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# Predictors of alcohol screening quality in a US general population sample and subgroups of heavy drinkers

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ABSTRACT

Alcohol screening is one of the most cost-effective clinical preventive services and important for intervening in the development of alcohol problems. We examine predictors of the quality of alcohol screening, approximated by *alcohol quantity screening,* which is a prerequisite for appropriate counseling, and compare conventional regression approach with Classification and Regression Trees (CART). Data come from the 2020 National Alcohol Survey, a population survey of US adults aged 18 years and over. Analyses focus on those reporting any alcohol screening at all (N = 989). The primary outcome was *whether a healthcare profession had ever asked how much they drink,* which is necessary to identify heavy drinking. We examined 12 potential predictors of alcohol quantity: gender, age, race and ethnicity, education, marital status, having a usual source of primary care, insurance, and health conditions. Analyses were replicated in heavy episodic drinking (HED) and high intensity drinking (HID) subgroups, both warranting alcohol counseling. Logistic regression results show that having diabetes and not having a college degree predict missed alcohol quantity screening in the sample overall, and younger age predicts missed alcohol quantity screening in the HED/HID subgroups. CART identified Black and Hispanic respondents who had not attended college at high risk of missed screening for heavy drinking in the overall sample, and those with public insurance at high risk of missed screening for heavy drinking in the HED/HID subgroups. The quality of alcohol screening needs improvement in general, and to avoid unintended disparities in alcohol-related health services.

## 1. Introduction

Alcohol Screening and Brief Intervention (ASBI) is one of the top five, most cost-effective clinical preventive services (National Council for Behavioral Health, 2018), strongly promoted by the United States (US) National Institute on Alcohol Abuse and Alcoholism (NIAAA) and the US Preventive Services Task Force (USPSTF), among others (National Council for Behavioral Health, 2018; Curry et al., 2018; National Institute on Alcohol Abuse and Alcoholism, 2005), and a core strategy for intervening on unhealthy drinking. Although some studies suggest ASBI has relatively modest effectiveness (Kaner et al., 2018), small effects of ASBI across the general population can translate into large public health impacts (Glass et al., 2017), especially since more than one out of four US adults drinks beyond NIAAA's recommended limits (National Institute on Alcohol Abuse and Alcoholism, 2005).

According to the US Centers for Disease Control (CDC), 85–96 % of providers report screening patients for alcohol misuse (Tan et al., 2018). This strikingly high estimate contrasts with patient reports: 2014 Behavioral Risk Factor Surveillance System (BRFSS) data show that 78 % of respondents reported being asked about drinking by a health professional in person or on a patient health form, and 33 % of all respondents reported being asked about heavy consumption (5 + drinks/occasion, also called binge drinking) (McKnight-Eily et al., 2017). Most importantly from a prevention standpoint, only 37.2 % of "binge drinkers," those at highest risk of alcohol problems, were asked about binge-level consumption (McKnight-Eily et al., 2017). Physician reports in the 2015–2016 National Ambulatory Medical Care Survey show that 72 % of office-based primary care physicians reported screening patients for alcohol misuse (Green et al., 2022). [31531] Yet only 38 % of the providers who reported screening for alcohol used a USPSTF-preferred

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screening tool (Tan et al., 2018). A key issue is the assessment of alcohol quantity, as BRFSS data show almost one-third of drinkers have not been asked by a healthcare provider about how much they drink (Tan et al., 2018; McKnight-Eily et al., 2017). These findings suggest that the quality of ASBI falls short of both national and international screening guidelines, which involve use of the Alcohol Use Disorders Identification Test (AUDIT) developed by the World Health Organization; the AUDIT requires asking about typical quantity as one of three primary questions (Babor et al., 2001). Furthermore, clinical guidelines for providing alcohol counseling and further assessment for alcohol problems depend upon knowing how much a patient drinks (National Institute on Alcohol Abuse and Alcoholism, 2005). Thus, screening for alcohol quantity is essential.

### 1.1. Predictors of ASBI receipt and differences across US subgroups

Surveys find that patients from racial and ethnic minority or lower socioeconomic status (SES) groups are more likely to receive ASBI than White or higher SES groups (Arndt et al., 2002; Mukamal, 2007; McKnight-Eily et al., 2014), even when restricting to heavy drinkers or abstainers (Arndt et al., 2002). However, a CDC study found that White and higher SES patients were more likely to be asked about alcohol at all, in general terms, while people from racial and ethnic minority groups and lower-SES patients were more often queried specifically about binge drinking and more often advised to reduce or abstain from drinking (McKnight-Eily et al., 2017). Thus, the quality of ASBI might differ across demographic subgroups.

