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## Predictors of Early and Sustained Cessation of Heavy Drinking Over 5 Years Among Adult Primary Care Patients

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### Abstract

**Aims:** To identify factors associated with early and sustained cessation of heavy drinking.

**Design:** Retrospective cohort study over 5 years.

**Setting:** Kaiser Permanente Northern California, USA.

**Participants:** Adults reporting heavy drinking during primary care-based alcohol screening between 06/01/2013 and 05/31/2014. The sample (n=85,434) was 41% female and 34% non-White; mean age was 50.3 years (SD=18.1).

**Measurements:** Following U.S. guidelines, *early and sustained cessation of heavy drinking* was defined as reporting lower-risk drinking or abstinence at 1 year and through 5 years after achieving early cessation, respectively. Associations between patient characteristics and service use and cessation outcomes were examined using logistic regression with inverse probability weights addressing attrition.

**Findings:** Nearly two-thirds of participants achieved early cessation of heavy drinking. Women (odds ratio (OR)=1.39, 95% confidence interval (CI)=1.35, 1.44), middle-age (35-64 years: ORs=1.16 to 1.19), non-White race/ethnicity (ORs=1.31 to 1.57), medical conditions (OR=1.05, 95% CI=1.04, 1.06), psychiatric (OR=1.10, 95% CI=1.06, 1.15) and drug use disorders (OR=1.35, 95% CI=1.17, 1.56), and addiction treatment (OR=1.19, 95% CI=1.09, 1.30) were associated with higher odds of early cessation, while older age (< 65 years: OR=0.91, 95% CI=0.86, 0.96), smoking (OR=0.81, 95% CI=0.77, 0.84), higher index drinking levels (exceeding both daily and weekly limits: OR=0.30, 95% CI=0.29, 0.32), and psychiatric treatment (OR=0.91, 95% CI=0.84, 0.99) were associated with lower odds. Among those who achieved early cessation (n=19,200), about 60% sustained cessation. Associations between patient factors and sustained cessation paralleled those observed in analyses of early cessation. Additionally, routine primary care (OR=1.57, 95% CI=1.44, 1.71) and addiction treatment post-1 year (OR=1.41, 95% CI=1.19, 1.66) were associated with higher odds of sustained cessation. Lower-risk drinking versus abstinence at 1-year was associated with lower odds of sustained cessation (OR=0.62, 95% CI=0.57, 0.66).

**Conclusions:** Nearly two-thirds of a large, diverse sample of patients who reported heavy drinking in a California USA healthcare system achieved early and sustained cessation of heavy drinking. Vulnerable subgroups (i.e., non-White patients and those with psychiatric disorders), patients who received routine primary care, and those who received addiction treatment were more likely to sustain cessation of heavy drinking than other participants.

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## Introduction

Heavy alcohol use is a major risk factor for chronic illness and mortality[1,2]. While heavy drinking in the United States (U.S.) is common [prevalence of 6% to 28%, depending on the definition and whether alcohol use disorder (AUD) is included][3–5], cessation of heavy drinking and recovery are possible. From U.S. general population surveys, the prevalence of recovery from AUD was 34% in 2012-2013[6], and the prevalence of heavy drinking cessation was 27% in 2004-2005[7].

Relatively little is known about who achieves heavy drinking cessation and for how long. Moreover, most studies have focused on AUD recovery among alcohol treatment populations, making it difficult to examine the role of treatment and generalize findings to the wider population that drinks heavily but does not meet criteria for an AUD. Additionally, studies have differed in recovery definitions, with more recent studies including asymptomatic, lower-risk drinking in addition to abstinence, given evidence that it can be a suitable goal for some individuals[8–10]. Consistent predictors of AUD recovery include female sex, older age, and lower severity drinking and AUD symptoms[6,11–18]. Other predictors of recovery include health service use (alcohol treatment[14,19], continuing care[20]), not smoking[14,15,21], better self-control[22], and having supportive relationships such as marriage[6,11].

Studies evaluating predictors of heavy drinking cessation among individuals with and without AUDs are sparse, though findings are consistent with those on AUD recovery. A recent U.S. population-based study found that older age, female sex, Black or Hispanic race/ethnicity, no AUD, no tobacco or drug use, alcohol treatment, and having children were associated with higher odds of heavy drinking cessation[7]. Additional evidence comes from latent class or trajectory analyses, which describe longitudinal drinking patterns, but are difficult for inferring categorical changes in drinking, such as heavy drinking cessation or recovery[23–27]. More studies of heavy drinking cessation are needed to understand service needs and inform targeted interventions.

The aim of this exploratory study was to identify predictors of early and sustained cessation of heavy drinking over 5 years among an adult primary care population within an integrated health care system where comprehensive data are collected in the electronic health record (EHR). Key factors of interest included sociodemographic characteristics, alcohol and tobacco use, medical and psychiatric diagnoses, and health service utilization, including routine primary care and specialty treatment. The ability to examine a multitude of diagnoses and different types of health service in association with heavy drinking cessation is novel. Findings may help inform future research on mechanisms of heavy drinking

cessation (e.g., examining how routine primary care services can influence recovery), which would help clinicians and health systems design new (or tailor existing) interventions.

## Methods

This manuscript followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cohort studies[28].

### Setting

Kaiser Permanente Northern California (KPNC) serves 4.3 million members, approximately one-third of the Northern Californian population. The membership is racially diverse and reflects the U.S. population with access to care[29]. Membership includes enrollees from Medicaid, Medicare, employer-based plans, and health insurance exchanges. The KPNC Institutional Review Board reviewed the study and granted a waiver of informed consent to examine EHR data.

Since June 2013, KPNC has systematically screened for heavy drinking in adult primary care[30], and has maintained an >80% average screening rate. Medical assistants ask patients 3 questions about their alcohol use, including a modified version of the evidence-based National Institute on Alcohol Abuse and Alcoholism (NIAAA) single-item screening question to determine the number of heavy drinking days: 1) “How many times in the past three months have you had 5 or more drinks containing alcohol in a day?” (for men aged 18-65 years), or “4 or more drinks” (for women 18 years and men 66 years)[3]; and two questions to calculate average drinks consumed per week: 2) “On average, how many days per week do you have an alcoholic drink?”; and 3) “On a typical drinking day, how many drinks do you have?”

