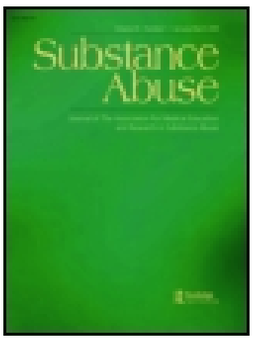

Substance Abuse

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ORIGINAL RESEARCH



# Alcohol and drug use among deaf and hard-of-hearing individuals: A secondary analysis of NHANES 2013–2014

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**ABSTRACT**

*Background*: Within the field of behavioral health research, one of the most understudied populations is the US deaf and hard-of-hearing (D/HH) population—a diverse group of individuals with hearing loss that have varied language and communication preferences, community affiliations, and sociocultural norms. Recent research identified concerning behavioral health disparities experienced by the D/HH population; yet, little research has been conducted to extend these findings to the topic of substance use disorder. *Methods*: To begin to fill this gap, the authors conducted a secondary analysis of data from the 2013–2014 administration of the National Health and Nutrition Examination Survey, comparing alcohol and drug use between participants based on their reported hearing status, i.e., D/HH or hearing. *Results*: Findings suggest that the overall lifetime prevalence of alcohol and drug use does not differ based on hearing status, and that D/HH and hearing adolescents begin using cannabis on a similar timeline. However, findings also revealed that D/HH respondents were more likely to have been regular cannabis users and heavy alcohol users than hearing respondents. In other words, when D/HH individuals use substances, they tend to be heavy users. *Conclusions*: These findings stress the importance of directing resources to the prevention and treatment of heavy alcohol use in the D/HH population, given that binge drinking is associated with a number of health problems and social consequences. Additionally, the continuation of this empirical work is rather urgent given recent legislative changes regarding cannabis use. D/HH individuals possess a number of risk factors for substance use disorder and, as such, may be more greatly impacted by these legislative changes than individuals from the general US population. It is imperative that this impact be captured by future research efforts in order to inform the development of prevention and intervention efforts for the traditionally underserved D/HH population.

**KEYWORDS**
Alcohol use; deaf; drug use; hard-of-hearing; substance use disorder

## Introduction

Within the field of behavioral health research, one of the most understudied populations is the US deaf and hard-of-hearing (D/HH) population—a group of individuals with hearing loss that have varied language and communication preferences (i.e., spoken English, American Sign Language [ASL]), community affiliations (i.e., general population, culturally deaf community), and sociocultural norms. Recent research employing an ASL public health survey identified concerning disparities experienced by the D/HH population—compared with the general population, D/HH individuals were more likely to be obese (34.2% vs. 26.6%), to have attempted suicide in the past year (2.2% vs. 0.4%), and to have experienced physical abuse (21.0% vs. 13.9%) and forced sex (20.8% vs. 5.8%).[1]

The findings from this groundbreaking study suggest that behavioral health conditions may be more prevalent among D/HH individuals than hearing individuals; yet, little research has been conducted to follow up on these findings or to extend these findings to the topic of substance use disorder (SUD). Although there is consensus among deaf-behavioral health clinicians that an increase in accessible mental health and SUD services is desperately needed, without further research, there is insufficient evidence to justify the establishment of such specialized services.[2]

Moreover, given recent changes in legislation regarding the use of particular substances (e.g., legalization of recreational cannabis in Colorado, Oregon, Massachusetts, and other states), it is imperative that we gain a better understanding of the rates and patterns of substance use within the underserved US D/HH population. Many D/HH people present with significant behavioral health literacy gaps that drive perception of low risk of substance use.[3–6] Low health literacy is caused by limited language access during key developmental periods and "a lifetime of limited access to information that is often considered common knowledge among hearing persons."[7] For example, many D/HH individuals do not know the meaning of *substance*, do not recognize cannabis as a *substance*, and believe that smoking cannabis is a fully natural, safe alternative to traditional prescription medications.[6] Very few are aware of reported effects of regular cannabis use—e.g., increased risk of respiratory problems, cardiovascular disease, activation of mood or psychotic disorders.[8,9] Such disparities in behavioral

