1924)	1.12 (0.91, 1.39)	1.26 (0.84, 1.89)	0.83 (0.35, 1.96)

Notes: Survey samples came from the Health and Retirement Study 1992–2012 waves. Cox proportional hazards regressions were performed to estimate the adjusted hazard ratios for depression, heavy drinking, or smoking among survey participants free from depression, heavy drinking, or smoking at the baseline, respectively. 95% confidence intervals are in parentheses.

**Table 3**  
 Estimated gender- and race/ethnicity-specific relationship (adjusted hazard ratios) between depression, heavy drinking, and smoking among Health and Retirement Study participants (95% confidence interval).

Subgroup	Variable	Depression	Heavy drinking	Smoking
All participants	Study sample			
	Baseline characteristics	No depression	No heavy drinking	No smoking
	Number of participants at baseline	24,759	27,331	24,669
	Number of observations	97,817	124,419	111,598
	Current depression status			
	Depressed	/	1.18 (1.06, 1.31)	1.41 (1.14, 1.74)
	Nondepressed (reference)	/	1.00	1.00
	Current heavy drinking status			
	Heavy drinking	1.05 (0.98, 1.13)	/	1.60 (1.26, 2.04)
	No heavy drinking (reference)	1.00	/	1.00
	Current smoking status			
Smoking	1.20 (1.12, 1.28)	1.34 (1.20, 1.50)	/	
Nonsmoking (reference)	1.00	1.00	/	
Males	Study sample			
	Baseline characteristics	No depression	No heavy drinking	No smoking
	Number of participants at baseline	11,364	10,771	10,386
	Number of observations	46,310	45,356	44,862
	Current depression status			
	Depressed	/	1.27 (1.10, 1.46)	1.59 (1.15, 2.19)
	Nondepressed (reference)	/	1.00	1.00
	Current heavy drinking status			
	Heavy drinking	1.05 (0.95, 1.17)	/	1.84 (1.34, 2.54)
	No heavy drinking (reference)	1.00	/	1.00
	Current smoking status			
Smoking	1.26 (1.14, 1.39)	1.31 (1.12, 1.52)	/	
Nonsmoking (reference)	1.00	1.00	/	
Females	Study sample			
	Baseline characteristics	No depression	No heavy drinking	No smoking
	Number of participants at baseline	13,395	16,560	14,283
	Number of observations	51,507	79,063	66,736
	Current depression status			
	Depressed	/	1.09 (0.94, 1.26)	1.28 (0.97, 1.69)
	Nondepressed (reference)	/	1.00	1.00
	Current heavy drinking status			
	Heavy drinking	1.09 (0.98, 1.20)	/	1.35 (0.90, 2.03)
	No heavy drinking (reference)	1.00	/	1.00
	Current smoking status			
Smoking	1.16 (1.07, 1.27)	1.40 (1.18, 1.65)	/	
Nonsmoking (reference)	1.00	1.00	/	
Non-Hispanic whites	Study sample			
	Baseline characteristics	No depression	No heavy drinking	No smoking
	Number of participants at baseline	17,988	18,845	17,353
	Number of observations	75,922	91,547	83,743
	Current depression status			
	Depressed	/	1.15 (1.01, 1.31)	1.38 (1.04, 1.83)
	Nondepressed (reference)	/	1.00	1.00
	Current heavy drinking status			
	Heavy drinking	1.02 (0.94, 1.11)	/	1.23 (0.90, 1.68)
	No heavy drinking (reference)	1.00	/	1.00
	Current smoking status			
Smoking	1.21 (1.12, 1.31)	1.17 (1.02, 1.34)	/	
Nonsmoking (reference)	1.00	1.00	/	
Non-Hispanic African Americans	Study sample			
	Baseline characteristics	No depression	No heavy drinking	No smoking
	Number of participants at baseline	3969	4899	3968
	Number of observations	13,000	19,336	15,470
	Current depression status			
	Depressed	/	1.37 (1.10, 1.72)	1.03 (0.66, 1.59)
	Nondepressed (reference)	/	1.00	1.00
	Current heavy drinking status			
	Heavy drinking	1.44 (1.21, 1.73)	/	1.78 (1.06, 2.97)
	No heavy drinking (reference)	1.00	/	1.00
	Current smoking status			
Smoking	1.13 (0.97, 1.31)	1.76 (1.36, 2.28)	/	
Nonsmoking (reference)	1.00	1.00	/	
Hispanics	Study sample			
	Baseline characteristics	No depression	No heavy drinking	No smoking
	Number of participants at baseline	2181	2830	2698
	Number of observations	6792	10,680	9982
	Current depression status			
Depressed	/	1.13 (0.86, 1.50)	1.97 (1.24, 3.12)	
Nondepressed (reference)	/	1.00	1.00	