### Study Design and Sample

We conducted a retrospective cohort study using observational, longitudinal EHR-based data from the KPNC Adult Alcohol Registry[31]. We identified 200,458 adults (>18 years) who screened positive for heavy drinking between June 1, 2013 and May 31, 2014; the index date was the first date during this period where the patient screened positive for heavy drinking. For each patient, all alcohol screenings after the index date through 63 months post-index were extracted. The screening closest to 12 months post-index (between 6 and 15 months) was chosen as the 1-year follow-up screening (1Y). The screening closest to 60 months post-index (between 54 and 63 months) was chosen as the 5-year follow-up screening (5Y).

### Cessation Outcomes

Definitions of heavy drinking cessation were based on the alcohol consumption component of the recent NIAAA *Recovery from AUD* definition[32]. **Heavy drinking** was defined as exceeding either the daily (>5 drinks/day for men 18-65 years, or >4 drinks/day for men 66 years and women) or weekly limits (>14 drinks/week for men 18-65 years, or >7 drinks/day for men 66 years and women) from the NIAAA drinking guidelines[3]. **Early cessation of heavy drinking** was defined as reporting lower-risk drinking (no heavy drinking days in the past 3 months and drinking within weekly limits) or abstinence at

1Y. *Sustained cessation of heavy drinking* was defined as achieving early cessation and reporting lower-risk drinking or abstinence at all screenings through 5Y.

## Predictors

We extracted EHR-based data from the KPNC Adult Alcohol Registry to create the following variables of interest[31]:

**Sociodemographic characteristics.**—Variables included sex, age, race/ethnicity, and household income. Household income was estimated by geocoding patients' most recent residential address in the year before index to 2010 U.S. Census blocks and using the median household income of the census block[33]. Household income was categorized into tertiles of the overall distribution (low: \$61,765, middle: \$61,766-\$89,952, and high: \$89,953).

**Smoking status.**—Based on the most recent tobacco screening in the year before the index date, patients were classified as whether they currently or never/formerly smoked.

**Index drinking level.**—We categorized patients into 3 mutually exclusive groups based on NIAAA guidelines: exceeding only daily limits, exceeding only weekly limits, and exceeding both daily and weekly limits[3].

**Baseline diagnoses.**—Using International Classification of Diseases, 9<sup>th</sup> Edition (ICD-9) codes in the year before the index date, we identified patients with chronic medical conditions prevalent in primary care[34], psychiatric disorders, non-remission AUD, and non-remission drug use disorder diagnoses[31]. More details can be found in Palzes et al. (2020).

**Health service utilization.**—Based on prior research[20], we evaluated health service utilization in the year (1Y) after index, and for those who achieved early cessation, also over 1Y to 5Y. An indicator for receiving addiction treatment was defined as receiving an AUD diagnosis and either having ≥ 1 outpatient visits in addiction medicine or receiving pharmacotherapy for AUD (i.e., acamprosate, disulfiram, naltrexone, or topiramate)[35,36] from an outpatient KPNC pharmacy, during the respective follow-up period (1=AUD and received treatment, or no AUD; 0=AUD and did not receive treatment). An indicator for receiving psychiatric treatment was defined as receiving a psychiatric diagnosis and either having ≥ 1 outpatient visits in psychiatry or filling a prescription for an antidepressant, mood stabilizer, sedative, benzodiazepine, other anxiolytic, or antipsychotic (1=psychiatric disorder and received treatment, or no psychiatric disorder; 0=psychiatric disorder and did not receive treatment)[37–39]. An indicator for routine primary care was defined as having an annual outpatient office or telephone visit in the post-1Y period.

**Type of early cessation.**—Alcohol use reported at 1Y was categorized into lower-risk drinking or abstinence based on NIAAA drinking guidelines[3].

**Control variables.**—To account for different follow-up times, we included the number of alcohol screenings and follow-up days (<2 years or ≥ 2 years) between 1Y to 5Y as control variables.

### Missing Data

Proportions of patients missing covariate data were low, with 0.1% (n=285) having unknown household income and 1.6% (n=3,249) having unknown smoking status. While there are many possible reasons why patients could be missing household income and smoking status data (e.g., geocoding failure, medical assistants forgetting to screen for smoking), we expect that data is missing at random and is not associated with the outcomes. Since the proportion of incomplete cases was low (<5% [43]), we imputed missing household income values as the mean (\$79,400) and missing smoking status as the mode (never or former) among the full sample of patients identified with heavy drinking (n=200,458).

### Analytical Samples

Two analytical samples were generated (Figure S1):

**Early cessation of heavy drinking.**—Among the 200,458 patients identified with heavy drinking, we excluded patients with incomplete index screenings (n=12,136) and patients with <70% KPNC membership in the year before the index date (n=31,133), resulting in 157,189 patients. Among these patients, 71,755 (45.6%) were lost to follow-up due to death (n=370), disenrollment from KPNC (n=8,159), or not having a 1Y screening (n=63,226), resulting in an analytical sample of 85,434 (54.4%) patients with observed outcome data.

**Sustained cessation of heavy drinking.**—Since sustained cessation of heavy drinking is conditional on achieving early cessation of heavy drinking[32], all patients that achieved early cessation were included with no further exclusion criteria applied (n=53,916). Among this sample, 34,716 (64.4%) patients were lost to follow-up due to death (n=2,267), disenrollment from KPNC (n=11,572), not having a 5Y screening (n=19,707), or having either <70% membership coverage between the index date and 5Y screening or no follow-up screenings between the 1Y and 5Y screening (n=1,170), resulting in an analytical sample of 19,200 (35.6%) patients with observed outcome data.

### Inverse Probability of Attrition Weights (IPAW)

Given the large proportions of patients lost to follow-up, we examined potential selection bias due to attrition by calculating standardized differences for patient characteristics between the subgroups retained and lost to follow-up, and found that age, index drinking level, and the number of chronic medical conditions meaningfully differed (standardized difference >0.2 [41,42]) between the subgroups retained and lost to follow-up in both analytical samples (Tables S1–S2).

