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Behavioral stability of alcohol consumption and socio-demographic correlates of change among a nationally representative cohort of US adults

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AUTHOR CONTRIBUTIONS

Klajdi Puka: Data curation; formal analysis; methodology; project administration; validation; visualization. **Charlotte Buckley:** Formal analysis; methodology. **Nina Mulia:** Methodology. **Robin Purshouse:** Formal analysis; methodology. **Aurelie Lasserre:** Methodology. **William C Kerr:** Methodology. **Jurgen Rehm:** Methodology. **Charlotte Probst:** Conceptualization; formal analysis; funding acquisition; methodology; resources.

DECLARATION OF INTERESTS

None.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Abstract

Aims: To estimate the probability of transitioning between different categories of alcohol use (drinking states) among a nationally representative cohort of United States (US) adults and to identify the effects of socio-demographic characteristics on those transitions.

Design, setting and participants: Secondary analysis of data from the National Epidemiologic Survey of Alcohol and Related Conditions (NESARC), a prospective cohort study conducted in 2001–02 and 2004–05; a US nation-wide, population-based study. Participants included 34 165 adults (mean age = 45.1 years, standard deviation = 17.3; 52% women).

Measurements: Alcohol use was self-reported and categorized based on the grams consumed per day: (1) non-drinker (no drinks in past 12 months), (2) category I (women = ≤ 20; men = ≤ 40), (3) category II (women = 21–40; men = 41–60) and (4) category III (women = ≥ 41; men = ≥ 61). Multi-state Markov models estimated the probability of transitioning between drinking states, conditioned on age, sex, race/ethnicity and educational attainment. Analyses were repeated with alcohol use categorized based on the frequency of heavy episodic drinking.

Findings: The highest transition probabilities were observed for staying in the same state; after 1 year, the probability of remaining in the same state was 90.1% [95% confidence interval (CI) = 89.7%, 90.5%] for non-drinkers, 90.2% (95% CI = 89.9%, 90.5%) for category I, 31.8% (95% CI = 29.7, 33.9%) category II and 52.2% (95% CI = 46.0, 58.5%) for category III. Women, older adults, and non-Hispanic Other adults were less likely to transition between drinking states, including transitions to lower use. Adults with lower educational attainment were more likely to transition between drinking states; however, they were also less likely to transition out of the 'weekly HED' category. Black adults were more likely to transition into or stay in higher use categories, whereas Hispanic/Latinx adults were largely similar to White adults.

Conclusions: In this study of alcohol transition probabilities, some demographic subgroups appeared more likely to transition into or persist in higher alcohol consumption states.

Keywords

Age; agent-based model; Markov model; race and ethnicity; sex; simulation model; socio-economic status; trajectory; transition probability

INTRODUCTION

Life expectancy in the United States has declined in recent years owing to increased mortality from specific causes of death, such as alcohol-attributable mortality [1–3]. Stark and widening socio-demographic inequalities in alcohol-attributable morbidity and mortality are also evident [2–4]. Although past studies have evaluated group-based trajectories of alcohol use [5–9] and have identified risk factors for heavy drinking and alcohol use disorders (AUD) [10–12], less is known about individual-level trajectories. Understanding the behavioral stability of individuals' drinking patterns over time and the characteristics associated with increased or decreased consumption has important implications for public

health interventions and the forecasting of the burden on health. Additionally, the probability of transitioning into different ‘drinking states’ among a general adult population is needed for computer simulation techniques such as microsimulations and agent-based modeling to ensure that synthetic populations are representative of the drinking behaviors of individuals by socio-demographic groups and over time. Computer simulation techniques are being increasingly utilized in public health research and can facilitate a high level of complexity to estimate population-level outcomes and expected intervention effects [13–16].

Of the studies that have evaluated changes in alcohol consumption, most have focused on trajectories among specific subgroups, and generally find that drinking begins in adolescence, peaks in the early 20s and decreases thereafter [5–9]. However, socio-demographic differences are evident; for example, alcohol use among non-Hispanic Black and Hispanic/Latinx groups peak in their mid-to-late 20s [6, 17, 18], and Hispanic/Latinx men and non-Hispanic Black women have shown greater relative risks for persistent (versus declining) heavy drinking beyond young adulthood compared to non-Hispanic White adults [19]. Studies evaluating change at the individual level typically provide a descriptive account or use a series of logistic regressions to identify the characteristics associated with specific transitions in isolation. These studies typically find stable drinking patterns over relatively short follow-ups (< 5 years) and greater changes observed over longer follow-ups, among younger adults, and among heavy drinkers [11, 20, 21]. Only a few studies have taken a comprehensive approach, evaluating transition probabilities. These studies suggest that, although there is movement across different levels of alcohol consumption, the highest probabilities are observed for staying in the same drinking category [22–24] and that female sex, higher age and higher socio-economic status (SES) are associated with transitions to lighter drinking over time [23]. Notably, studies evaluating transition probabilities have focused pon youth and young adults [23–26] or specific populations, such as people with AUD, problem drinking or those seeking treatments [22, 27–29]; transition probabilities for alcohol consumption have not been previously evaluated among a general adult population in the United States or elsewhere.