Table 3 (continued)

Subgroup	Variable	Depression	Heavy drinking	Smoking
	Current heavy drinking status			
	Heavy drinking	0.88 (0.68, 1.14)	/	2.88 (1.52, 5.44)
	No heavy drinking (reference)	1.00	/	1.00
	Current smoking status			
	Smoking	1.26 (1.01, 1.57)	1.71 (1.21, 2.43)	/
	Nonsmoking (reference)	1.00	1.00	/

Notes: Survey samples came from the Health and Retirement Study 1992–2012 waves. Cox proportional hazards regressions were performed to estimate the adjusted hazard ratios for depression, heavy drinking, or smoking among survey participants free from depression, heavy drinking, or smoking at the baseline, respectively. 95% confidence intervals are in parentheses.

the number of self-reported depressive symptoms in the past week, which can vary substantially from week to week. The relatively low sensitivity and specificity of CES-D introduce measurement errors and may result in underestimation of its relationship with smoking and drinking. The measure on heavy drinking may not distinguish between habitual drinking from clinical alcohol abuse disorders. In addition, underreporting of alcohol use in surveys (Embree and Whitehead, 1993) may result in underestimation of the impact of heavy drinking on subsequent smoking and depression onset. One possible link between smoking/heavy drinking and depression among middle-aged and older adults might be through reduced physical activity level. However, we were not able to control for physical activity in our models due to rather crude and inconsistent questions regarding physical activity across HRS survey waves.

The potential associations between smoking, heavy drinking and depression have important implications for health promotion interventions in midlife and older age. Smokers with depression have higher level of nicotine dependence, frequently suffer from severe negative moods, and are at elevated risk of major depression after quitting (Cosci et al., 2011). Mendelsohn (2012) suggested comprehensive screening for smoking behavior among all patients with depression. Cognitive behavioral mood management, nicotine replacement therapy, varenicline and bupropion were recommended for smoking cessation in patients with depression, combined with additional support and extended courses of treatment. On the other hand, given that depression in older life is frequently missed and inadequately treated (Birrer and Vemuri, 2004), increasing awareness of the potential psychological consequence of smoking may help increase access to depression treatment. Because the clustering of smoking and heavy drinking may jointly increase the risk for many adverse health outcomes (De Leon et al., 2007), it is essential for smoking cessation and alcohol treatment programs to take into consideration the potential involvement of the other risk behavior.

As the associations between smoking, heavy drinking and depression are highly complex and extend across multiple domains of health care, the central role of family physicians and general practitioners in screening/assessing health risks, referring/coordinating different treatments, and monitoring overall progress should not be understated. A co-management model of smoking cessation and depression involving general practitioners and a nationwide smoking cessation program (Quitline) has recently been developed and pilot-tested in Australia (Segan et al., 2011). The Quitline-doctor co-management model was found to be valued by smokers and increase the probability of quit attempts and sustained cessation. Smoking cessation was not found to increase the risk of exacerbation of depression.

## Conclusions

This study examined the relationship between smoking, heavy drinking and depression among U.S. middle-aged and older adults. Bidirectional associations were found between smoking and depression and between smoking and heavy drinking. Depression also predicted future engagement in heavy drinking among baseline non-heavy drinkers. Health promotion programs in midlife and older age should

be mindful of these relationships in order to improve intervention effectiveness.

## Conflict of interest statement

The authors declare that there are no conflicts of interest.

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