We next estimated and applied inverse probability of attrition weights (IPAW) for each observation in models of early and sustained cessation. In both, the IPAW were estimated based on predicted probabilities of no attrition through logistic regression models, conditional on a set of covariates that were hypothesized to be associated with attrition

and the outcome. For the analysis on early cessation (n=157,189), the IPAW model was fit using baseline patient characteristics. For the analysis on sustained cessation (n=53,916), the IPAW model was fit on the same set of covariates, plus receiving addiction and psychiatric treatment in 1Y after index and the type of early cessation. The distribution of the weights was reasonable for both models of early cessation (mean=1.84, median=1.84, min=1.04, max=3.41) and sustained cessation (mean=2.81, median=2.46, min=1.82, max=6.32), and they were not unacceptably unstable according to guidelines by Seaman & White (2013) [43].

## Statistical Analysis

For analyses of *early cessation of heaving drinking*, we fit a multivariable logistic regression model among the analytical sample with observed outcome data (n=85,434), weighted by IPAW, including all baseline patient characteristics (sex, age group, race/ethnicity, household income, smoking status, index drinking level, AUD, number of chronic medical conditions, any psychiatric disorder, and any drug use disorder) and health service utilization (addiction and psychiatric treatment) in 1Y after index. Variance was estimated using the conservative robust sandwich standard error estimator approach[44]. We also examined whether there was effect measure modification of addiction treatment (in 1Y after index) by sex, age, race/ethnicity, and index drinking level by including an interaction term in separate models and evaluating whether the Type 3 test was statistically significant at  $p<0.05$ .

For analyses of *sustained cessation of heavy drinking*, we fit a multivariable logistic regression model among the analytical sample who achieved early cessation and had observed outcome data (n=19,200), weighted by IPAW, including all baseline patient characteristics, addiction and psychiatric treatment in 1Y after index, and post-1Y variables (type of early cessation, number of alcohol screenings during follow-up, number of days of follow-up, routine primary care, addiction and psychiatric treatment). We also examined whether there was effect measure modification of addiction treatment (post-1Y) by sex, age, race/ethnicity, and the type of early cessation (e.g., abstinence, lower-risk drinking), and whether AUD was an effect measure modifier for type of early cessation. We utilized the same methods for estimating variance and testing for effect measure modification as described above.

All statistical analyses were conducted using SAS software, Version 9.4 (SAS Institute Inc., Cary, NC). The analysis plan was not pre-registered, thus results should be considered exploratory.

## Results

### Early Cessation of Heavy Drinking

The analytical sample with observed outcome data consisted of 85,434 patients with heavy drinking. About two-fifths (n=34,761) were female; 56,581 (66.2%) were White, 7,186 (8.4%) were Asian, Native Hawaiian or Pacific Islander, 5,096 (6.0%) were Black, 14,184 (16.6%) were Latinx/Hispanic, and 1,008 (1.2%) were Native American (Table 1). The mean

age was 50.3 years (SD=18.1) and 13.9% (n=11,914) reported current smoking. Based on the index alcohol screening, 50,193 (58.8%) patients exceeded only daily limits, 20,835 (24.4%) exceeded only weekly limits, and 14,406 (16.9%) exceeded both daily and weekly limits. There were 4,057 (4.7%) patients with an AUD.

A total of 53,916 (63.1%) patients achieved early cessation of heavy drinking (Table 1); of them, 25,289 (46.9%) reported abstinence and 28,627 (53.1%) reported lower-risk drinking. From the main effects model weighted by IPAW (Table 2), baseline characteristics associated with higher odds of early cessation were female versus male, middle age (35-64 years) versus younger age (18-34 years), and low versus middle household income. All non-White races/ethnicities were associated with higher odds of early cessation, with Black patients having the highest relative likelihood compared to White patients (OR=1.57, 95% CI=1.46, 1.68). Having more chronic medical conditions or a psychiatric or drug use disorder were associated with higher odds of early cessation. Receiving addiction treatment in 1Y after index was associated with higher odds of early cessation (OR=1.19, 95% CI=1.09, 1.30). Older (≥ 65 years) versus younger age (18-34 years), high versus middle household incomes, smoking, higher index drinking levels, and receiving psychiatric treatment in 1Y after index were associated with lower odds of early cessation. Having an AUD was not associated with early cessation.

Index drinking level moderated the association between receiving addiction treatment in 1Y after index and early cessation of heavy drinking (Figure 1). Among patients who reported exceeding only daily limits, those who received addiction treatment in 1Y after index, compared to those who did not, had higher odds of early cessation (OR=1.50, 95% CI=1.29,1.75). Receiving addiction treatment in 1Y after index was not associated with early cessation among those who reported exceeding only weekly limits (OR=1.03, 95% CI=0.90,1.19) or both daily and weekly limits (OR=1.10, 95% CI=0.97, 1.26). We did not find evidence of effect measure modification of addiction treatment (in 1Y after index) by sex, age group, and race/ethnicity.

### **Sustained Cessation of Heavy Drinking**

Sustained cessation of heavy drinking was examined among the subgroup that achieved early cessation and had observed outcome data (n=19,200). A total of 11,539 (60.0%) patients sustained cessation of heavy drinking over 5 years (Table 3). From the main effects model weighted by IPAW (Table 4), baseline characteristics associated with higher odds of sustained cessation of heavy drinking were female versus male and middle-to-older (≥ 35 years) versus younger age (18-34 years). Asian, Native Hawaiian, or Pacific Islander, Latinx/Hispanic, and Native American patients had higher odds of sustained cessation compared to White patients, but no association was observed among Black patients. Having more chronic medical conditions or a psychiatric disorder were associated with higher odds of sustained cessation. Routine primary care (OR=1.57, 95% CI=1.44, 1.71) and receiving addiction treatment post-1Y (OR=1.41, 95% CI=1.19,1.66) were associated with higher odds of sustained cessation. Higher index drinking levels, smoking, and lower-risk drinking (versus abstinence) at 1Y were associated with lower odds of sustained cessation. Household income, AUD, drug use disorders, receiving addiction treatment in 1Y after index, and



receiving psychiatric treatment in 1Y after index were not associated with sustained cessation.

AUD modified the findings for the type of early cessation. Overall, achieving lower-risk drinking was associated with lower odds of sustained cessation compared to abstinence (OR=0.62, 95% CI=0.57, 0.66; Table 4); however, the odds were lower among those with AUD (OR=0.44, 95% CI=0.31, 0.62; Figure 2) compared to those without (OR=0.62, 95% CI=0.58,0.67).

