



Short communication

Age trends in alcohol use behavior patterns among U.S. adults ages 18–65

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ABSTRACT

Introduction: Although much of the work on risky alcohol use behaviors, such as heavy drinking, focuses on adolescence and young adulthood, these behaviors are associated with negative health consequences across all ages. Existing studies on age trends have focused on a single alcohol use behavior across many ages, using methods such as time-varying effect modeling, or a single age period with many behaviors, using methods such as latent class analysis. This study integrates aspects of both modeling approaches to examine age trends in alcohol use behavior patterns across ages 18–65.

Methods: Data from the National Epidemiologic Survey on Alcohol and Related Conditions-III were used to identify past-year alcohol use behavior patterns among a nationally representative sample of U.S. adults ($n = 30,997$; 51.1% women; 63.5% White Non-Hispanic) and flexibly estimate nonlinear trends in the prevalences of those patterns across ages 18–65.

Results: Five patterns were identified: Non-Drinkers, Frequent Light Drinkers, Infrequent Heavy Episodic Drinkers, Frequent Heavy Episodic Drinkers, and Extreme Drinkers. Pattern prevalences were allowed to vary flexibly across the entire age range. Prevalences of the Infrequent Heavy Episodic and Extreme Drinkers peaked around ages 22–24, but peaked for Frequent Heavy Episodic Drinkers around age 49. Non-Drinkers were most prevalent across all ages except during the early 20s when Extreme Drinkers were more prevalent. Around ages 24–30, the Non-, Frequent Light, and Extreme Drinkers were approximately equally prevalent.

Conclusions: The approach used here holds promise for understanding characteristics associated with behavior patterns at different ages and long-term age trends in complex behaviors.

1. Introduction

Alcohol use in the U.S. remains a critical public health issue associated with injury, sexual assault, dependence, cancer, and death (National Institute on Alcohol Abuse and Alcoholism [NIAAA], 2006; Substance Abuse and Mental Health Services Administration [SAMHSA], 2015; Sacks et al., 2015; World Health Organization, 2014). Although underage drinking and college student drinking receive considerable attention due to peak rates of onset and use, these behaviors are associated with negative health consequences across all ages. Existing studies on age trends have focused on a single alcohol use behavior across many ages or a single age period with many behaviors. This study integrates aspects of both approaches to examine age trends in alcohol use behavior patterns across ages 18–65.

Alcohol use is a complex, multifaceted behavior best characterized

by simultaneously considering aspects of frequency, quantity, and intensity (Auerbach and Collins, 2006). NIAAA's and SAMHSA's definitions of low-risk drinking, binge drinking, and heavy drinking reflect aspects of all three dimensions. Latent class analysis (LCA; Collins and Lanza, 2010) is ideally suited to model multifaceted behaviors, and is commonly used to examine substance use behaviors at particular ages, including poly-tobacco use (Sutfin et al., 2014) and poly-substance use (Tomczyk et al., 2016). Several recent studies have focused on alcohol use patterns in young adulthood (Kuvaas et al., 2014; Lau-Barraco et al., 2014; Ward et al., 2013). These studies, however, have focused on a single age period or collapsed age into a small number of groups.

Existing studies on alcohol use age trends have focused on single behaviors across many ages, using methods such as growth curve modeling (e.g., Zehe and Colder, 2014) and growth mixture modeling (e.g., Capaldi et al., 2013). These approaches provide a parsimonious

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summary of change as a parametric (e.g., linear, quadratic) function of time. They have provided evidence that high-risk alcohol use behaviors increase during late adolescence, peak around ages 21–23, and then decline through adulthood (e.g., Patrick et al., 2016; White et al., 2005). Much of this work, however, has focused on adolescence and young adulthood, with less attention to middle and late adulthood. Recently, time-varying effect modeling (TVEM; Tan et al., 2012) has also been used to understand how prevalences of single substance use behaviors vary flexibly across many ages (e.g., Evans-Polce et al., 2015). A limitation of this work, however, is that these approaches assume that the outcome can be expressed as a single dimension, whether continuous (e.g., drinking consequences scale score), count (e.g., number of drinks per typical drinking occasion), or binary (e.g., any past-year heavy drinking).