The objective of the current study was to estimate the probability of transitioning between different categories of alcohol use (henceforth ‘drinking states’) defined by the (1) quantity (grams per day) and (2) pattern of consumption [frequency of heavy episodic drinking (HED)] among a nationally representative, population-based cohort of US adults. Discerning transition probabilities for both the quantity and pattern of alcohol use is important, as they have been found to have different effects on morbidity and mortality [30]. The second objective was to identify the socio-demographic characteristics associated with the likelihood of transitioning between drinking states. Beyond providing important information on an individual’s likelihood of change in the quantity and pattern of alcohol consumption over time, these findings are important for informing computer simulation models to estimate intervention effects [15, 16].

METHODS

Data

Data came from the National Epidemiologic Survey of Alcohol and Related Conditions (NESARC), previously described in detail [31, 32]. NESARC is a nation-wide household survey of the civilian, non-institutionalized US adult population, which used a complex, multi-stage sampling design. The first wave (NESARC I) was conducted in 2001–02 and recruited 43 093 adults (18+ years) for a computer-assisted face-to-face interview. A second wave (NESARC II) was conducted 3 years later, between 2004 and 2005, and re-interviewed 34 653 adults. Of the 8440 participants who did not complete the follow-up, 3134 were not eligible at follow-up (e.g. were institutionalized, mentally/physically impaired, on active duty in the armed forces). The overall response rate was 81% (NESARC I) and 87% (NESARC II), yielding a cumulative survey response rate of 70%. Our sample was comprised of adults who completed the baseline and follow-up assessment; importantly, the sampling weights account for the non-response and sample attrition, as well as the study design. Missing data on socio-demographic characteristics (age, sex, educational attainment and race and ethnicity) were imputed by National Institute on Alcohol Abuse and Alcoholism (NIAAA) using assignment or a 'hot deck' procedure, as described in Grant *et al.* [33]. Participants with missing data on the quantity or pattern of alcohol consumption (< 1%) were removed.

In 2012–13, NESARC III was conducted using nearly identical methodology [34]. Notably, NESARC III is not a prospective follow-up, and was composed of a new, cross-sectional sample of 36 309 adults (response rate 61%).

Alcohol use and covariates

Alcohol use was operationalized based on the quantity and pattern of alcohol consumption. Quantity of consumption was operationalized based on the average grams of pure alcohol consumed per day, calculated based on participants' report of the frequency, quantity and size of drinks consumed in the past 12 months (for multiple types of alcoholic beverages, as per the NESARC manuals). Average grams of alcohol per day was categorized according to the standards of the World Health Organization (WHO) [35]: (1) non-drinker (no drinks in the past 12 months), (2) category I [≤ 20 g (women) or ≤ 40 g (men)], (3) category II [21–40 g (women) or 41–60 g (men)] and (4) category III [≥ 41 g (women) or ≥ 61 g (men)]. In the model selection process, alternative operationalizations were considered whereby (1) non-drinkers were separated into life-time abstainers and former drinkers, and (2) category III was separated into category III [41–60 g (women) or 61–100 g (men)] and category IV [≥ 61 g (women) or ≥ 101 g (men)], as described by the WHO [35].

The pattern of alcohol consumption was operationalized based on the frequency of HED [4+ (women) or 5+ (men) drinks] in the last 12 months, and categorized into (1) non-drinkers, (2) drinker, but no HED, (3) occasional HED (less than once a month), (4) monthly HED (less than once per week but more than once per month) and (5) weekly HED (at least once a week).

Participants also reported on their sex, age, educational attainment (as a proxy for SES [36, 37]) and race and ethnicity. Age was categorized into seven categories (18–20, 21–25, 26–29, 30–39, 40–49, 50–64 and 65+ years), given that alcohol consumption does not change linearly with age [9, 38], and for consistency with past research using NESARC [11]. In the model selection process, alternative operationalizations for age were considered, coding age as a categorical variable (18–29, 30–49, 50+ years), or as a continuous variable with linear or quadratic effects. Educational attainment was categorized as low (high school diploma or less), medium (some college but no bachelor's degree) or high (bachelor's degree or more). Race and ethnicity were categorized as non-Hispanic White (hereafter, White), non-Hispanic Black/African American (hereafter, Black), Hispanic/Latinx, and all other non-Hispanic racial and ethnic groups (hereafter, non-Hispanic Other).