## Discussion

In a large, diverse sample of patients who reported heavy drinking in a Northern California healthcare system, we found that nearly two thirds achieved early and sustained cessation of heavy drinking, which was much higher than a prior U.S. general population study that found less than a third ceased heavy drinking[7]. This is of great clinical importance, since reducing drinking is associated with decreased risks of alcohol-related problems and health conditions, such as AUDs and liver disease, in addition to death[45,46]. Heavy drinking cessation is a critical component of recovery from AUD, as it is associated with reduction in AUD symptoms and improved quality of life[8,14]. In this study, we identified many patient characteristics (many of which were consistent with prior research, i.e., sex, age, and drinking severity[6,7,11–18]) and health service factors associated with early and sustained cessation of heavy drinking. Findings are largely generalizable to patients with access to care and can inform the development of strategies to reduce the significant harm caused by heavy drinking.

Routine primary care was one of the strongest predictors of sustained cessation of heavy drinking in our study. The role of primary care providers has become increasingly important in addressing alcohol problems, particularly because heavy drinking may lead to chronic illness and impact disease progression and severity[47–49]. Screening, brief intervention, and referral to treatment (SBIRT) workflows in primary care are essential for identifying alcohol problems and determining appropriate care, and are effective in reducing drinking in adults with less severe problems[50]. The prevalence of AUD diagnoses in our study was low, which speaks to the utility of primary care-based SBIRT in addressing heavy drinking widely, regardless of whether AUD criteria are met. For individuals with AUDs, routine primary care is associated with long-term remission and reduced overall costs of care[20,51]. Although understanding the mechanisms that underlie these associations was beyond the scope of this study, we were able to examine the important role of primary care, which has not been examined in other studies. Having annual primary care visits may help address medical needs, identify and treat relapse, and promote healthier lifestyles and better self-management skills, leading to recovery from AUD.

A key contribution of this study is the examination of treatment utilization as predictors of heavy drinking cessation. Overall, receiving addiction treatment was associated with a higher likelihood of early and sustained heavy drinking cessation, which underscore its importance in short-term and long-term recovery for individuals with AUD. Specifically, receiving addiction treatment in 1Y after index was associated with a higher likelihood of

early cessation among patients who reported exceeding only daily limits, suggesting that early initiation and better retention in addiction treatment, higher intensity of treatment, or more emphasis on alcohol use reduction may be needed for those with higher baseline levels of drinking. Among patients who achieved early cessation, we found that receiving addiction treatment when needed was important for sustaining heavy drinking cessation long-term. Interestingly, patients who received psychiatric treatment were less likely to achieve early cessation of heavy drinking, yet patients with a psychiatric disorder were more likely. This finding is similar to our prior study among AUD patients and suggests that receiving psychiatric treatment may be a marker for more severe psychiatric disorders[13]. However, psychiatric treatment may not be as important for predicting sustained cessation of heavy drinking, as we did not find an association with this outcome. Factors such as treatment engagement and retention, and motivation and readiness to change, can influence treatment effectiveness and should be examined in future studies[16,30,52–54].

We did not find AUD to be associated with early cessation of heavy drinking but found that it was an effect measure modifier of the type of early cessation on sustained cessation. Prior studies suggest that lower-risk drinking is a suitable goal for some individuals[8], while others show that abstinence tends to lead to better outcomes[9,10]. In our study, patients who reported lower-risk drinking at 1Y had a lower likelihood of sustained cessation of heavy drinking compared to those who reported abstinence, but the difference was more pronounced among individuals with AUD. This finding supports the notion that while lower-risk drinking is a suitable goal for alcohol treatment, certain individuals, such as those with AUD, might require more frequent monitoring and support post-treatment in sustaining long-term heavy drinking cessation.

Compared to White patients, non-White patients were generally more likely to achieve heavy drinking cessation, which is consistent with a recent study of the general U.S. population[7]. Studies of individuals with AUD have reported mixed results, with some showing non-White patients are more likely to recover[13], and others showing they are less likely[6], which might be due to differences in populations (i.e., primary care versus general U.S. populations, respectively). The mechanism underlying why non-White patients may be more likely to stop drinking heavily is unclear, though lower cultural and social acceptance of heavy drinking, higher religiosity, and financial factors are possible explanations[55,56]. In this study, non-White patients had higher proportions of patients who reported abstinence at 1Y (47% to 58%) compared to White patients (38%). Additionally, Black and Hispanic/Latinx patients had the highest proportions who received routine primary care (83% and 85%, respectively), which could be driven by health disparities observed in these subgroups[57,58], but is promising in terms of increasing the likelihood of sustained cessation.

### Strengths and Limitations

We demonstrate that data recorded in the EHR during patient care can be leveraged to identify patient-level factors, including service utilization, associated with different stages of heavy drinking cessation. As the aim of this study was to conduct an exploratory analysis of multiple predictors of heavy drinking cessation, we did not adjust for multiple

hypothesis testing[59]. Future studies are needed to confirm these exploratory findings. Results concerning demographics and drinking levels were consistent with prior longitudinal survey studies and suggest the utility of EHR-based data in understanding heavy drinking cessation. However, the availability of EHR-based alcohol screening data depends on when patients receive care, making it difficult to infer exact durations of heavy drinking cessation. We were not able to examine reductions in total daily alcohol consumption (i.e., drinks or grams of alcohol per day), a continuous unit of measure that the World Health Organization (WHO) utilizes in defining drinking risk levels. Prior studies have shown that reductions in the WHO drinking risk levels were associated with fewer alcohol-related consequences and better mental health and quality of life[46,60–65]; thus, it is possible that patients in our study may have experienced good health outcomes without necessarily reducing consumption below the NIAAA recommended limits. Future research examining our findings in the context of other study settings using other valid alcohol use measures is warranted.

We could not exclude the possibility that the decreases in alcohol use were due to regression to the mean, a statistical phenomenon. Self-report alcohol use data collected during clinical care is also subject to social desirability bias; however, the healthcare system in this study underwent a trial to determine the best workflow for conducting alcohol screening in a way that would minimize stigma and optimize patient comfort in disclosing alcohol use[30], and its findings informed the subsequent system-wide implementation. However, future research, including collection of in-depth qualitative data, might help clarify the role and extent of this potential bias.

Attrition in our study was mainly due to missing outcome alcohol screening data. While screenings are conducted systematically, a patient may not be screened every year due to busy workflows, medical assistants forgetting, patients arriving late to appointments or not having a primary care visit every year. We found that patients with observed outcome data were older with more medical conditions compared to those lost to follow-up, so we adjusted for potential selection bias due to attrition using IPAW.