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health literacy make the D/HH population especially vulnerable to further increases in cannabis use following legislative changes, and the behavioral health system is currently unprepared to deliver accessible services to meet potential increases in demand.[6,10,11]

### SUD and the D/HH population

Overall, individuals with disabilities report higher rates of alcohol and drug use disorder than nondisabled individuals,[10,12] with SUD rates approximately double to the general population.[10] Increased risk for developing SUD may be related to chronic medical difficulties, lack of access to services and resources, unemployment, isolation, perceived discrimination, and level of disability acceptance.[13,14]

In addition to the potential influence of the disability-related factors noted above, it has been suggested that D/HH individuals may be at increased risk for SUD due to a number of factors unique to being a D/HH person in a hearing majority world—limited communication with hearing parents; reduced opportunities for family discussion and incidental learning regarding the consequences of substance use; isolation from and subsequent desire to fit in with hearing peers in mainstream school settings; and the lack of prevention materials provided in ASL or D/HH-accessible formats.[15]

One of the first attempts to estimate SUD in the D/HH population, a 1980 report by the National Institute on Drug Abuse (NIDA), concluded that approximately 206,200 D/HH people have experienced SUD.[16] Broken down by substance, they estimated a national prevalence of 8500 D/HH individuals with heroin use disorder, 14,700 with cocaine use disorder, 73,000 with alcohol use disorder, and 110,000 with cannabis use disorder—rates not wholly dissimilar from the general population.[17] This finding is corroborated by studies with D/HH adolescents, which also describe lifetime rates of drug and alcohol use that are largely similar to hearing youth and, depending on the particular substance, even lower for D/HH youth.[18]

Yet, these findings conflict with the literature on individuals with disabilities, as well as the general consensus among most deaf-behavioral health clinicians—"most professionals familiar with substance abuse and deafness identify a level of substance abuse that is *at least equal to* the traditional field estimate of 8% to 10% in the general population."[19] The discrepancy in prevalence rates may, therefore, exist due to a number of methodological issues present in the current literature on SUD in the D/HH population, as described below.

### State of the deaf SUD literature

The primary obstacle to estimating rates of SUD within the US D/HH population has been researchers' use of recruitment, sampling, and data collection procedures that are inaccessible to ASL users and other individuals with hearing loss.[7,20,21] For example, one of the most common methods for collecting national health data—random-digit-dial surveys—fails to sample deaf ASL users, who use videophones rather than standard telephone technology, and may also not be an effective method for collecting data from individuals with hearing loss who use spoken language.

Even in-person studies, such as the National Comorbidity Study Replication, often sample only English users and make no documentation of accommodations for D/HH individuals.[25] When D/HH individuals *are* included in these general population studies, a common misstep is the failure to provide ASL interpreters or other accommodations for hearing loss. Without these accommodations, the explanation of research procedures, process of obtaining informed consent, and data collection occur without guarantee of effective communication, seriously calling into question the reliability of the data and the ethical conduct of the researchers.[23]

In addition to language access concerns, available epidemiological surveys apply inadequate and inconsistent measures of disability as a key diversity variable.[21] Therefore, even when D/HH individuals or individuals with disabilities participate in general population research, information about their hearing status or disability status is not captured in a way that allows for useful comparison between groups. One example, a study by Buss and Cramer[24] reported higher rates of alcoholism among persons with disabilities, including D/HH individuals, than the general population; however, because the group of D/HH individuals was not analyzed separately from other individuals with disabilities, we are unable to draw any conclusions about D/HH individuals' alcohol use disorder compared with the general population.

### Study objectives and hypotheses

To begin to fill the gap in D/HH SUD literature, we conducted a secondary analysis of data from the 2013–2014 administration of the National Health and Nutrition Examination Survey (NHANES), comparing alcohol and drug use between participants based on their reported hearing status (i.e., D/HH, hearing). Drawing on observations from deaf-behavioral health clinicians as well as the literature on individuals with disabilities, we made the following hypotheses:

1. Lifetime rates of alcohol and drug use (i.e., "ever use") would be higher for D/HH participants than hearing participants.
2. Age of first drug use and age of initiation of regular drug use would be earlier for D/HH participants than hearing participants.
3. Frequency and quantity of alcohol and drug use would be higher for D/HH participants than hearing participants.