Statistical analyses

NESARC I and II were used to estimate the average annual transition probabilities between drinking states by fitting a multi-state Markov model with a homogeneous, continuous-time process [39]; this assumes that transitions can happen at any time along a continuous interval (e.g. not restricted to once per year), and that transition probabilities stay constant over time. Separate models were estimated for the quantity and pattern of alcohol consumption and adjusted for age and education (as reported at each time-point), as well as sex and race and ethnicity (as reported at baseline). Permissible instantaneous transitions included all adjacent states (Figure 1); this assumes that participants move through each state sequentially, rather than jumping over states (e.g. from category I instantaneously to category III, skipping category II). Transition probabilities are estimated using maximum likelihood estimation, with confidence intervals calculated by sampling from the assumed multivariate normal distribution of the maximum likelihood estimates and covariance matrix. The final model showed the best model fit, as determined by Akaike's information criteria; alternative models considered used different operationalizations for alcohol use and age (as outlined earlier) and allowed for instantaneous transitions from any drinking state directly to a 'non-drinker' (as a potential consequence of intervention programs or illness). Lastly, to account for non-response and study design, observations were replicated in accordance with their sample weight and analyses completed; the resulting confidence intervals were transformed into standard errors and corrected to the original sample size before being back-transformed into confidence intervals. The *msm* package (version 1.6.9) in R 4.2.0 [39] was used for analyses; the statistical code is provided in the Supporting information file. The analysis was not pre-registered and the results should be considered exploratory.

For external validation, we used the NESARC III data (an independent source of data collected 11 years after NESARC I). The calculated annual transition probabilities, specific to each combination of the covariates (Supporting information, Supplements 1 and 2) were applied repeatedly to each individual in the NESARC I population 11 times (simulating 11 years); the socio-demographic characteristics of the group were unchanged. The predicted proportions of individuals in each drinking state from this simulated sample were compared to those observed in NESARC III.

RESULTS

Baseline characteristics of the 34 165 included adults are presented in Table 1. Participants (52% female) were on average 45.1 years of age [standard deviation (SD) = 7.3] at baseline. The Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines were followed [40].

Quantity of alcohol consumption

Quantity of alcohol consumption was best modeled using four drinking states (non-drinker, category I, category II and category III) and using age as a seven-level categorical variable; this model showed strong external validity, whereby the predicted proportions after 11 years were very similar to those observed in NESARC III, differing by 1% or less (Supporting information, Table S6). The annual transition probabilities, at the mean value of each covariate, are presented in Table 2; transition probabilities from an unadjusted model are presented in Supporting information, Table S4. The highest transition probabilities were observed for staying in the same state, particularly among non-drinkers and category I drinkers. Notably, category II drinkers were equally likely to remain in the same state or transition to categories I or III over a 1-year period; however, over time, most transitioned to category I. Figure 2a shows the transition probability between drinking states over time at the mean value of each covariate, stratified by their initial drinking state; Supporting information, Figures S1–S4 additionally stratify by each covariate. Over a 1-year period 10% of non-drinkers were predicted to start drinking, which increased to 36% by the 5-year follow-up; notably, this was largely driven by younger adults (Supporting information, Figure S1). Over a 1- and 5-year period, 6 and 21% of category I drinkers were predicted to cease drinking (with older adults more likely to do so; Supporting information, Figure S1), respectively, and 3 and 10% were predicted to increase their alcohol consumption (with younger adults more likely to so; Supporting information, Figure S1). Over a 1- and 5-year period, 1 and 12% of category II drinkers were predicted to cease drinking, 31 and 59% were predicted to lower their alcohol consumption and 36 and 17% were predicted to increase their alcohol consumption. Lastly, over a 1- and 5-year period, 0.4 and 9% of category III drinkers were predicted to cease drinking and 48 and 71% were predicted to lower their alcohol consumption.

The effect of each covariate on the permitted instantaneous transitions are presented in Table 3. Women, older adults and non-Hispanic Other adults were less likely to transition between drinking states, except for transitions to non-drinker status; notably, those who were in higher use categories were less likely to transition to lower use. Individuals with lower educational attainment (relative to high educational attainment) and Black adults (relative to White adults) were more likely to remain or become a non-drinker. However, among drinkers, the drinking pattern of Black adults was less stable (i.e. more likely to transition into and out of heavier use), except for transitions from categories III– II, which were similar to White adults. Lastly, Hispanic/Latinx adults were largely similar to White adults, although Hispanic/Latinx adults were more likely to stop drinking.

Pattern of alcohol consumption

The results with respect to the pattern of alcohol consumption were largely similar to those for the quantity of alcohol consumption. The final Markov model showed strong external validity, whereby the predicted proportions after 11 years were very similar to those observed in NESARC III, differing by 2.2% or less (Supporting information, Table S7). The annual transition probabilities at the mean value of each covariate are presented in Table 2; transition probabilities from an unadjusted model are presented in Supporting information, Table S4. The highest probabilities were largely observed for staying in the same state, particularly among non-drinkers, those reporting no HED and those reporting weekly HED. Figure 2b shows the transition probability between each drinking state over time at the mean value of each covariate, stratified by their initial drinking state; Supporting information, Figures S5–S8 additionally stratify by each covariate. Among non-drinkers, 99 and 93% were predicted to not engage in any HED by the 1- and 5-year follow-up, respectively. Similarly for drinkers not reporting HED, 90 and 78% were predicted to not engage in any HED by the 1- and 5-year follow-up, respectively. Among those reporting HED, 72–98% and 42–63% were predicted to continue engaging in HED by the 1- and 5-year follow-up, respectively.