## Conclusion

This study highlights patient characteristics and health service factors related to early and sustained cessation of heavy drinking. Vulnerable subgroups (i.e., non-White patients and those with psychiatric disorders), patients who received routine primary care, and those who received addiction treatment were more likely to sustain cessation of heavy drinking, an encouraging outcome; however, more research is needed to understand the mechanisms underlying these findings. Findings may inform primary care-based interventions that can be implemented within health systems (in the U.S. or internationally) to facilitate heavy drinking cessation. Future studies should examine whether these cessation durations are associated with improved physical and mental health, and overall functioning.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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### Conflict of interest declaration:

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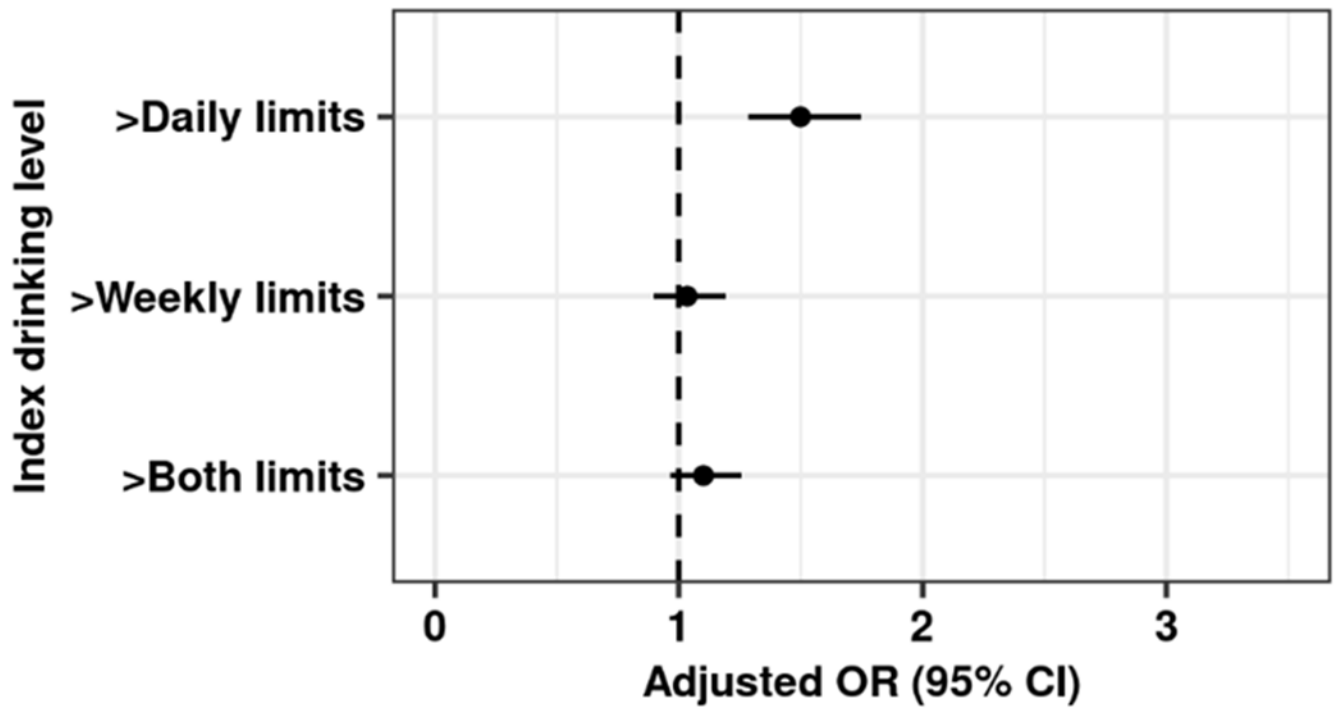
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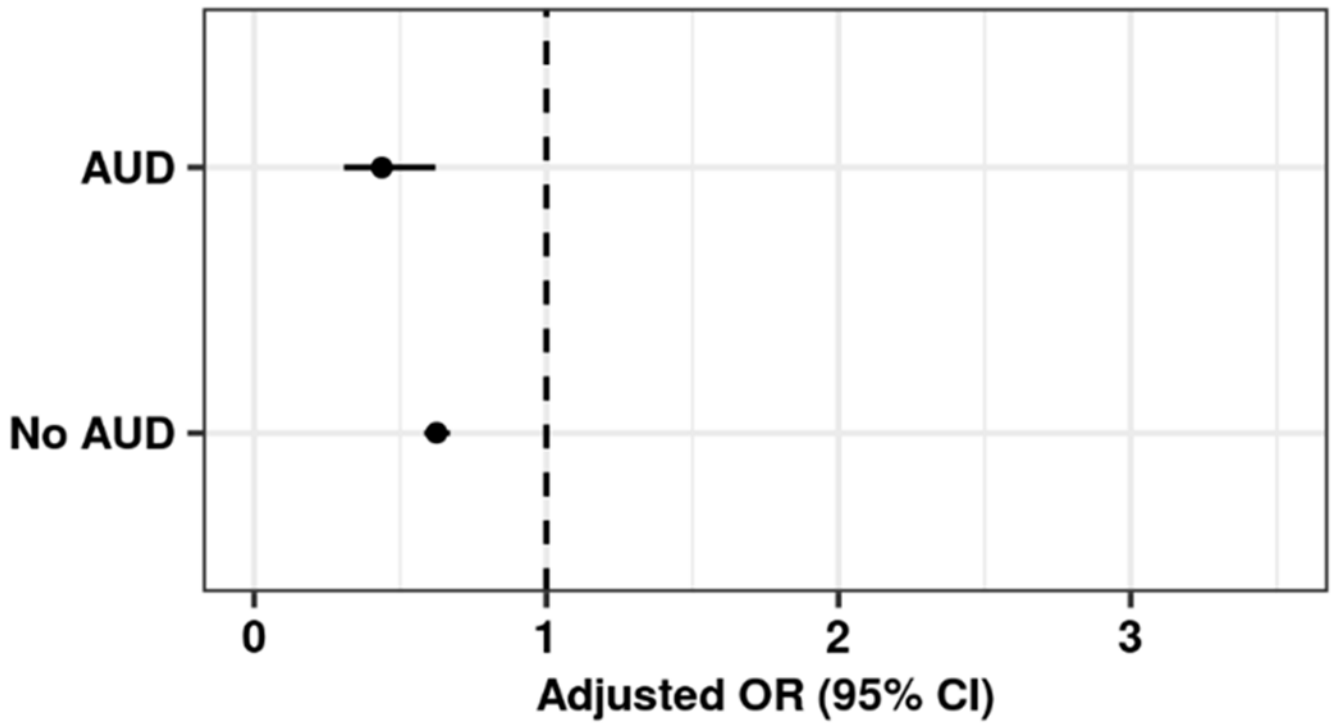
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**Figure 1.** ORs and 95% CIs of early cessation of heavy drinking, comparing patients who received addiction treatment in 1Y after index to those who did not, by index drinking level (>Daily limits: exceeding only daily limits, >Weekly limits: exceeding only weekly limits, >Both limits: exceeding both daily and weekly limits).