The current study examines trends in the prevalences of multi-dimensional alcohol use patterns over a wide range of ages among U.S. adults. We use LCA with smoothly age-varying class proportions to estimate prevalences of alcohol use patterns as nonlinear functions of age. This approach has been used only once before, by Linden-Carmichael et al. (2018). This study will (1) identify comprehensive alcohol use behavior patterns among a nationally representative, contemporary sample of U.S. adults, and (2) estimate nuanced age trends in prevalences of those behavior patterns across ages 18–65.

2. Methods

Data were from the National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III), a cross-sectional, nationally representative sample of the civilian, non-institutionalized population of adults aged 18 years and older in the U.S., collected in 2012–2013 (Grant et al., 2014). The analysis sample ($n = 30,997$; weighted descriptives: 51.1% women; 63.5% White Non-Hispanic, 12.5% Black Non-Hispanic, 16.2% Hispanic, 7.8% other race/ethnicity) included all participants aged 18–65 years who responded to at least one indicator of alcohol use (original sample $n = 36,309$; 5310 excluded due to age > 65; 2 lost due to missing data on all indicators). Although the NESARC-III sample included participants older than age 65, this cutoff was used in order to avoid model estimation challenges with a diminishing number of participants at the oldest ages.

2.1. Measures

Five indicators of alcohol use, coded based on guidelines provided by NIAAA (2019), were used to identify behavior patterns. *Alcohol use frequency* indicated how often participants drank any alcoholic beverage in the last 12 months: frequently (once per month or more often), infrequently (less than once per month), or no use. *Typical number of drinks* indicated the number of drinks usually consumed on days when participants drank in the last 12 months: moderate or greater use (3+ / 2+ drinks for men/women) versus light or no use (0–2/0–1 drinks for men/women). *Heavy episodic drinking* (HED) indicated how often individuals drank 5+ / 4+ drinks for men/women in a single day in the last 12 months: frequently (once per month or more often), infrequently (less than once per month), or none. *Intoxication frequency* indicated how often participants drank enough to feel intoxicated in the last 12 months: frequently (once per month or more), infrequently (less than once per month), or none. *High-intensity drinking* indicated whether participants drank 10+ / 8+ drinks for men/women in a single day at least once in the last 12 months (yes/no).

2.2. Data analysis

LCA uses multiple indicators to divide a population into underlying classes (Collins and Lanza, 2010). Latent class membership probabilities represent the estimated prevalences of classes (here, alcohol use behavior patterns). The estimated probabilities of endorsing particular

responses to the indicators, conditional on class membership, are used to interpret the classes. The number of classes was chosen considering both fit criteria and theoretical interpretability; model identification of each candidate model was checked using 100 sets of starting values.

Prevalence rates of the multinomial latent class outcome (i.e., alcohol use behavior patterns) across ages 18–65 were allowed to vary flexibly across age as a continuous dimension, without dividing age into fixed categories and without assuming a simple (e.g., linear) shape for the prevalence rate trends, using higher-order polynomial regression, made feasible by the large sample size of the NESARC-III. Age was centered at 40 years to reduce correlation between the polynomial terms. Measurement invariance across ages was assumed to maintain consistent interpretations of the alcohol use behavior patterns. Sampling weights were used in all models to ensure that the age trends were representative of the population of U.S. adults aged 18–65. Models were estimated using PROC LCA (Lanza et al., 2015) in SAS 9.4.

3. Results

Models with 1–7 classes were considered. Penalized fit criteria (e.g., AIC, BIC) continued to improve with increasing numbers of classes (e.g., 2-class BIC = 13939, 5-class BIC = 1076, 7-class BIC = 667). However, parameter estimate identifiability, as measured by percent agreement across multiple sets of random starting values, steadily declined with increasing numbers of classes (e.g., 2-class = 100%, 5-class = 7%, 6-class = 1%), becoming unacceptably low for the 6- and 7-class models. Furthermore, the 6-class model contained two classes with redundant substantive interpretations. Therefore, the 5-class model was selected for interpretation and further analysis. Then, functions of age were added as covariates to this model; based on successive significance testing of the high-order terms, a 6th degree polynomial (i.e., age, age², ..., age⁶ after centering age at 40) was selected.