The effect of each covariate on the permitted instantaneous transitions are presented in Table 4. The probability of transitions between HED categories was similar for men and women, except that women were less likely to initiate HED. Overall, younger adults were more likely to engage in occasional HED, being both more likely transition into, and less likely to transition out of, occasional HED. The drinking pattern of adults with lower educational attainment was less stable (i.e. they were more likely to initiate HED, transition to greater HED and transition to lower HED); however, they were also less likely to transition out of weekly HED. Black adults (relative to White adults) were less likely to transition into HED and more likely to transition out of HED. However, among those in the higher use categories, transitions to higher use (e.g. monthly and weekly HED) were three to four times more likely among Black adults, whereas transitions out of these high use categories were similar for Black and White adults. Relative to White adults, Hispanic/Latinx adults were more likely to transition into and out of weekly HED, and more likely to transition out of HED. Lastly, non-Hispanic Other adults were less likely to initiate HED, more likely to transition between higher use HED categories and more likely to transition out of HED, compared to White adults.

DISCUSSION

Using a representative US adult population, we estimated individuals' probability of transitioning to different categories of alcohol use, and accounted for the effects of age, sex, race and ethnicity and SES (educational attainment). These results are important in delineating the behavioral stability of alcohol consumption among a nationally representative US adult population and provide important information for simulation models predicting alcohol consumption and related health and other consequences over time. Overall, women, older adults and non-Hispanic Other adults were less likely to transition between drinking states, including transitions to lower use. Individuals with lower

educational attainment and Black adults were more likely to transition into or stay in higher use categories.

Drinking states were largely stable over the follow-up period of the NESARC survey, especially among those at the lower end of the drinking spectrum. These results are consistent with studies of young adults [23, 24] and problem drinkers [22]. Heavier drinkers were more likely to transition between states and the majority were predicted to transition to category I drinking over the longer term. These findings are consistent with studies evaluating group-based trajectories which report that alcohol consumption appears largely stable across the life-course except for heavier drinkers, where consumption declines over time, but is not typically to abstinence [41]. The results with respect to the pattern of alcohol consumption (frequency of HED) were largely similar. Notably, the majority of those engaging in HED were predicted to continue HED over the longer term and remain an at-risk group. The observed transition probabilities for drinking states also highlights the value of computer simulation techniques which can integrate and utilize transition probabilities to more accurately capture the complex relationships between alcohol use over time and a multitude of outcomes; this is in contrast to the typical longitudinal study, which risks misclassification of alcohol use over time given the typical reliance upon a single, baseline measure of drinking.

Our results also provide insight into the characteristics associated with transitions in alcohol consumption over time. As expected and reported previously [11, 24], sex and age showed strong association with the transitions in the quantity of alcohol consumption; SES and race and ethnicity are also important factors. We found that women, older adults and non-Hispanic Other adults were less likely to initiate drinking and transition to higher use and more likely to cease drinking. Notably however, among heavier drinkers (e.g. categories II and III), women, older adults and non-Hispanic Other adults were less likely to transition to lower use, highlighting important subgroups that may remain at risk for a more prolonged period. SES and race and ethnicity were also important risk factors, whereby low SES and Black adults were less likely to initiate drinking and more likely to cease drinking; however, among low SES and Black drinkers, transitions to higher use were more likely, highlighting an at-risk group. In contrast, a past study using the same data set reported that SES was not an important risk factor and that transitions from ‘low-risk’ (inclusive of non-drinkers and low-risk drinkers) to ‘at-risk’ alcohol use were less likely among Black Americans [11]. Notable differences between this study and ours include the operationalization of alcohol use (binary, using NIAAA guidelines, versus categorical, using WHO guidelines, respectively) and the analytical approach (logistic regressions for each transition versus a single Markov model for all transitions, respectively). Our analytical approach and evaluation of multiple transitions adds important new insights, highlighting specific subgroups at risk of heavy drinking and identifying the time-points for transitions to heavy use. Other studies using Markov models have similarly found that low SES (among a cohort of young adults) [23] and Black Americans (among a cohort of problem drinkers) [24] are at higher risks of transitioning to higher alcohol use. Lastly, we found that Hispanic/Latinx adults were largely similar to White adults; however, Hispanic/Latinx adults were more likely to cease drinking. Similar results have been previously reported for Hispanic/Latinx adults [11, 24]. Overall, women, younger adults, Black and non-Hispanic Other adults, and those with

lower educational attainment were more likely to transition into or stay in heavy drinking categories, and interventions targeting to these groups could yield important public health benefits.