**Figure 2.** ORs and 95% CIs of sustained cessation of heavy drinking, comparing patients who reported lower-risk drinking versus abstinence at 1Y, by whether patients had an AUD diagnosis.

**Table 1.**

Baseline characteristics and health service utilization of the analytical sample of patients who reported heavy drinking between 6/1/2013 and 5/31/2014 in Kaiser Permanente Northern California for examining predictors of *early cessation of heavy drinking*.<sup>a,b</sup>

Characteristic	Achieved early cessation of heavy drinking		
	Overall (n=85,434)	Yes (n=53,916)	No (n=31,518)
<b>Baseline characteristics</b>			
Sex, n (%)			
Male	50,673 (59.3)	30,704 (56.9)	19,969 (63.4)
Female	34,761 (40.7)	23,212 (43.1)	11,549 (36.6)
Age, mean (SD)	50.3 (18.1)	48.9 (17.8)	52.7 (18.3)
Age group, n (%)			
18-34	21,249 (24.9)	14,267 (26.5)	6,982 (22.2)
35-49	19,303 (22.6)	13,183 (24.5)	6,120 (19.4)
50-64	20,969 (24.5)	13,776 (25.6)	7,193 (22.8)
65	23,913 (28.0)	12,690 (23.5)	11,223 (35.6)
Race/ethnicity, n (%)			
White	56,581 (66.2)	33,520 (62.2)	23,061 (73.2)
Asian, Native Hawaiian, or Pacific Islander	7,186 (8.4)	5,173 (9.6)	2,013 (6.4)
Black	5,096 (6.0)	3,762 (7.0)	1,334 (4.2)
Latinx/Hispanic	14,184 (16.6)	9,913 (18.4)	4,271 (13.6)
Native American	1,008 (1.2)	664 (1.2)	344 (1.1)
Other/Unknown	1,379 (1.6)	884 (1.6)	495 (1.6)
Household income, n (%)			
Low ( < \$61,765)	26,882 (31.5)	17,567 (32.6)	9,315 (29.6)
Middle (\$61,766-\$89,952)	28,672 (33.6)	18,264 (33.9)	10,408 (33.0)
High ( > \$89,953)	29,880 (35.0)	18,085 (33.5)	11,795 (37.4)
Smoking status, n (%)			
Never or former	73,520 (86.1)	46,918 (87.0)	26,602 (84.4)
Current	11,914 (13.9)	6,998 (13.0)	4,916 (15.6)
Index drinking level, n (%)			
Exceeding only daily limits	50,193 (58.8)	36,682 (68.0)	13,511 (42.9)
Exceeding only weekly limits	20,835 (24.4)	11,060 (20.5)	9,775 (31.0)
Exceeding both limits	14,406 (16.9)	6,174 (11.5)	8,232 (26.1)
Alcohol use disorder (AUD), n (%)	4,057 (4.7)	2,194 (4.1)	1,863 (5.9)
Number of chronic medical conditions, n (%)			
0	29,835 (34.9)	19,583 (36.3)	10,252 (32.5)
1	17,095 (20.0)	11,018 (20.4)	6,077 (19.3)
2	11,815 (13.8)	7,131 (13.2)	4,684 (14.9)
3	26,689 (31.2)	16,184 (30.0)	10,505 (33.3)
Any psychiatric disorder, n (%)	15,078 (17.6)	9,927 (18.4)	5,151 (16.3)

Characteristic	Achieved early cessation of heavy drinking		
	Overall (n=85,434)	Yes (n=53,916)	No (n=31,518)
Anxiety disorder	8,219 (9.6)	5,519 (10.2)	2,700 (8.6)
Mood disorder	9,730 (11.4)	6,419 (11.9)	3,311 (10.5)
Psychoses	281 (0.3)	205 (0.4)	76 (0.2)
Any drug use disorder	1,148 (1.3)	801 (1.5)	347 (1.1)
Cannabis	551 (0.6)	368 (0.7)	183 (0.6)
Cocaine	96 (0.1)	75 (0.1)	21 (0.1)
Opioid	236 (0.3)	188 (0.3)	48 (0.2)
Other drug	373 (0.4)	273 (0.5)	100 (0.3)
Stimulant	118 (0.1)	97 (0.2)	21 (0.1)
<b>Health service utilization in 1Y after index</b>			
Addiction treatment, n (%)			
AUD and did not receive treatment	3,051 (3.6)	1,552 (2.9)	1,499 (4.8)
AUD and received treatment, or no AUD	82,383 (96.4)	52,364 (97.1)	30,019 (95.2)
AUD and received outpatient care	1,130 (1.3)	791 (1.5)	339 (1.1)
AUD and received pharmacotherapy	144 (0.2)	111 (0.2)	33 (0.1)
No AUD	81,224 (95.1)	51,559 (95.6)	29,665 (94.1)
Psychiatric treatment, n (%)			
Psychiatric disorder and did not receive treatment	3,116 (3.6)	2,094 (3.9)	1,022 (3.2)
Psychiatric disorder and received treatment, or no psychiatric disorder	82,318 (96.4)	51,822 (96.1)	30,496 (96.8)
Psychiatric disorder and received outpatient care	4,816 (5.6)	3,388 (6.3)	1,428 (4.5)
Psychiatric disorder and received pharmacotherapy	12,864 (15.1)	8,391 (15.6)	4,473 (14.2)
No psychiatric disorder	68,577 (80.3)	42,815 (79.4)	25,762 (81.7)

<sup>a</sup>Heavy drinking was defined as exceeding either daily or weekly drinking limits recommended by the NIAAA ( 5 drinks/day or >14 drinks/week for men 18-65 years, or 4 drinks/day or >7 drinks/week for men >65 years).