Individuals who engage in heavy episodic drinking (HED, 5 + drinks/day) or high intensity drinking (HID, here defined as 8 + drinks/day) particularly need high quality screening, which requires screening for alcohol quantity. US trend analyses show increases in HED among middle-aged and older adults, who more likely have chronic health conditions than young adults (Grucza et al., 2018). However, prior screening studies rarely account for history of health conditions exacerbated by heavy drinking (e.g., hypertension, diabetes). Documenting the magnitude and severity of such missed opportunities is vital since ASBI helps reduce drinking among persons with chronic alcohol-related health conditions (Chi et al., 2017). Two large-scale studies that did account for alcohol-related health conditions found that Black patients were more likely than White patients to receive ASBI (Williams et al., 2012). However, a study using the 2013 National Survey of Drug Use and Health (NSDUH) reported neither racial and ethnic nor SES disparities, finding that alcohol-related health conditions were the strongest predictors of being advised to "cut down" on drinking and that female heavy episodic drinkers were 50 % less likely to receive advice to cut back than their male counterparts (Glass et al., 2016).

### 1.2. Potential methodological limitations of prior studies

Prior studies of screening often rely on standard regression models, which assume specified covariates (predictors) are related linearly to the outcome. However, predictor variables likely interact in complex ways and may have nonlinear relationships to the outcome. In addition, combinations of demographic and other factors inherently create multivariable subgroups in the general population, and alcohol screening likely differs across these subgroups. Yet if the specified model does not include the proper covariates as well as their interactions, which are usually impossible to know *a priori,* standard regression approaches may fail to capture important predictors, alone or in interactions (Hayes et al., 2015). Identifying significant interactions between predictors better distinguishes key subgroups for intervention than testing independent associations of predictors because interactions highlight groups that are more specific.

Another limitation specific to logistic regression is that coefficients are interpreted as the change in log-odds of the outcome given a one-unit change in the dependent variable, holding covariates constant; coefficients are not meant for determining or directly comparing the importance of predictor variables *per se*. An alternative technique designed to identify complex interactions and model nonlinearities in a systematic, automated manner is Classification and Regression Trees (CART) (Hayes et al., 2015). CART relies on the same mathematics as regression, but often yields a more informative model for determining important predictors than standard, pre-specified regression models. Since publication of the seminal work on CART (Breiman et al., 1984), hundreds of studies have used this technique to identify pertinent clinical risk factors.

### 1.3. Study rationale and aims

As noted above, a large majority of US adults have been asked by a health professional about their alcohol use generally, whereas far fewer have been specifically asked how much they drink. Who is screened for alcohol quantity, especially among individuals who engage in HED or HID, is an important, under-studied question. Studies have examined predictors of alcohol screening with methods that were not developed for identifying significant predictors or comparing their relative importance. Considering prior limitations and the kinds of information that would be useful to clinicians, healthcare administrators and policymakers, we examine predictors of being screened for alcohol quantity. Screening for how much an individual drinks is critical for providers to gauge whether the patient is exceeding recommended limits. Thus, our substantive aim is to identify predictors of screening for alcohol quantity in a general population sample, both overall and among heavy and high-intensity drinkers. Our methodological aim is to compare results using conventional regression with results using CART.

## 2. Methods

### 2.1. Sample

The Public Health Institute's Institutional Review Board approved this secondary data analysis. Data were from the latest National Alcohol Survey (NAS), conducted between February 2019 and April 2020. The NAS is a nationally-representative population survey of US adults aged ≥18 years, which used two probability samples (a random-digit dialed cell phone sample and an address-based sample, ABS) supplemented with a nonprobability sample from a pre-recruited web panel (Reif et al., 2020). Interviews were via telephone and on-line (for the ABS and panel samples) in English or Spanish. Black and Hispanic populations were oversampled. The total NAS sample included 9,668 respondents, with 1,572 telephone respondents, 5,661 from the ABS sample, and 2,435 from the panel. The American Association for Public Opinion Research (The American Association for Public Opinion Research, 2011) COOP4 cooperation rate for the combined telephone and ABS samples was 42.2 %.

### 2.2. Measures

The primary outcome was *screening for alcohol quantity,* specifically whether a doctor ever asked respondents who had been screened at all how much they drink. All respondents were first asked, "Has a doctor or other health professional ever talked with you about your alcohol use?" Respondents who said yes were then asked, "When your doctor or other health professional asked about your alcohol use, what did they say?" and were able to check multiple options: They asked how much you drink; They asked how often you drink; They asked if you have any problems because of your drinking; They advised you to cut down on your drinking; They gave you information about treatment for alcohol problems; and They said something else.