In interpreting the results presented above, limitations should be considered. First, longitudinal data were only available at two time-points set 3 years apart, preventing an evaluation of cohort effects and leaving an unobserved period which may limit generalizations with respect to long-term transition probabilities. Markov models also assume that the duration spent in a given state is not associated with the probability to transition states. Additionally, the model fit did not support the addition of instantaneous transitions between non-adjacent states (such as those described by the 'sick-quitter' phenomenon), and we implicitly assume that age, sex, SES (education attainment) and race and ethnicity do not interact and have no causal effect on each other. Nonetheless, the final models showed excellent concurrent validity, yielding similar proportions for each drinking state as those observed in NESARC III, 11 years after baseline. Notably, this external validation assumes that the composition of the participants in NESARC I and III are similar, and that drinking patterns in the United States have not changed over the period between the surveys. Secondly, it should also be noted that our lowest category of drinking [equivalent to ≤ 10 (women) or ≤ 20 (men) drinks per week] [35] are higher than the US guidelines recommending that alcohol use be limited to ≤ 7 (women) or ≤ 14 (men) drinks per week [42]. Lastly, the model selection process found that the best model included a 'non-drinker category', as opposed to modeling life-time abstainers and former drinkers as unique groups. Although life-time abstainers and former drinkers are known to be unique groups with unique health outcomes merging these groups may be necessary for estimating transitions, given the inconsistent reporting of life-time abstainers [43]. Subsequently, microsimulation methods can differentiate the life-time abstainers from former drinkers so that epidemiological modeling of health outcomes can be applied appropriately. Microsimulation models are also needed to verify whether the estimated transition probabilities remain valid over the long term and the years since the NESARC surveys.

The results presented above delineate transition probabilities for quantity and pattern of alcohol consumption and identified at-risk transition points and subgroups. Implementation of interventions should be a priority in settings that reach women, younger adults, Black and non-Hispanic Other adults, and those with lower educational attainment. In addition, the transition probabilities identified will be an important component of microsimulation models and alcohol prevention policy models, that have previously relied upon more limited evidence in US settings [26].

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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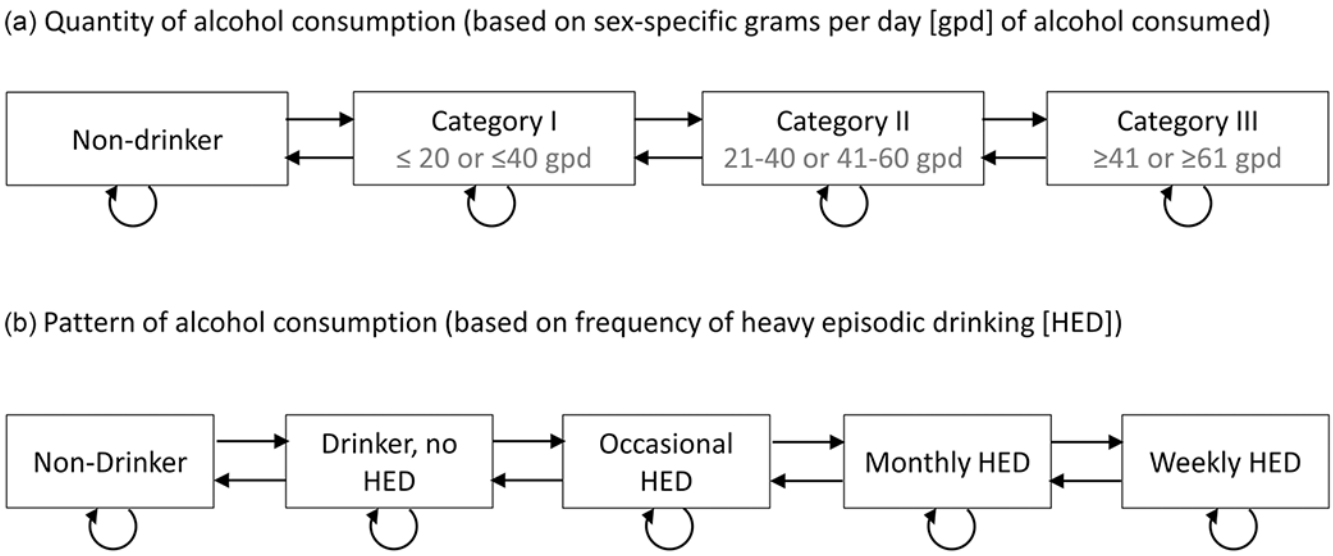