Table 1 shows parameter estimates from the 5-class model with the polynomial age terms included during estimation. Class 1 members (*Non-Drinkers*) typically did not use any alcohol in the past year, and none engaged in heavier use. Class 2 members (*Frequent Light Drinkers*) reported frequent alcohol use but low levels of use on typical drinking days. Class 3 members (*Infrequent Heavy Episodic Drinkers*) reported frequent alcohol use with infrequent HED and intoxication. Class 4 members (*Frequent Heavy Episodic Drinkers*) likely engaged in HED at least monthly. Class 5 members (*Extreme Drinkers*) reported frequent HED and intoxication and high-intensity drinking. Overall class prevalences and for females and males, collapsed across ages, are shown in Table 1: males were less likely to be Non- and Frequent Light Drinkers, approximately equally likely to be Infrequent Heavy Episodic Drinkers, and more likely to be Frequent Heavy Episodic and Extreme Drinkers.

Fig. 1 shows age-varying trends in class prevalences and corresponding 95% pointwise confidence intervals. For any particular age, the prevalences sum to 100%. Prevalence of Non-Drinkers decreased rapidly with age from 60% to 22% across ages 18–24 but then increased steadily throughout adulthood to a peak prevalence of 64% at age 65. Prevalence of Extreme Drinkers showed the opposite trend, increasing rapidly from 15% to 32% across ages 18–22, peaking at age 22, dropping rapidly with age in young adulthood, and then decreasing steadily to 1% at age 65. Prevalence of Frequent Light Drinkers increased gradually from 14% at age 18 to 32% at age 60, then decreased to 25% at age 65. Prevalence of Infrequent Heavy Episodic Drinkers increased rapidly from 10% at age 18 to peak at 18% at age 24, then decreased steadily to 3% across ages 24–65. Finally, prevalence of Frequent Heavy Episodic Drinkers increased gradually from 1% at age 18 to 11% at age 31 and was between 7% and 12% for adults aged 31 and older; peak prevalence was 12% at age 49.

Non-Drinkers were the most prevalent across all ages, except in the early 20s when the Extreme Drinkers were significantly more prevalent. The Frequent Light Drinkers were the next most prevalent across

Table 1
Parameter estimates for the 5-class model of past-year alcohol use behaviors, ages 18–65 (unweighted $n = 36,309$).

		Non- Drinkers	Frequent Light Drinkers	Infrequent Heavy Episodic Drinkers	Frequent Heavy Episodic Drinkers	Extreme Drinkers
<i>Average Class Prevalences (collapsing across ages)</i>						
Overall		0.39	0.27	0.11	0.09	0.13
For Females		0.42	0.30	0.11	0.08	0.09
For Males		0.36	0.25	0.12	0.11	0.17
<i>Class-Specific Item Response Probabilities</i>						
Item	Response					
Alcohol use frequency	No Use	0.61	0.00	0.00	0.00	0.00
	Infrequent	0.25	0.31	0.26	0.00	0.00
	Frequent	0.14	0.69	0.74	1.00	1.00
Typical no. of drinks	None/Light	1.00	0.54	0.24	0.13	0.04
	Moderate/Heavy	0.00	0.46	0.76	0.87	0.96
	None	1.00	0.85	0.00	0.00	0.00
Heavy episodic drinking frequency	Infrequent	0.00	0.15	1.00	0.08	0.02
	Frequent	0.00	0.00	0.00	0.92	0.98
	None	1.00	0.67	0.16	0.41	0.00
Intoxication frequency	Infrequent	0.00	0.28	0.78	0.49	0.36
	Frequent	0.00	0.05	0.06	0.11	0.64
	No	1.00	1.00	0.76	0.71	0.26
High-intensity drinking	Yes	0.00	0.00	0.24	0.29	0.74

Note: Item-response probabilities greater than 0.50 appear in bold to facilitate interpretation.

all ages, again except for the early 20 s. Around ages 24-30, confidence intervals suggest that the Non-Drinkers, Frequent Light Drinkers, and Extreme Drinkers were approximately equally prevalent with about one-fourth of the population in each. For adults ages 30–53, the prevalence of the Extreme Drinkers class was not significantly different from that of the Infrequent Heavy Episodic Drinkers or Frequent Heavy Episodic Drinkers.