For the primary outcome, *screening for alcohol quantity,* respondents who checked "They asked how much you drink" were coded as Yes; all others were coded as No. Because we wanted our sample to be as

comparable as possible to published samples (e.g., BRFSS, NSDUH), we restricted analyses to those who answered Yes to "Has a doctor or other health professional *ever talked with you* about your alcohol use?" and additionally reported having a routine check-up in the past two years (analytic N = 989).

We examined 12 potential predictors: having a usual source of primary care, health conditions that could be exacerbated by alcohol use, insurance coverage, and demographics. (1) *Having a usual source of primary care* was determined from two questions, the first being, "Is there a place you usually go when you are sick or need advice about your health?" Those who responded Yes were asked, "What kind of place do you go to most often - a clinic or health center, a doctor's office, an emergency room, or some other place?" Those who responded that they go to a clinic, health center, or doctor's office were categorized as having a usual source of primary care. *Health conditions* were ever being told by a health professional that the respondent has (2) hypertension, (3) heart problems, (4) diabetes, (5) stroke, and (6) cancer, each coded as separate indicators. (7) *Insurance coverage* included private, public (Medicare and Medicaid), uninsured, and other. Self-reported demographics were (8) *sex* (female or male), (9) *age* (18–34, 35–49, 50–64, ≥65), (10) *race and ethnicity* (Hispanic, Non-Hispanic Black (Black), Non-Hispanic American Indian or Alaska Native, Non-Hispanic Asian or Pacific Islander, Non-Hispanic White (White), combined Other racial and ethnic groups and Missing), (11) *educational attainment* (less than high school, high school graduate, some college, college graduate), and (12) *marital status* (married or cohabitating versus not).

Heavy episodic drinking and high intensity drinking were determined by asking about the maximum number of drinks consumed in one occasion in the past year (Greenfield, 2000; Greenfield et al., 2009). HED was coded for all who reported a maximum of 5 or more drinks, and HID was a maximum of 8 or more drinks in one occasion.

### 2.3. Statistical analyses

We implemented all analyses for the total analytic sample (i.e., those screened at all) and for subgroups defined by HED and HID. First, we estimated prevalence of alcohol quantity screening. Then, we used logistic regression to estimate the odds of screening based on all potential predictors. Finally, we implemented CART to identify the most important predictors of screening and their interactions.

CART identifies the most important predictors of outcomes based on minimizing the mean-squared error, similarly to standard regression, in addition to minimizing impurity, or the probability that a random observation is misclassified (Breiman et al., 1984; Therneau et al., 2019). CART first splits the sample based on homogeneity in the outcome across all potential predictors, iteratively testing different cut-points of predictors. For each predictor, CART chooses the split that yields subgroups with the most homogeneous outcomes as the best split, then repeats the process for each predictor to identify its best split based on greatest reduction in impurity (Hayes et al., 2015). CART then uses recursive partitioning to test interactions between predictors and identify key subgroups based on these combinations.

CART creates trees, in which each node or "leaf" represents a cell of the variable split. Nodes further down a tree are conditional on those further up. Terminal nodes, at the bottom of each tree, imply that after that particular split, further partitioning does not explain enough variance to be relevant (Morgan, 2014). Terminal node size can be restricted, e.g., set to some pre-specified minimum to avoid over-fitting and increase generalizability. Rather than setting an arbitrary minimum node size, we used cost-complexity pruning (Hayes et al., 2015). Cost-complexity pruning iteratively compares variable splits in a training dataset and cross-validates them in a testing dataset, with the goals of minimizing misclassification risk associated with complex trees and improving generalizability.

## 3. Results

Table 1 describes characteristics of the total analytic sample (those screened at all) and among the HED and HID subgroups. Table 2 displays prevalence of alcohol quantity screening across groups independently defined by potential predictors. Chi-square tests for proportions show significant differences across groups defined by age, race and ethnicity, education, and having a usual source of primary care.

Table 3 contains results from standard regression models. In the total sample, the only significant predictors were being a college graduate, which was related to higher odds of alcohol quantity screening (OR = 1.66, 95 % CI: 1.12, 2.46), and having diabetes, which was related to lower odds of screening (OR = 0.67, 95 % CI: 0.46, 0.96). In the HED group, older age (35 + ) groups, college graduates, and those with cancer had increased odds of alcohol quantity screening. Within the HID group, older age was related to higher odds and having hypertension was related to lower odds of alcohol quantity screening.