FIGURE 1.
Possible instantaneous transitions. HED, heavy episodic drinking

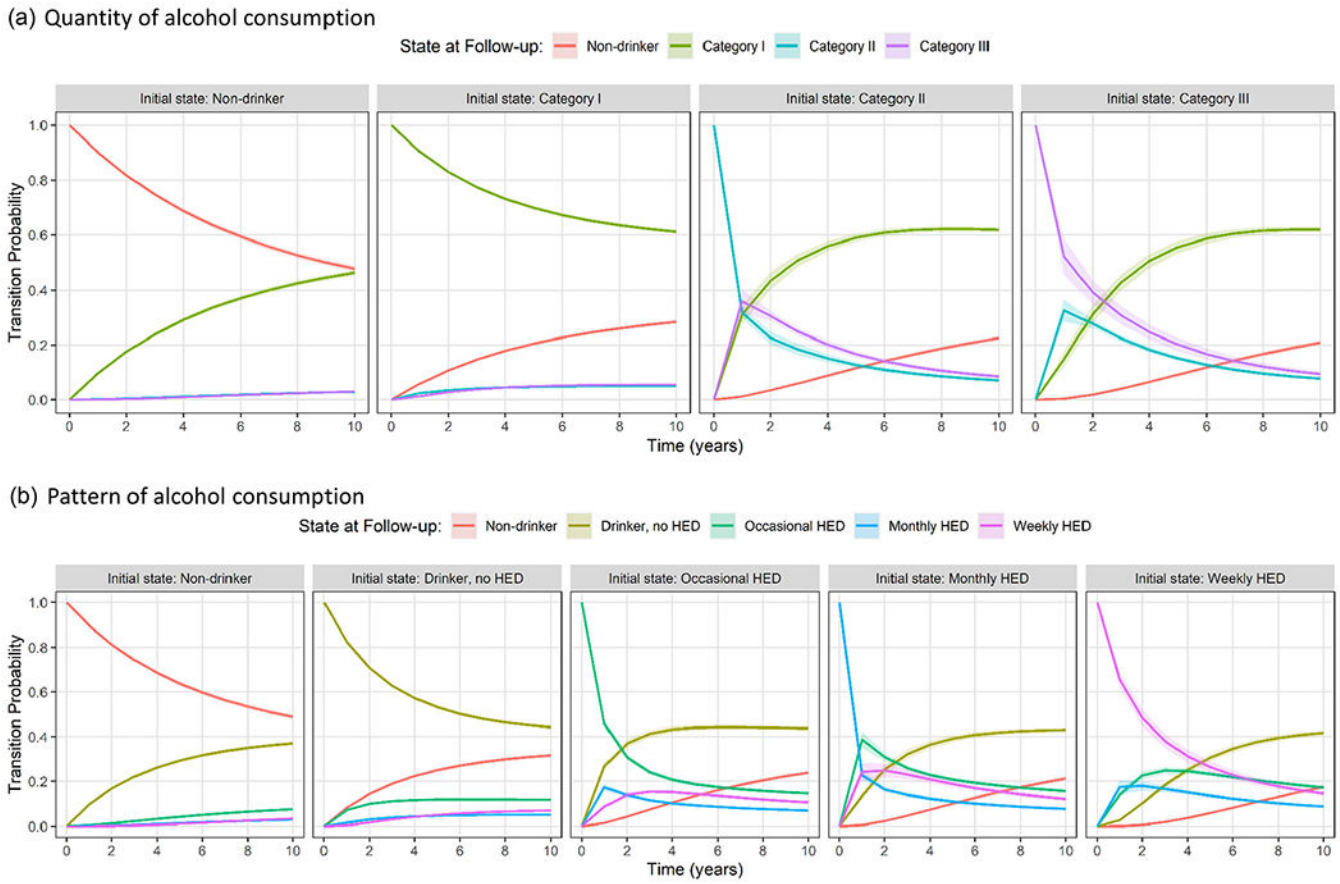

FIGURE 2.

Probability of transitioning to each drinking state (or staying in the same state) over time, stratified by the initial drinking state. Shaded regions represent the 95% confidence interval. HED, heavy episodic drinking

TABLE 1

Participant characteristics

	NESARC I (baseline)	NESARC II (follow-up)
Sex, % female	52%	52%
Age, mean years (SD)	45.1 (17.3)	48.2 (17.3)
18–20	6%	0%
21–25	9%	9%
26–29	7%	7%
30–39	20%	19%
40–49	21%	21%
50–64	21%	24%
65+	16%	19%
Race and ethnicity		
White, non-Hispanic	73%	71%
Black, non-Hispanic	11%	11%
Hispanic/Latinx	12%	12%
Other, non-Hispanic	5%	6%
Educational attainment		
Low	44%	41%
Medium	31%	31%
High	26%	27%
Quantity of alcohol consumption		
Non-drinker	34%	35%
Category I	56%	55%
Category II	4%	4%
Category III	5%	5%
Pattern of alcohol consumption		
Non-drinker	34%	35%
Drinker, no HED	42%	38%
Occasional HED	10%	13%
Monthly HED	5%	6%
Weekly HED	8%	9%

Observations were replicated in accordance with their sample weight.

HED = heavy episodic drinking; NESARC = National Epidemiologic Survey of Alcohol and Related Conditions; SD = standard deviation.