## Methods

### Data set

Study data were downloaded from the publicly available NHANES 2013–2014 data set (https://wwwn.cdc.gov/nchs/nhanes/continuousnhanes/Overview.aspx?BeginYear=2013), which was the most current data at the time of our analysis. Our secondary analysis did not require institutional review board (IRB) approval, as the publicly available data set did not include respondents' identifying information and the definition of "human subject" research in 45 CFR 46.102(f) includes only "living individuals about whom an investigator obtains identifiable private information for research purposes."

One of the objectives of NHANES is to estimate the number and percentage of persons in the US population, and in designated subgroups, with particular diseases or disease risk factors. NHANES uses a complex, multistage probability design to sample the civilian, noninstitutionalized population residing in the 50 states and Washington, DC. Every year, approximately 5000 individuals of all ages are interviewed in their homes and complete the health examination in a mobile examination center.

The NHANES survey includes a number of questionnaires. We analyzed data collected from the Demographics Questionnaire, Disability Questionnaire, Alcohol Use Questionnaire, and Drug Use Questionnaire. Of note, the Alcohol Use Questionnaire was administered to participants aged 12 years and older; however, only the data for participants aged 18 years and older are publicly available. Additionally, the Drug Use Questionnaire was administered to participants aged 12 to 69 years, but many questions were posed only to participants aged 12 to 59 years. As such, in our analyses, we included data only from those participants aged 18 to 59 years ($N = 4139$) in order to draw conclusions from a uniformly aged sample.

## Study variables

### Hearing status

To define our particular subgroup, we used the following question from the Disability Questionnaire: "Are you deaf or do you have serious difficulty hearing?" Individuals who responded *yes* to this item were placed in the deaf/hard-of-hearing (D/HH) subgroup, whereas those who responded *no* were placed in the hearing subgroup.

We determined this variable to be the *best available* in this data set to serve as a proxy for hearing status. However, we recognize that such a classification system does not clearly delineate between culturally Deaf ASL users (i.e., individuals who are born into the Deaf community and whose first language is ASL) and other individuals with hearing loss who do not identify as part of the Deaf community, nor does the data set include additional information that could help us make such delineations (e.g., type and severity of hearing loss, age of onset of hearing loss, primary/preferred language). Additional considerations of this limitation can be found in Discussion.

### Demographic characteristics

The following variables were extracted from the Demographics Questionnaire and included as covariates in our analyses: age (*in years*); gender (*male/female*); race (*White*, *Black/African American*, or *Other*); and education (*<12th grade*, *high school/GED/some college*, or *college graduate or higher*).

### Alcohol use

Using items from the Alcohol Use Questionnaire and accounting for skip patterns in survey administration, we analyzed the following alcohol-related variables: lifetime alcohol use (*yes/no*; ≥12 drinks in lifetime); consumption of at least 12 alcoholic beverages in any 1 year (*yes/no*); number of days respondent consumed alcohol in the past 12 months; total number of drinks consumed in the past 12 months; and heavy alcohol use (*yes/no*; "Was there ever a time or times in your life when you consumed 4 or more (for women)/5 or more (for men) drinks of any kind of alcoholic beverage per day almost every day?"). See Figure 1 for detailed information about derivation of alcohol-related study variables. Across these variables, less than 10% of data were missing.