Fig. 1a illustrates the CART tree for the total analytic sample. Percentages are those who have been screened for quantity, e.g., 61.2 % of White respondents have been screened, whereas only 41.8 % of Hispanic, Black, and Other racial and ethnic minority respondents with a high school education or less were screened for quantity. Age also is important among Hispanic, Black, and Other racial and ethnic minority respondents with more than a high school education. In the HED group (Fig. 1b), among those with some college or more, 62.0 % were screened for quantity, while only 24.5 % of those with a high school education or less and who have public or other insurance were so screened. By contrast, 56.8 % of those with low education and private insurance or no insurance were screened. In the HID group (Fig. 1c), among those age 35 and older, 67.6 % were screened for quantity, while only 11.8 % of respondents age 18–34 with public insurance were screened. *Post hoc* sensitivity analyses (not shown) using logistic regression to test significance of the interactions identified in CART (e.g., race/ethnicity*education*age) corroborate CART results for the total analytic sample and HED and HID subgroups.

## 4. Discussion

The goals of this study were to 1) identify significant predictors of the quality of alcohol screening, i.e., screening for alcohol quantity among those receiving any screening at all, and 2) compare significant predictors identified by standard regression to those identified by CART. Results show that screening for alcohol quantity could be improved overall and highlight subgroups who are receiving screening for alcohol quantity even less than average. If we relied on standard regression results, we would conclude that not having a college degree and having diabetes are independent and significant risk factors for not being screened for alcohol quantity. A US general population study also using logistic regression found that having more health conditions that could contraindicate alcohol use was unrelated to receiving any kind of alcohol screening at all (Glass et al., 2016). Though that study did not examine diabetes or whether a doctor asked about how much the respondent drinks specifically, results contrast with our standard regression findings which show individuals with diabetes, an alcohol-related health condition, are less likely to be properly screened for alcohol use. Similarly, we found that hypertension was related to lower odds of screening for quantity in the HID subgroup, though reporting a cancer diagnosis was related to higher odds of screening for quantity in the HED subgroup. Thus, our standard regression results suggest that providers could improve screening for alcohol quantity among those with diabetes and those with hypertension (both prevalent health conditions) in particular.

Standard regression results also suggest ages ≥ 35 consistently predict screening in the HED and HID subgroups. CART results corroborate this finding, showing that among the HED and HID subgroups, those with public insurance were screened least often, with alarmingly low

**Table 1**
Descriptive prevalence (%) estimates for Total Sample and by High Intensity Drinking groups in the 2020 National Alcohol Survey[a].

| % | Total Sample (N = 989) | HED[b] group (n = 357) | HID group (n = 296) |
|---|---|---|---|
| Demographics and health conditions[c] | | | |
| Female | 41.2 | 30.5 | 26.0 |
| Male | 58.9 | 69.5 | 74.0 |
| 18–34 years old | 28.3 | 39.8 | 46.4 |
| 35–49 years old | 21.4 | 24.7 | 25.5 |
| 50–64 years old | 29.1 | 25.2 | 21.9 |
| ≥65 years old | 21.1 | 10.4 | 6.1 |
| Hispanic | 20.8 | 21.6 | 19.4 |
| Non-Hispanic Black | 21.1 | 18.5 | 19.9 |
| Non-Hispanic White | 50.4 | 54.3 | 53.6 |
| Other/Missing | 7.7 | 5.6 | 7.1 |
| High school graduate or less | 25.6 | 24.1 | 27.0 |
| Some college | 31.9 | 31.4 | 33.2 |
| College graduate or more | 42.5 | 44.5 | 39.8 |
| Married/cohabitating | 53.5 | 52.4 | 51.5 |
| Not married/cohabitating | 46.5 | 47.6 | 48.5 |
| Has usual source of primary care | 89.1 | 87.6 | 83.0 |
| Does not have usual source of primary care | 11.0 | 12.4 | 17.0 |
| Insurance type | | | |
| Private | 41.5 | 46.5 | 48.8 |
| Public | 37.9 | 31.3 | 26.8 |
| Uninsured | 5.8 | 6.7 | 8.3 |
| Other | 14.8 | 15.5 | 16.1 |
| Health conditions | | | |
| Hypertension | 52.7 | 49.9 | 49.0 |
| Heart problems | 19.3 | 20.2 | 25.5 |
| Diabetes | 20.4 | 19.9 | 25.0 |
| Stroke | 4.8 | 7.0 | 9.2 |
| Cancer | 12.0 | 11.8 | 11.7 |
| Number of health conditions (mean (SE)) | 1.1 (0.03) | 1.1 (0.07) | 1.2 (0.1) |
| Drinking levels | | | |
| Non-drinker | 18.1 | 0.0 | 0.0 |
| 0–4 max drinks/occasion | 45.8 | 0.0 | 0.0 |
| 5–7 max drinks/occasion | 16.3 | 45.1 | 0.0 |
| 8–11 max drinks/occasion | 10.3 | 28.6 | 52.0 |
| 12 + max drinks/occasion | 9.5 | 26.3 | 48.0 |
| Alcohol Screening Items | | | |
| Doctor ever asked… | | | |
| How much you drink? | 55.5 | 56.3 | 58.7 |
| How often you drink? | 55.2 | 57.4 | 59.2 |
| How much *and* how often you drink? | 44.4 | 43.7 | 42.9 |
| Any alcohol problems? | 32.0 | 35.6 | 34.2 |
| Doctor advised cut down | 31.1 | 40.9 | 43.9 |
| Doctor gave treatment info | 15.7 | 18.5 | 22.5 |
| Doctor said something else | 14.9 | 10.4 | 8.2 |