TABLE 2

Annual transition probabilities (expressed as a percentage) and 95% confidence interval between drinking states, conditioned on age, sex, education and race and ethnicity

	Quantity of alcohol consumption				
		1-year follow-up			
		Non-drinker	**Category I**	**Category II**	**Category III**
Initial state	Non-drinker	90.1 (89.7, 90.5)	9.7 (9.3, 10.1)	0.2 (0.1, 0.2)	0.1 (0.0, 0.1)
	Category I	5.9 (5.7, 6.2)	90.2 (89.9, 90.5)	2.5 (2.2, 2.8)	1.3 (1.1, 1.6)
	Category II	1.2 (1.1, 1.4)	31.1 (27.5, 34.6)	31.8 (29.7, 33.9)	35.9 (31.5, 40.4)
	Category III	0.4 (0.3, 0.5)	14.8 (12.1, 17.6)	32.5 (28.7, 36.4)	52.2 (46.0, 58.5)

	Pattern of alcohol consumption					
		1-year follow-up				
		Non-drinker	**Drinker, no HED**	**Occasional HED**	**Monthly HED**	**Weekly HED**
Initial state	Non-drinker	89.7 (89.3, 90.1)	9.7 (9.3, 10.1)	0.5 (0.4, 0.5)	0.1 (0.1, 0.1)	0.0 (0.0, 0.0)
	Drinker, no HED	8.3 (8.0, 8.6)	82.4 (81.8, 82.9)	7.2 (6.7, 7.7)	1.6 (1.4, 1.8)	0.5 (0.4, 0.5)
	Occasional HED	1.5 (1.3, 1.6)	26.7 (24.8, 28.6)	45.8 (44, 47.5)	17.3 (15.5, 19.1)	8.7 (7.6, 9.9)
	Monthly HED	0.6 (0.5, 0.6)	13.5 (11.8, 15.3)	38.8 (35.1, 42.4)	22.9 (20.5, 25.2)	24.3 (20.2, 28.4)
	Weekly HED	0.1 (0.1, 0.1)	2.8 (2.4, 3.1)	14.1 (12.5, 15.7)	17.5 (14.6, 20.4)	65.5 (62.1, 68.9)

HED = heavy episodic drinking.

TABLE 3

Hazard ratios (95% confidence intervals) corresponding to the estimated effects of each covariate on the transition intensity

	Transitions to higher use			**Transitions to lower use**		
Quantity of alcohol consumption	**Non-drinker → Category I**	**Category I → Category II**	**Category II → Category III**	**Category III → Category II**	**Category II → Category I**	**Category I → Non-drinker**
Women	**0.89 (0.82, 0.96)**	**0.81 (0.72, 0.92)**	**0.22 (0.15, 0.32)**	**0.63 (0.43, 0.92)**	**0.54 (0.47, 0.62)**	**1.20 (1.11, 1.30)**
Ages 18–20 years	**6.51 (5.55, 7.64)**	**3.27 (2.45, 4.36)**	**7.50 (1.64, 34.26)**	**4.97 (1.07, 22.99)**	**1.84 (1.29, 2.63)**	**0.49 (0.39, 0.62)**
Ages 21–25 years	**3.62 (3.05, 4.30)**	**1.47 (1.09, 1.98)**	5.05 (0.61, 41.79)	4.33 (0.54, 34.71)	**1.47 (1.07, 2.02)**	**0.60 (0.51, 0.70)**
Ages 26–29 years	**2.59 (2.13, 3.14)**	1.24 (0.92, 1.66)	**10.42 (1.09, 99.79)**	**11.58 (1.23, 108.94)**	**1.44 (1.05, 1.98)**	**0.55 (0.46, 0.66)**
Ages 30–39 years	**2.85 (2.47, 3.29)**	0.99 (0.79, 1.25)	**3.14 (1.26, 7.83)**	**2.70 (1.11, 6.54)**	1.13 (0.88, 1.46)	**0.65 (0.57, 0.73)**
Ages 40–49 years	**2.22 (1.93, 2.56)**	1.17 (0.93, 1.47)	0.98 (0.59, 1.64)	0.79 (0.50, 1.26)	1.19 (0.92, 1.52)	**0.61 (0.54, 0.69)**
Ages 50–64 years	**1.56 (1.35, 1.80)**	0.95 (0.76, 1.20)	0.96 (0.57, 1.63)	0.87 (0.54, 1.40)	**0.78 (0.60, 0.99)**	**0.73 (0.65, 0.82)**
Low education	**0.76 (0.69, 0.85)**	0.98 (0.84, 1.14)	1.46 (0.94, 2.27)	1.01 (0.66, 1.55)	1.08 (0.90, 1.30)	**2.02 (1.83, 2.24)**
Medium education	**0.87 (0.78, 0.98)**	1.06 (0.91, 1.24)	**1.91 (1.18, 3.10)**	1.51 (0.95, 2.39)	1.16 (0.97, 1.38)	**1.36 (1.22, 1.52)**
Black, non-Hispanic	**0.82 (0.73, 0.92)**	**1.48 (1.17, 1.87)**	**3.10 (1.03, 9.36)**	1.95 (0.65, 5.86)	**1.71 (1.28, 2.29)**	**1.64 (1.45, 1.85)**
Hispanic/Latinx	1.02 (0.91, 1.15)	0.82 (0.65, 1.03)	4.88 (0.43, 56.02)	5.01 (0.44, 56.69)	1.24 (0.95, 1.64)	**1.69 (1.50, 1.89)**
Other, non-Hispanic	**0.69 (0.58, 0.82)**	**0.72 (0.51, 1.01)**	**0.38 (0.17, 0.84)**	**0.29 (0.12, 0.68)**	0.78 (0.51, 1.19)	**2.10 (1.77, 2.50)**

Reference groups: men, ages 65+ years, high education and non-Hispanic White.