4. Discussion

Previous studies on alcohol use behaviors have had to focus on either (1) a single alcohol use behavior across age periods, such as with growth curve modeling or TVEM, or (2) a single age period with multiple behaviors, such as with traditional LCA. This study integrated the strengths of each approach, reflecting both the complexities of behavior and long-term age trends. Although the alcohol use behavior patterns identified in this study are similar to those reported previously using other U.S. adult samples (e.g., Auerbach and Collins, 2006; Linden-Carmichael et al., 2017; Lee et al., 2013; Sacco et al., 2009), these studies focused on a single age period or collapsed age into a small number of groups.

Two classes, Non-Drinkers and Frequent Light Drinkers, represent patterns that comprise low-risk behavior. Infrequent and Frequent Heavy Episodic Drinkers may be considered higher risk. The final class,

Extreme Drinkers, was characterized by high-intensity drinking, a high-risk behavior that can result in severe, life-threatening levels of impairment (Hingson and White, 2013; Patrick et al., 2016). Notably, the prevalence of Extreme Drinkers decreases rapidly after the early 20’s and the prevalence of Non-Drinkers increases. These findings are consistent with those of Patrick et al. (2016) and White et al. (2005). Prevalences of classes with intermediate drinking intensity remained stable or declined gradually across most of adulthood.

Interestingly, 41% of individuals in the Frequent Heavy Episodic Drinkers class reported never feeling intoxicated and only 11% reported frequently feeling intoxicated despite frequent HED, which is likely to result in impairment. In contrast, Infrequent Heavy Episodic Drinkers and Extreme Drinkers reported feelings of intoxication more in line with their drinking. This merits further study, including possible acute tolerance to alcohol among frequent binge drinkers (Fillmore and Weafer, 2012) and possible simultaneous use of other substances, such as marijuana, that might affect perceived intoxication (Lee et al., 2017).

4.1. Limitations

This study used cross-sectional data, which limits our ability to disentangle the effects of age and historical cohort; the age-varying trends presented here do not necessarily represent within-person change over time. A second limitation was the assumption of

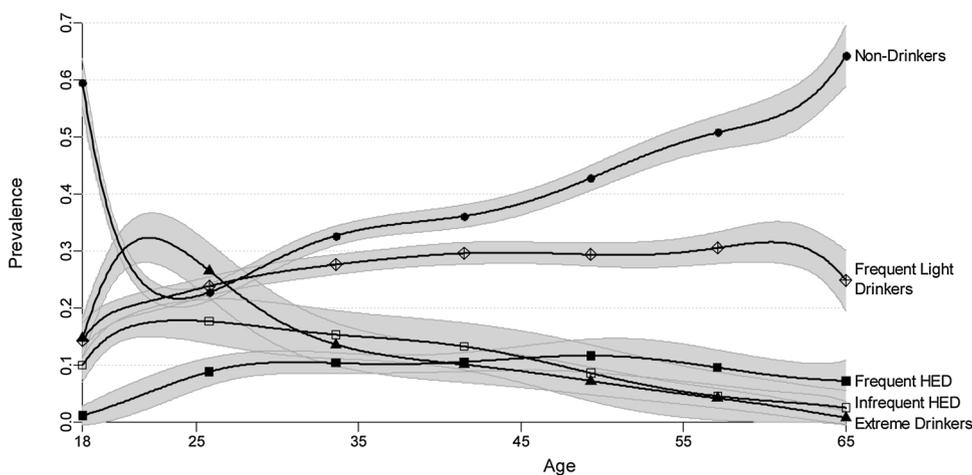


Fig. 1. Fitted latent class prevalences across ages 18–65 for the five past-year alcohol use behavior patterns; HED = heavy episodic drinking. Lines for the classes are marked with the following shapes: Non-Drinkers = filled circles, Frequent Light Drinkers = unfilled diamonds, Infrequent HED = unfilled squares, Frequent HED = filled squares, and Extreme Drinkers = filled triangles. The highest prevalences for the classes corresponded to the following ages in years: Non-Drinkers = 65.0, Frequent Light Drinkers = 60.4, Infrequent HED = 24.1, Frequent HED = 49.1, and Extreme Drinkers = 22.1.