[a] Analytic sample is restricted to those who have had a routine check-up in the past two years and answered Yes to the question, "Has a doctor or other health professional ever talked with you about your alcohol use?

[b] HED = heavy episodic drinking, defined as 5 + drinks in one occasion in the past 12 months. HID = high intensity drinking, defined as 8 + drinks in one occasion in the past 12 months.

[c] Demographic and health conditions are included as the 12 potential predictors in the regression and CART models.

**Table 2**
Prevalence (%) estimates of whether a doctor has ever asked how much respondent drinks across levels of potential predictors.

| *Potential predictors* | % Ever asked how much alcohol by doc | $p$[a] |
|---|---|---|
| Female | 56.8 | |
| Male | 54.6 | 0.510 |
| 18–34 years old | 53.9 | |
| 35–49 years old | 60.4 | |
| 50–64 years old | 49.7 | |
| ≥65 years old | 60.8 | **0.034** |
| Non-Hispanic White | 61.2 | |
| Hispanic | 51.0 | |
| Non-Hispanic Black | 48.3 | |
| Other/Missing | 50.0 | **0.003** |
| High school or less | 45.9 | |
| Some college | 56.2 | |
| College or more | 60.9 | **0.001** |
| Married/cohabitating | 52.6 | |
| Not married/cohabitating | 58.0 | 0.087 |
| Has usual source of primary care | 57.3 | |
| Does not have usual source of primary care | 46.9 | **0.050** |
| Insurance type | | |
| Private | 57.0 | |
| Public | 55.3 | |
| Uninsured | 57.7 | |
| Other | 50.4 | 0.604 |
| Health conditions | | |
| Hypertension | | |
| Yes | 54.7 | |
| No | 56.4 | 0.589 |
| Heart problems | | |
| Yes | 55.5 | |
| No | 55.6 | 0.983 |
| Diabetes | | |
| Yes | 49.5 | |
| No | 57.1 | 0.054 |
| Stroke | | |
| Yes | 55.3 | |
| No | 55.5 | 0.978 |
| Cancer | | |
| Yes | 57.1 | |
| No | 55.3 | 0.702 |
| Non-drinker | 46.9 | |
| 0–4 max drinks/occasion | 58.3 | |
| 5–7 max drinks/occasion | 53.4 | |
| 8–11 max drinks/occasion | 57.8 | |
| 12 + max drinks/occasion | 59.6 | 0.096 |

[a]From chi-square tests of differences in proportions across levels of potential predictors

**Bold** signifies $p \leq 0.05$

rates of proper screening among 18–34 year olds with public insurance in the HID subgroup (11.8 %) in particular. One plausible explanation for lower rates of screening among adults <35 could be that they have fewer health conditions and are thus assumed lower priority by healthcare professionals who do not have a lot of time to meet with patients. Still, particular attention should be paid to those <35 because mean alcohol quantity and heavy drinking prevalence rates are highest in younger adults (Dawson et al., 2015; Substance Abuse and Mental Health Services Administration, 2018). The finding that age <35 is related to lower alcohol screening in the HED and HID subgroups specifically suggests that younger adults who need screening and intervention the most are being missed. Here, public insurance consists of

**Table 3**
Odds ratios and 95% CIs from logistic regression models of having had a doctor ask how much respondent drinks regressed on potential predictors, Total Sample[a] and by HID subgroups.