Bold text highlights variables that showed an association with the transition.

TABLE 4

Hazard ratios (95% confidence intervals) corresponding to the estimated effects of each covariate on the transition intensity

	Transitions to higher use				Transitions to lower use			
Pattern of alcohol consumption	**Non-drinker → Drinker, no HED**	**Drinker, no HED → Occasional HED**	**Occasional → Monthly HED**	**Monthly → Weekly HED**	**Weekly → Monthly HED**	**Monthly → Occasional HED**	**Occasional HED → Drinker, no HED**	**Drinker, no HED → Non-drinker**
Women	**0.87 (0.80, 0.94)**	**0.58 (0.53, 0.64)**	0.87 (0.67, 1.13)	0.84 (0.65, 1.07)	1.23 (0.98, 1.55)	1.08 (0.83, 1.40)	0.93 (0.83, 1.04)	0.93 (0.86, 1.01)
Ages 18–20 years	**7.53 (6.31, 8.97)**	**10.8 (7.67, 15.22)**	0.92 (0.36, 2.37)	1.31 (0.63, 2.74)	0.70 (0.36, 1.37)	0.73 (0.28, 1.95)	**0.33 (0.21, 0.50)**	**1.61 (1.24, 2.09)**
Ages 21–25 years	**4.14 (3.46, 4.95)**	**6.43 (4.69, 8.81)**	**0.40 (0.21, 0.78)**	0.94 (0.47, 1.88)	0.87 (0.50, 1.51)	**0.45 (0.25, 0.83)**	**0.35 (0.25, 0.49)**	**1.47 (1.23, 1.75)**
Ages 26–29 years	**2.83 (2.32, 3.45)**	**6.53 (4.72, 9.04)**	0.53 (0.26, 1.06)	1.24 (0.59, 2.63)	0.90 (0.48, 1.67)	0.73 (0.38, 1.40)	**0.40 (0.28, 0.56)**	**1.21 (1.01, 1.45)**
Ages 30–39 years	**3.11 (2.69, 3.60)**	**4.84 (3.61, 6.49)**	**0.51 (0.26, 0.99)**	1.04 (0.53, 2.05)	0.78 (0.46, 1.35)	0.75 (0.41, 1.38)	**0.38 (0.28, 0.52)**	**1.22 (1.07, 1.39)**
Ages 40–49 years	**2.34 (2.03, 2.70)**	**2.95 (2.20, 3.95)**	0.86 (0.42, 1.74)	0.98 (0.51, 1.90)	**0.57 (0.34, 0.97)**	1.18 (0.61, 2.29)	**0.36 (0.26, 0.49)**	0.93 (0.82, 1.05)
Ages 50–64 years	**1.60 (1.39, 1.85)**	**1.84 (1.37, 2.48)**	1.42 (0.61, 3.31)	1.21 (0.60, 2.44)	0.77 (0.44, 1.37)	1.80 (0.80, 4.01)	**0.45 (0.33, 0.62)**	0.91 (0.81, 1.03)
Low education	**0.79 (0.71, 0.88)**	**1.73 (1.52, 1.96)**	**3.85 (2.60, 5.69)**	1.16 (0.79, 1.71)	**0.58 (0.41, 0.83)**	**2.81 (1.90, 4.16)**	**1.85 (1.59, 2.16)**	**2.36 (2.12, 2.62)**
Medium education	**0.89 (0.80, 1.00)**	**1.37 (1.22, 1.54)**	**2.39 (1.76, 3.25)**	1.13 (0.77, 1.65)	**0.65 (0.46, 0.92)**	**2.34 (1.73, 3.17)**	**1.34 (1.17, 1.54)**	**1.50 (1.34, 1.68)**
Black, non-Hispanic	**0.81 (0.72, 0.91)**	**0.79 (0.65, 0.97)**	**3.72 (1.04, 13.31)**	**4.59 (1.22, 17.36)**	3.21 (0.83, 12.44)	2.72 (0.72, 10.26)	**1.92 (1.50, 2.47)**	**1.26 (1.11, 1.42)**
Hispanic/Latinx	1.07 (0.95, 1.21)	1.07 (0.90, 1.26)	1.42 (0.95, 2.12)	**1.76 (1.11, 2.79)**	**1.63 (1.04, 2.55)**	1.21 (0.80, 1.83)	**1.48 (1.21, 1.80)**	**1.74 (1.54, 1.97)**
Other, non-Hispanic	**0.69 (0.58, 0.82)**	**0.64 (0.49, 0.83)**	**4.42 (1.31, 14.91)**	0.72 (0.44, 1.20)	0.83 (0.55, 1.24)	**3.30 (0.96, 11.35)**	**1.48 (1.06, 2.06)**	**1.69 (1.41, 2.02)**

Abbreviation: HED, heavy episodic drinking.

Reference groups: men, ages 65+ years, high education and non-Hispanic White.

Bold text highlights variables that showed an association with the transition.