measurement invariance in order to ensure that classes have the same interpretation across all ages. To evaluate the plausibility of this assumption, we conducted model selection separately for three age groups (18–25, 25–58, 58–65), as well as overall with age group included as a grouping variable; the identified classes presented here had consistent interpretations across subsamples.

4.2. Conclusion

The approach used here allowed us to examine nuanced age trends in prevalences of alcohol use behavior patterns using a nationally representative, contemporary sample of U.S. adults aged 18–65, and holds promise to identify age-specific risk factors for complex addictive behavior patterns. This approach could be applied to a variety of behaviors (e.g., Linden-Carmichael et al., 2018) to shed new light on their age-varying prevalences and correlates.

Author note

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Contributors

Bethany C. Bray and Stephanie T. Lanza obtained funding for the research and conceptualized the study. Bethany C. Bray conducted the statistical analyses and John J. Dziak assisted with the statistical analyses. All authors contributed to the writing and editing of the article, which was led by Bethany C. Bray. All authors have approved the final article.

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Declaration of Competing Interest

None.

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References

Auerbach, K.J., Collins, L.M., 2006. A multidimensional developmental model of alcohol

- use during emerging adulthood. *J. Stud. Alcohol* 67, 917–925.
- Capaldi, D.M., Feingold, A., Kim, H.K., Yoerger, K., Washburn, L.J., 2013. Heterogeneity in growth and desistance of alcohol use for men in their 20s: prediction from early risk factors and association with treatment. *Alcohol. Clin. Exp. Res.* 37, E347–E355.
- Collins, L.M., Lanza, S.T., 2010. *Latent Class and Latent Transition Analysis: with Applications in the Social, Behavioral, and Health Sciences*. John Wiley and Sons, Hoboken, NJ.
- Evans-Polce, R.J., Vasilenko, S.A., Lanza, S.T., 2015. Changes in gender and racial/ethnic disparities in rates of cigarette use, regular heavy episodic drinking, and marijuana use: ages 14 to 32. *Addict. Behav.* 41, 219–222.
- Fillmore, M.T., Weafer, J., 2012. Acute tolerance to alcohol in at-risk binge drinkers. *Psychol. Addict. Behav.* 26, 693–702.
- Grant, B.F., Chu, A., Sigman, R., Amsbary, M., Kali, J., Sugawara, Y., Jiao, R., Ren, W., Goldstein, R., 2014. Source and Accuracy Statement: National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III). NIAAA, Rockville, MD.
- Hingson, R.W., White, A., 2013. Trends in extreme binge drinking among US high school seniors. *JAMA Pediatr.* 167, 996–998.
- Kuvaas, N.J., Dvorak, R.D., Pearson, M.R., Lamis, D.A., Sargent, E.M., 2014. Self-regulation and alcohol use involvement: a latent class analysis. *Addict. Behav.* 39, 146–152.
- Lanza, S.T., Dziak, J.J., Huang, L., Wagner, A., Collins, L.M., 2015. PROC LCA and PROC LTA Users' Guide (Version 1.3.2). The Methodology Center, Penn State, University Park, PA. Retrieved from <http://methodology.psu.edu> accessed on 2/27/2017.
- Lau-Barraco, C., Millettich, R.J., Linden, A.N., 2014. Caffeinated alcohol consumption profiles and associations with use severity and outcome expectancies. *Addict. Behav.* 39, 308–315.