| *Covariates* | **Total Sample (N = 989)** | | | **HED[b] group (n = 357)** | | | **HID[b] group (n = 196)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **OR** | **95 % CI** | | **OR** | **95 % CI** | | **OR** | **95 % CI** | |
| Male vs Female | 0.79 | 0.59 | 1.06 | 0.67 | 0.37 | 1.21 | 0.53 | 0.20 | 1.41 |
| Age vs 18–34 | | | | | | | | | |
| 35–49 | 1.15 | 0.75 | 1.76 | **2.14** | **1.07** | **4.28** | **3.45** | **1.24** | **9.59** |
| 50–64 | 0.80 | 0.53 | 1.20 | **2.40** | **1.17** | **4.95** | **12.81** | **3.79** | **43.33** |
| 65+ | 1.19 | 0.74 | 1.92 | 2.42 | 0.91 | 6.44 | 3.48 | 0.66 | 18.43 |
| Race and ethnicity vs Non-Hispanic White | | | | | | | | | |
| Non-Hispanic Black | 0.71 | 0.48 | 1.05 | 0.72 | 0.33 | 1.56 | 0.85 | 0.25 | 2.83 |
| Hispanic | 0.75 | 0.50 | 1.12 | 0.77 | 0.38 | 1.55 | 1.36 | 0.45 | 4.15 |
| Other/Missing | 0.78 | 0.45 | 1.38 | 0.86 | 0.28 | 2.67 | 1.62 | 0.32 | 8.21 |
| Education vs High school or less | | | | | | | | | |
| Some college | 1.30 | 0.88 | 1.92 | 1.47 | 0.71 | 3.03 | 2.16 | 0.70 | 6.65 |
| College graduate | **1.66** | **1.12** | **2.46** | **2.42** | **1.18** | **4.96** | 2.87 | 0.95 | 8.62 |
| Married/cohabitating vs Not | 1.14 | 0.84 | 1.54 | 1.16 | 0.66 | 2.02 | 1.87 | 0.78 | 4.47 |
| Has usual source of primary care vs Not | 1.14 | 0.69 | 1.86 | 0.51 | 0.20 | 1.33 | 0.60 | 0.17 | 2.14 |
| Insurance type vs Private | | | | | | | | | |
| Public | 1.04 | 0.71 | 1.53 | 0.66 | 0.32 | 1.35 | 0.92 | 0.32 | 2.63 |
| Uninsured | 1.22 | 0.60 | 2.49 | 0.82 | 0.25 | 2.71 | 1.12 | 0.22 | 5.77 |
| Other | 0.89 | 0.57 | 1.38 | 0.62 | 0.28 | 1.34 | 1.15 | 0.37 | 3.57 |
| Has hypertension vs Not | 0.99 | 0.72 | 1.36 | 0.60 | 0.33 | 1.11 | 0.23 | **0.08** | **0.64** |
| Has heart problems vs Not | 1.00 | 0.67 | 1.49 | 0.96 | 0.41 | 2.24 | 1.00 | 0.28 | 3.54 |
| Has diabetes vs Not | **0.66** | **0.46** | **0.97** | 0.48 | 0.22 | 1.03 | 0.72 | 0.24 | 2.16 |
| Has had a stroke vs Not | 0.72 | 0.34 | 1.51 | 0.43 | 0.10 | 1.91 | 2.06 | 0.23 | 18.46 |
| Has had cancer vs Not | 1.15 | 0.72 | 1.85 | **3.02** | **1.06** | **8.63** | 1.12 | 0.23 | 5.45 |

[a] Analytic sample is restricted to those who have had a routine check-up in the past two years and answered Yes to the question, "Has a doctor or other health professional ever talked with you about your alcohol use?

[b] HED = heavy episodic drinking, defined as 5 + drinks in one occasion in the past 12 months. HID = high intensity drinking, defined as 8 + drinks in one occasion in the past 12 months.

**Bold** signifies $p \leq 0.05$

Medicare and Medicaid; as Medicare is usually for adults ≥65 years, results suggest that Medicaid providers specifically could improve their screening practices as well.

CART analyses identified additional important predictors and significant interactions, namely an interaction of race and ethnicity with both education and age for the full analytic sample; education and insurance type for the HED group; and age and insurance type for the HID group. These results highlight specific subgroups at particularly high risk for not being screened appropriately. For example, people who are Hispanic, Black, or Other race or ethnicity with a high school education or less, were least likely to be screened for alcohol quantity. Most notably, CART results show that racial and ethnic minority groups at all education levels were less likely to receive alcohol quantity screening than White respondents. Though prior studies report mixed findings regarding differences in screening across racial or ethnic groups and SES levels (McKnight-Eily et al., 2017; Williams et al., 2012; Arndt et al., 2002; Mukamal, 2007; McKnight-Eily et al., 2014), our results suggest a need for improved quality of screening among Hispanic, Black, and Other racial and ethnic minority groups, especially given existing racial and ethnic disparities in midlife heavy drinking, persistent AUD, and poor health (Mulia et al., 2017; Grant et al., 2012; Brown et al., 2012; Adler and Stewart, 2010).