### Drug use

Using items from the Drug Use Questionnaire and accounting for skip patterns in survey administration, we created

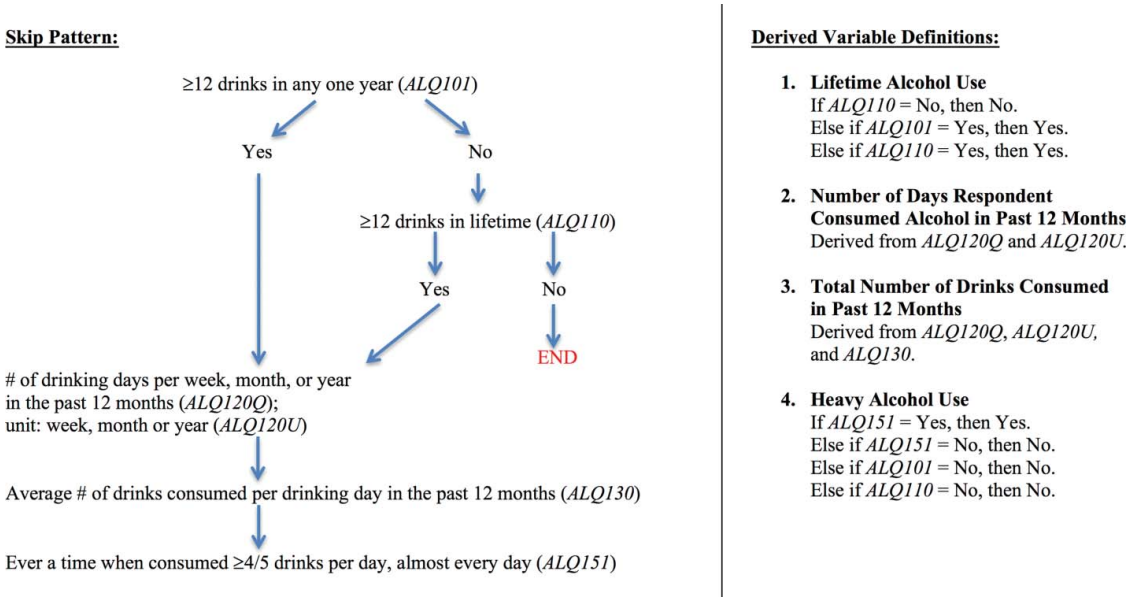


**Figure 1.** Alcohol-related variable derivations based on skip patterns in the NHANES 2013–2014 Alcohol Use Questionnaire.

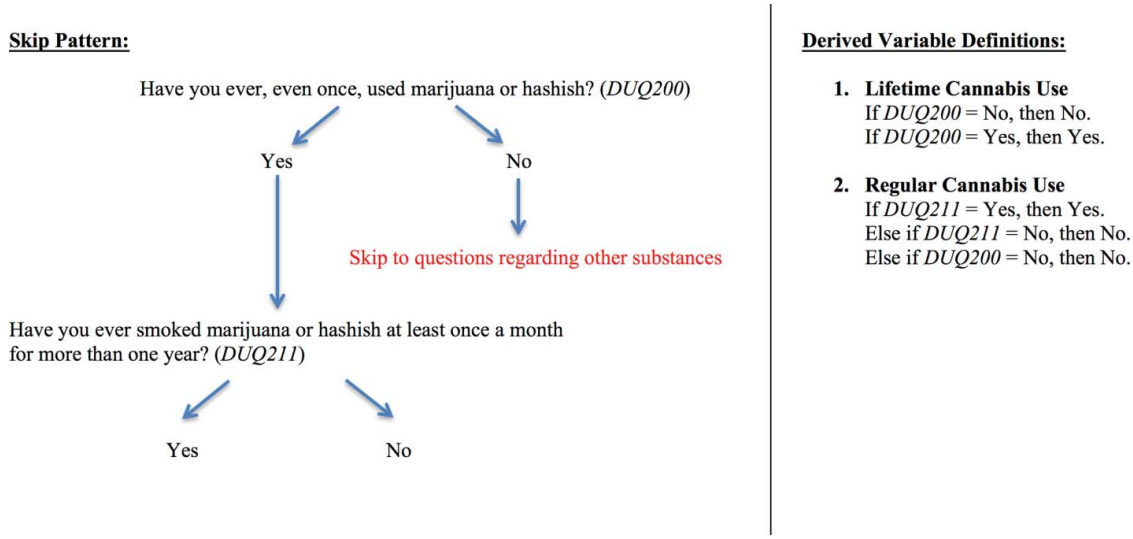


**Figure 2.** Cannabis-related variable definitions based on skip patterns in the NHANES 2013–2014 Drug Use Questionnaire.