<sup>b</sup>Early cessation of heavy drinking was defined as reporting lower-risk drinking (no heavy drinking days in the past 3 months and drinking within weekly limits) or abstinence at 1Y.

**Table 2.**

Inverse probability of attrition weighted (IPAW) associations of baseline and follow-up patient characteristics and utilization with early cessation of heavy drinking,  $n=85,434$ .<sup>a</sup>

Characteristic	OR (95% CI)	p-value
<b>Baseline characteristics</b>		
Female (reference group: male)	1.39 (1.35, 1.44)	<.001
Age group (reference group: 18-34 years)		
35-49 years	1.16 (1.11, 1.21)	<.001
50-64 years	1.19 (1.14, 1.25)	<.001
65 years	0.91 (0.86, 0.96)	<.001
Race/ethnicity (reference group: White)		
Asian, Native Hawaiian, or Pacific Islander	1.46 (1.38, 1.55)	<.001
Black	1.57 (1.46, 1.68)	<.001
Latinx/Hispanic	1.32 (1.27, 1.38)	<.001
Native American	1.31 (1.14, 1.51)	<.001
Other/Unknown	1.03 (0.91, 1.16)	0.642
Household income (reference group: middle)		
Low	1.06 (1.02, 1.10)	0.005
High	0.91 (0.88, 0.94)	<.001
Smoking status (reference group: never or former)	0.81 (0.77, 0.84)	<.001
Index drinking level (reference group: exceeding only daily limits)		
Exceeding only weekly limits	0.45 (0.43, 0.46)	<.001
Exceeding both daily and weekly limits	0.30 (0.29, 0.32)	<.001
Alcohol use disorder	0.94 (0.87, 1.02)	0.155
Number of chronic medical conditions	1.05 (1.04, 1.06)	<.001
Any psychiatric disorder	1.10 (1.06, 1.15)	<.001
Any drug use disorder	1.35 (1.17, 1.56)	<.001
<b>Utilization in 1Y after index</b>		
Addiction treatment	1.19 (1.09, 1.30)	<.001
Psychiatric treatment	0.91 (0.84, 0.99)	0.025

<sup>a</sup>Early cessation of heavy drinking was defined as reporting lower-risk drinking (no heavy drinking days in the past 3 months and drinking within weekly limits) or abstinence at 1Y.

**Table 3.**

Baseline and follow-up patient characteristics and health service utilization of the analytical sample of patients who achieved early cessation of heavy drinking for examining predictors of *sustained cessation of heavy drinking*.<sup>a,b</sup>

Characteristic	Sustained cessation of heavy drinking		
	Overall (n=19,200)	Yes (n=11,539)	No (n=7,661)
<b>Baseline characteristics</b>			
Sex, n (%)			
Male	11,039 (57.5)	6,328 (54.8)	4,711 (61.5)
Female	8,161 (42.5)	5,211 (45.2)	2,950 (38.5)
Age, mean (SD)	53.3 (16.8)	52.0 (16.8)	55.2 (16.8)
Age group, n (%)			
18-34	3,253 (16.9)	2,106 (18.3)	1,147 (15.0)
35-49	4,345 (22.6)	2,838 (24.6)	1,507 (19.7)
50-64	5,664 (29.5)	3,456 (30.0)	2,208 (28.8)
65	5,938 (30.9)	3,139 (27.2)	2,799 (36.5)
Race/ethnicity, n (%)			
White	12,252 (63.8)	6,865 (59.5)	5,387 (70.3)
Asian, Native Hawaiian, or Pacific Islander	1,749 (9.1)	1,252 (10.9)	497 (6.5)
Black	1,332 (6.9)	862 (7.5)	470 (6.1)
Latinx/Hispanic	3,387 (17.6)	2,243 (19.4)	1,144 (14.9)
Native American	243 (1.3)	159 (1.4)	84 (1.1)
Other/Unknown	237 (1.2)	158 (1.4)	79 (1.0)
Household income, n (%)			
Low ( < \$61,765)	5,975 (31.1)	3,695 (32.0)	2,280 (29.8)
Middle (\$61,766-\$89,952)	6,489 (33.8)	3,861 (33.5)	2,628 (34.3)
High ( > \$89,953)	6,736 (35.1)	3,983 (34.5)	2,753 (35.9)
Smoking status, n (%)			
Never or former	17,091 (89.0)	10,313 (89.4)	6,778 (88.5)
Current	2,109 (11.0)	1,226 (10.6)	883 (11.5)
Index drinking level, n (%)			
Exceeding only daily limit	12,181 (63.4)	8,462 (73.3)	3,719 (48.5)
Exceeding only weekly limit	4,674 (24.3)	2,157 (18.7)	2,517 (32.9)
Exceeding both limits	2,345 (12.2)	920 (8.0)	1,425 (18.6)
Alcohol use disorder (AUD), n (%)	736 (3.8)	372 (3.2)	364 (4.8)
Number of chronic medical conditions, n (%)			
0	5,309 (27.7)	3,327 (28.8)	1,982 (25.9)
1	3,838 (20.0)	2,357 (20.4)	1,481 (19.3)
2	2,973 (15.5)	1,718 (14.9)	1,255 (16.4)
3	7,080 (36.9)	4,137 (35.9)	2,943 (38.4)
Any psychiatric disorder, n (%)	3,577 (18.6)	2,202 (19.1)	1,375 (17.9)