- Lee, C.M., Cadigan, J.M., Patrick, M.E., 2017. Differences in reporting of perceived acute effects of alcohol use, marijuana use, and simultaneous alcohol and marijuana use. *Drug Alcohol Depend.* 180, 391–394.
- Lee, M.R., Chassin, L., Villalta, I.K., 2013. Maturing out of alcohol involvement: transitions in latent drinking statuses from late adolescence to adulthood. *Dev. Psychopathol.* 25, 1137–1153.
- Linden-Carmichael, A.N., Dziak, J.J., Lanza, S.T., 2018. Dynamic features of problematic drinking: alcohol use disorder latent classes across ages 18–64. *Alcohol Alcohol.* 54, 97–103.
- Linden-Carmichael, A.N., Lanza, S.T., Dziak, J.J., Bray, B.C., 2017. Contemporary alcohol use patterns among a national sample of U.S. adult drinkers. *J. Addict. Dis.* 36, 222–226.
- National Institute on Alcohol Abuse and Alcoholism (NIAAA), 2006. Alcohol Alert no. 67: Underage Drinking. Rockville, MD: NIAAA. Retrieved from <https://pubs.niaaa.nih.gov/publications/AA67/AA67.htm> Accessed on 2/27/17.
- National Institute on Alcohol Abuse and Alcoholism (NIAAA), n.d. Recommended alcohol questions. Rockville, MD: NIAAA. Retrieved from <http://www.niaaa.nih.gov/research/guidelines-and-resources/recommended-alcohol-questions>; accessed on 2/27/17.
- Patrick, M.E., Terry-McElrath, Y.M., Kloska, D.D., Schulenberg, J.E., 2016. High-intensity drinking among young adults in the United States: prevalence, frequency, and developmental change. *Alcohol. Clin. Exp. Res.* 40, 1905–1912.
- Sacco, P., Bucholz, K.K., Spitznagel, E.L., 2009. Alcohol use among older adults in the National Epidemiologic Survey on Alcohol and Related Conditions: a latent class analysis. *J. Stud. Alcohol Drugs* 70, 829–838.
- Sacks, J.J., Gonzales, K.R., Bouchery, E.E., Tomedi, L.E., Brewer, R.D., 2015. 2010 national and state costs of excessive alcohol consumption. *Am. J. Prev. Med.* 49, e73–e79.
- Substance Abuse and Mental Health Services Administration (SAMHSA), 2015. Results from the 2015 National Survey on Drug Use and Health (NSDUH): Detailed Tables. SAMHSA, Rockville, MD. Retrieved from <https://www.samhsa.gov/data/sites/default/files/NSDUH-DET-Tabs-2015/NSDUH-DET-Tabs-2015/NSDUH-DET-Tabs-2015.htm#tab2-46b> Accessed on 2/27/17.
- Sutfin, E.L., Song, E.Y., Reboussin, B.A., Wolfson, M., 2014. What are young adults smoking in their hookahs? A latent class analysis of substances smoked. *Addict. Behav.* 39, 1191–1196.
- Tan, X., Shiyko, M., Li, R., Li, Y., Dierker, L., 2012. A time-varying effect model for intensive longitudinal data. *Psychol. Methods* 17, 61–77.
- Tomczyk, S., Pedersen, A., Hanewinkel, R., Isensee, B., Morgenstern, M., 2016. Polysubstance use patterns and trajectories in vocational students—a latent transition analysis. *Addict. Behav.* 58, 136–141.
- Ward, R.M., Cleveland, M.J., Messman-Moore, T.L., 2013. Latent class analysis of college women's Thursday drinking. *Addict. Behav.* 38, 1407–1413.
- White, H.R., Labouvie, E.W., Papadaratsakis, V., 2005. Changes in substance use during the transition to adulthood: a comparison of college students and their non-college age peers. *J. Drug Issues* 35, 281–306.
- World Health Organization (WHO), 2014. *Global Status Report on Alcohol and Health*. WHO, Geneva, Switzerland. Retrieved from http://www.who.int/substance_abuse/publications/global_alcohol_report/msb_gsr_2014_1.pdf?ua=1 accessed on 2/27/17.
- Zehe, J.M., Colder, C.R., 2014. A latent growth curve analysis of alcohol-use specific parenting and adolescent alcohol use. *Addict. Behav.* 39, 1701–1705.