the following drug-related variables: lifetime cannabis use (*yes/no*); regular cannabis use (*yes/no*; "Have you ever smoked cannabis or hashish at least once a month for more than 1 year?"); age when respondent first tried cannabis (*in years*); age when respondent started regularly using cannabis (*in years*); and lifetime drug use (*yes/no*; i.e., ever use of cocaine, crack cocaine, heroin, methamphetamine, or injection drug). We focused primarily on cannabis use because of low rates of use for each of the other drugs. See Figure 2 for detailed information about derivation of cannabis-related study variables. There were less than 11% missing data across drug-related variables.

### Statistical analyses

Per NHANES analytical guidelines, we applied survey sample weights (2-year) to account for complex survey design in our analysis (https://www.cdc.gov/nchs/nhanes/analyticguidelines.aspx). We included only those subjects with complete data in the analysis. With missing data of less than 11%, such an approach is not likely to influence the validity of our results.[25]

We compared the D/HH and hearing subgroups on demographic characteristics (*age*, *gender*, *race*, and *education*) using Rao-Scott modified chi-square test (for categorical variables) and *t* test (for continuous variables). The comparisons between the 2 subgroups on rates of alcohol use (lifetime use and heavy use) and drug use (lifetime use and regular use) were performed first using Rao-Scott modified chi-square test without adjusting for any covariates, and then using logistic regression to adjust for the 4 demographic characteristics noted above. The frequency and amount of alcohol consumption in the past 12 months, as well as the age of first cannabis use and age of regular cannabis use, were compared between the 2 subgroups, first using *t* test without adjusting for any covariates and then using linear regression analysis to adjust for the 4 demographic characteristics described above.

All analyses were conducted using survey procedures in SAS software, version 9.3 (copyright 2011; SAS Institute, Cary, NC, USA). We report *P* values in the tables for all unadjusted comparisons, with $P < .05$ indicating a statistically significant difference.

## Results

### Sample characteristics

One hundred thirty-three survey respondents identified themselves as D/HH, approximately 3.3% of the overall sample after applying sample weights. As can be seen in Table 1, compared with the hearing subgroup, D/HH respondents were older (mean age: 44 vs. 38 years, $P < .001$), more likely to be male (63% vs. 49%, $P = .009$), and more likely to be non-Hispanic white (70% vs. 61%, $P = .032$). Education levels were similar between the 2 subgroups.

### Alcohol use

More than three quarters of the D/HH and hearing subgroups were lifetime alcohol users, with a similar percentage of respondents reporting that they had consumed at least 12 drinks in any year (Table 2). The number of days of alcohol consumption and total number of drinks consumed during the past 12 months were also not significantly different between the 2 subgroups (Table 2).

The percentage of heavy alcohol users among D/HH respondents was nearly 3 times that of hearing respondents (33% vs. 12%, $P = .002$; Table 2). Logistic regression results indicated that, even after adjusting for age, gender, race, and education, D/HH respondents were more likely to report heavy alcohol use than their hearing counterparts (adjusted odds ratio [OR] = 2.5, 95% confidence interval [CI] = 1.51–4.20, $P = .0004$).

### Drug use

A similar percentage of D/HH and hearing respondents endorsed lifetime cannabis use and lifetime use of other drugs