It has been two decades since the seminal Institute of Medicine report on "Unequal Treatment" has been released (Smedley et al., 2002), and while there has greater attention to systemic racism in health care, much research and intervention remains to be done to address this. Provider biases and differing levels of comfort across patient demographic groups may cause disparities in alcohol screening (Glass et al., 2017; Williams et al., 2012; Weisner and Matzger, 2003; van Boekel et al., 2015), indicating a potential need for training on culturally- and socially-relevant approaches to discuss alcohol consumption with diverse patients. Supporting this idea, almost a quarter of physicians report that training on ASBI would be helpful (Green et al., 2022). [31531] Understanding the reasons for not talking about alcohol quantity to certain patients, e.g., fear of stigmatizing or antagonizing people, might help improve physician training (Green et al., 2022).[31531].

Differences between standard regression results and CART results are simply due to *a priori* assumptions or lack thereof. We assumed a logistic regression model without interaction terms because we could not possibly have tested all combinations of predictors, nor had we *a priori* bases to test the interactions ultimately identified by CART. CART does not make the same assumptions as standard regression, and the ability to identify high-level interactions (e.g., three-way or more) and uncover specific subgroups that would otherwise remain hidden is one of CART's primary advantages. Sensitivity analyses corroborating these interactions in standard regression models reflect the utility of both methods for informing targeted prevention and intervention efforts, assuming preliminary hypotheses to inform meaningful covariate selection. Neither standard regression nor CART showed sex as a significant predictor of having been screened for alcohol quantity. Still, given that alcohol consumption among women is increasing, and that rates of HED are increasing more dramatically among females than males (Grucza et al., 2018; Keyes et al., 2019), future research should continue monitoring screening for alcohol quantity among women. This could have significant implications for health policy and programs.

### 4.1. Limitations

CART relies on a pre-specified set of variables for testing, and there may be important predictors that were omitted or not available.