Characteristic	<b>Sustained cessation of heavy drinking</b>		
	<b>Overall (n=19,200)</b>	<b>Yes (n=11,539)</b>	<b>No (n=7,661)</b>
Anxiety disorder	2,002 (10.4)	1,249 (10.8)	753 (9.8)
Mood disorder	2,354 (12.3)	1,471 (12.7)	883 (11.5)
Psychoses	71 (0.4)	37 (0.3)	34 (0.4)
Any drug use disorder, n (%)	238 (1.2)	151 (1.3)	87 (1.1)
Cannabis	101 (0.5)	60 (0.5)	41 (0.5)
Cocaine	19 (0.1)	8 (0.1)	11 (0.1)
Opioid	62 (0.3)	50 (0.4)	12 (0.2)
Other drug	86 (0.4)	65 (0.6)	21 (0.3)
Stimulant	32 (0.2)	21 (0.2)	11 (0.1)
<b>Health service utilization in 1Y after index</b>			
Addiction treatment, n (%)			
AUD and did not receive treatment	542 (2.8)	278 (2.4)	264 (3.4)
AUD and received treatment, or no AUD	18,658 (97.2)	11,261 (97.6)	7,397 (96.6)
AUD and received outpatient care	243 (1.3)	157 (1.4)	86 (1.1)
AUD and received pharmacotherapy	20 (0.1)	11 (0.1)	9 (0.1)
No AUD	18,413 (95.9)	11,104 (96.2)	7,309 (95.4)
Psychiatric treatment, n (%)			
Psychiatric disorder and did not receive treatment	705 (3.7)	442 (3.8)	263 (3.4)
Psychiatric disorder and received treatment, or no psychiatric disorder	18,495 (96.3)	11,097 (96.2)	7,398 (96.6)
Psychiatric disorder and received outpatient care	1,125 (5.9)	720 (6.2)	405 (5.3)
Psychiatric disorder and received pharmacotherapy	2,978 (15.5)	1,824 (15.8)	1,154 (15.1)
No psychiatric disorder	15,325 (79.8)	9,147 (79.2)	6,178 (80.6)
<b>Post-1Y characteristics and utilization</b>			
Type of early cessation, n (%)			
Abstinence	8,561 (44.6)	5,759 (49.9)	2,802 (36.6)
Lower-risk drinking	10,639 (55.4)	5,780 (50.1)	4,859 (63.4)
Number of follow-up alcohol screenings			
3	14,070 (73.3)	9,737 (84.4)	4,333 (56.6)
>3	5,130 (26.7)	1,802 (15.6)	3,328 (43.4)
Follow-up duration			
<2 years	8,183 (42.6)	5,128 (44.4)	3,055 (39.9)
2 years	11,017 (57.4)	6,411 (55.6)	4,606 (60.1)
Routine primary care, n (%)	15,038 (78.3)	9,020 (78.2)	6,018 (78.6)
Addiction treatment, n (%)			
AUD and did not receive treatment	909 (4.7)	399 (3.5)	510 (6.7)
AUD and received treatment, or no AUD	18,291 (95.3)	11,140 (96.5)	7,151 (93.3)
AUD and received outpatient care	541 (2.8)	289 (2.5)	252 (3.3)
AUD and received pharmacotherapy	149 (0.8)	82 (0.7)	67 (0.9)
No AUD	17,729 (92.3)	10,839 (93.9)	6,890 (89.9)
Psychiatric treatment, n (%)			

Characteristic	<b>Sustained cessation of heavy drinking</b>		
	<b>Overall (n=19,200)</b>	<b>Yes (n=11,539)</b>	<b>No (n=7,661)</b>
Psychiatric disorder and did not receive treatment	802 (4.2)	489 (4.2)	313 (4.1)
Psychiatric disorder and received treatment, or no psychiatric disorder	18,398 (95.8)	11,050 (95.8)	7,348 (95.9)
Psychiatric disorder and received outpatient care	2,937 (15.3)	1,857 (16.1)	1,080 (14.1)
Psychiatric disorder and received pharmacotherapy	5,721 (29.8)	3,474 (30.1)	2,247 (29.3)
No psychiatric disorder	12,295 (64.0)	7,332 (63.5)	4,963 (64.8)

<sup>a</sup>Heavy drinking was defined as exceeding either daily or weekly drinking limits recommended by the NIAAA.

<sup>b</sup>Sustained cessation of heavy drinking was defined as achieving early cessation of heavy drinking and reporting lower-risk drinking or abstinence through 5Y.

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**Table 4.**

Inverse probability of attrition weighted (IPAW) associations of baseline and follow-up patient characteristics with *sustained cessation of heavy drinking*,  $n=19,200$ .<sup>a</sup>

Characteristic	OR (95% CI)	p-value
<b>Baseline characteristics</b>		
Sex (female vs male)	1.37 (1.27, 1.47)	<.001
Age group (reference group: 18-34 years)		
35-49 years	1.22 (1.10, 1.35)	<.001
50-64 years	1.35 (1.21, 1.50)	<.001
65 years	1.40 (1.23, 1.59)	<.001
Race/ethnicity (reference group: White)		
Asian, Native Hawaiian, or Pacific Islander	1.56 (1.37, 1.77)	<.001
Black	1.11 (0.97, 1.28)	0.125
Latinx/Hispanic	1.20 (1.09, 1.32)	<.001
Native American	1.35 (1.00, 1.82)	0.050
Other/Unknown	1.18 (0.88, 1.59)	0.266
Household income (reference group: middle)		
Low	1.08 (0.99, 1.17)	0.084
High	1.02 (0.94, 1.10)	0.651
Smoking status (reference group: never or former)	0.88 (0.79, 0.98)	0.021
Index drinking level (reference group: exceeding only daily limits)		
Exceeding only weekly limits	0.41 (0.37, 0.44)	<.001
Exceeding both daily and weekly limits	0.32 (0.29, 0.36)	<.001
Alcohol use disorder	0.86 (0.70, 1.05)	0.130
Number of chronic medical conditions	1.08 (1.06, 1.10)	<.001
Any psychiatric disorder	1.14 (1.04, 1.25)	0.005
Any drug use disorder	1.17 (0.84, 1.64)	0.349
<b>Utilization in 1Y after index</b>		
Addiction treatment	0.92 (0.73, 1.15)	0.453
Psychiatric treatment	1.00 (0.83, 1.20)	0.969
<b>Post-1Y characteristics and utilization</b>		
Type of early cessation (lower-risk drinking vs abstinence)	0.62 (0.57, 0.66)	<.001
Number of alcohol screenings during follow-up	0.42 (0.39, 0.44)	<.001
Number of days of follow-up (reference group: <2 years)	1.10 (1.03, 1.18)	0.006
Routine primary care	1.57 (1.44, 1.71)	<.001
Addiction treatment	1.41 (1.19, 1.66)	<.001
Psychiatric treatment	1.02 (0.86, 1.21)	0.804

<sup>a</sup>Sustained cessation of heavy drinking was defined as achieving early cessation of heavy drinking and reporting lower-risk drinking or abstinence through 5Y.