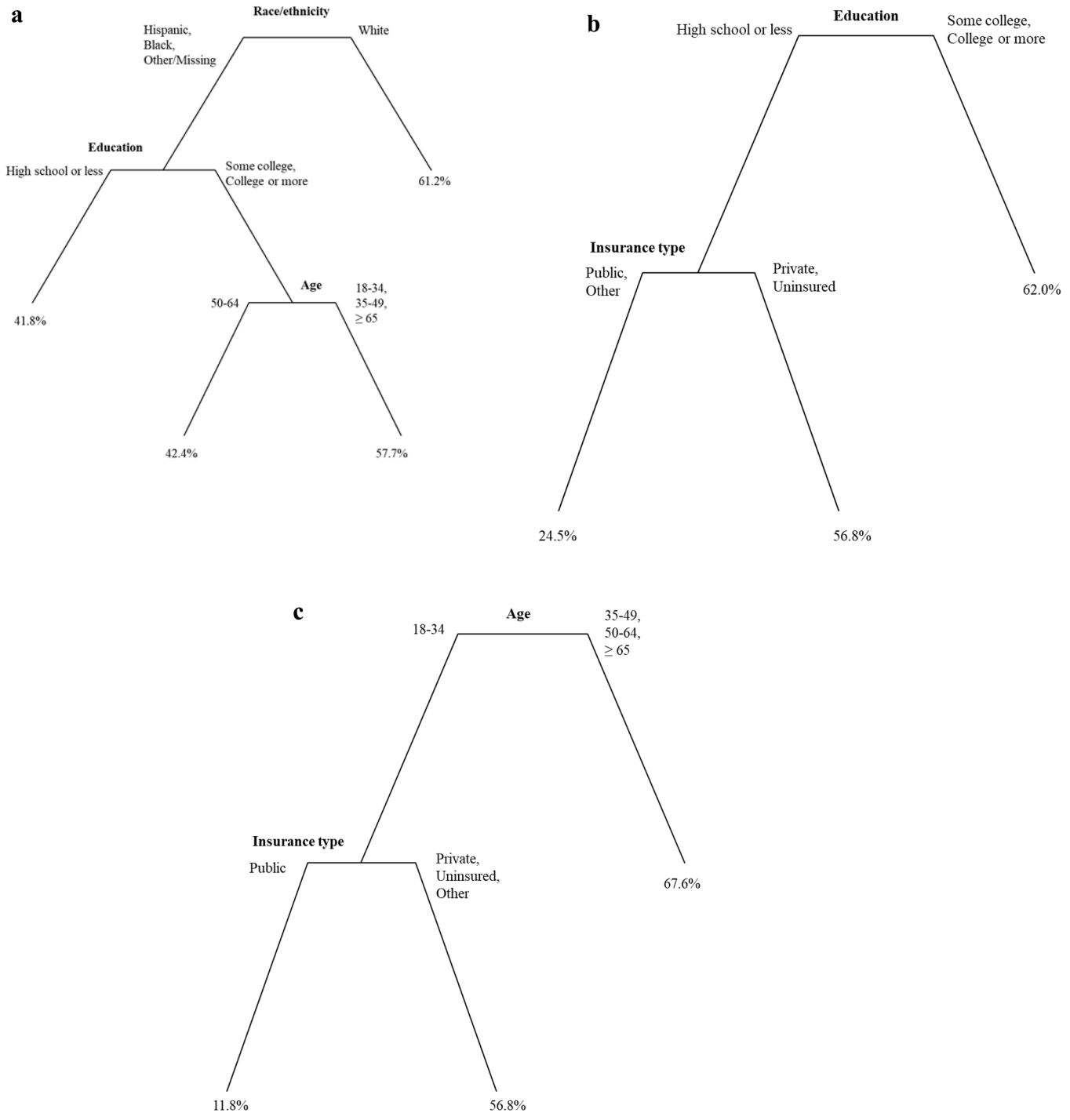


**Fig. 1. a. Classification and Regression Tree results for predicting having had a doctor ask how much respondent drinks, Total Sample (N = 989)[a].** [a]Percentages are those who have been asked how much they drink by a doctor, e.g., 41.8 % of Hispanic, Black, and Other/Missing respondents with a high school education or less have been asked how much they drink by a doctor. **1b. Classification and Regression Tree results for predicting having had a doctor ask how much respondent drinks, HED group (those reporting any 5 + occasions, n = 357)[a].** [a]Percentages are those who have been asked how much they drink by a doctor, e.g., 24.5 % of respondents with a high school education or less and Public or Other insurance have been asked how much they drink by a doctor. **1c. Classification and Regression Tree results for predicting having had a doctor ask how much respondent drinks, HID groups (those reporting any 8 + occasions, n = 196)[a].** [a]Percentages are those who have been asked how much they drink by a doctor, e.g., 11.8 % of respondents age 18–34 with Public insurance have been asked how much they drink by a doctor.

Responses are self-reported and subject to biases related to social acceptability and recall. However, the magnitude of bias should be relatively minimal due to the nature of the survey questions posed. Some respondents may have reported not receiving screening for quantity because they do not drink. The high prevalence of past-12 month drinkers (82 %) in our sample lessens this potential problem. Data come from the US and while some findings might be relevant for other countries, future studies should use international data to confirm. We did not use survey-weights because we used cross-validated prediction models, which violate the assumptions needed to use survey weights (i.e., that each training set is formed in a way that reflects the actual sampling design). This may affect generalizability. Similarly, prediction-

based models like CART often have limited generalizability, though our use of cross-validation alleviates this concern. Finally, predictors of screening quality might differ from predictors of screening in general; since this sample was restricted to those who had talked to a health professional about alcohol, results may not necessarily generalize to individuals who have not.

## 5. Conclusions

Using a large, general population survey, we aimed to identify primary predictors of screening for alcohol use quantity and to compare results obtained using conventional regression with those using CART. Substantively, we identified several subgroups who are not receiving adequate screening for heavy alcohol use. People who identified as Hispanic, Black, or Other racial and ethnic minority group who have not attended any college and heavy drinkers with public insurance are at particularly high risk of being missed by appropriate screening, reflecting clear clinical gaps. Methodologically, CART demonstrated utility for uncovering interactions and identifying related detailed subgroups missed by standard regression approaches.

## CRediT authorship contribution statement

**Meenakshi S. Subbaraman:** Conceptualization, Methodology, Software, Formal analysis, Visualization, Writing – original draft, Funding acquisition. **Camillia K. Lui:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Supervision. **Katherine J. Karriker-Jaffe:** Data curation, Methodology, Writing – review & editing. **Thomas K. Greenfield:** Writing – review & editing. **Nina Mulia:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Supervision.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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