**Table 1.** Descriptive statistics for D/HH and hearing respondents (18–59 years old), NHANES 2013–2014.

| | D/HH ($n = 133$) | | | Hearing ($n = 4006$) | | | |
|---|---|---|---|---|---|---|---|
| Variable | *n* | Weighted *n* | % | *n* | Weighted *n* | % | $P^a$ |
| Gender | | | | | | | |
| Male | 78 | 3,689,289 | 63.08 | 1897 | 82,849,614 | 48.65 | .009 |
| Female | 55 | 2,159,373 | 36.92 | 2109 | 87,439,857 | 51.35 | |
| Race | | | | | | | |
| White | 71 | 4,096,539 | 70.04 | 1548 | 103,975,179 | 61.06 | .032 |
| Black/African American | 20 | 537,450 | 9.19 | 828 | 21,113,349 | 12.40 | |
| Other | 42 | 1,214,674 | 20.77 | 1630 | 45,200,943 | 26.54 | |
| Education level | | | | | | | |
| <12th grade | 32 | 989,388 | 16.92 | 826 | 26,977,708 | 15.85 | .225 |
| HS/GED/some college | 83 | 3,627,189 | 62.02 | 2198 | 93,330,549 | 54.83 | |
| ≥College graduate | 18 | 1,232,085 | 21.07 | 980 | 49,910,362 | 29.32 | |
| | *n* | Mean | SE | *n* | Mean | SE | $P^b$ |
| Age at screening (in years) | 133 | 44.33 | 1.10 | 4006 | 38.18 | 0.30 | <.001 |

[a]Rao-Scott modified chi-square test.
[b]*t* test.

**Table 2.** Alcohol use variables for D/HH and hearing respondents (18–59 years old), NHANES 2013–2014.

| | D/HH ($n = 133$) | | | Hearing ($n = 4006$) | | | |
|---|---|---|---|---|---|---|---|
| Variable | $n^a$ | Weighted *n* | % | $n^a$ | Weighted *n* | % | $P^b$ |
| Lifetime alcohol use | | | | | | | |
| Yes | 108 | 4,862,777 | 87.86 | 2993 | 135,477,572 | 86.46 | .650 |
| No | 18 | 672,013 | 12.14 | 628 | 21,208,359 | 13.54 | |
| ≥12 alcoholic beverages in any 1 year | | | | | | | |
| Yes | 93 | 4,398,101 | 79.46 | 2593 | 121,668,003 | 77.78 | .432 |
| No | 33 | 1,136,690 | 20.54 | 1024 | 34,767,730 | 22.22 | |
| Heavy alcohol use[d] | | | | | | | |
| Yes | 36 | 1,825,725 | 32.99 | 429 | 19,338,880 | 12.35 | .002 |
| No | 90 | 3,709,066 | 67.01 | 3190 | 137,299,905 | 87.65 | |
| | *n* | Mean | SE | *n* | Mean | SE | $P^c$ |
| Number of days of alcohol consumption in past 12 months | 108 | 76.34 | 10.56 | 2992 | 65.71 | 3.51 | .380 |
| Total number of drinks in past 12 months | 90 | 358.69 | 77.69 | 2594 | 235.30 | 13.21 | .131 |

[a]*n* does not add up to the total number due to missing data.
[b]Rao-Scott modified chi-square test.
[c]*t* test.
[d]Heavy alcohol use is defined as ever having 4/5 or more drinks per day almost every day for female/male.

**Table 3.** Cannabis and other drug use variables for D/HH and hearing respondents (18–59 years old), NHANES 2013–2014.

| | D/HH ($n = 133$) | | | Hearing ($n = 4006$) | | | |
|---|---|---|---|---|---|---|---|
| Variable | $n^a$ | Weighted *n* | % | *n* | Weighted *n* | % | $P^c$ |
| Lifetime cannabis use | | | | | | | |
| Yes | 73 | 3,427,683 | 62.88 | 1918 | 91,457,930 | 59.04 | .265 |
| No | 48 | 2,023,488 | 37.12 | 1651 | 63,447,500 | 40.96 | |
| Regular cannabis use[b] | | | | | | | |
| Yes | 45 | 1,949,636 | 35.77 | 908 | 41,282,003 | 26.68 | .007 |
| No | 76 | 3,501,535 | 64.23 | 2657 | 113,460,449 | 73.32 | |
| Lifetime drug use | | | | | | | |
| Yes | 28 | 1,253,994 | 23.00 | 586 | 28,667,942 | 18.49 | .343 |
| No | 93 | 4,197,177 | 77.00 | 2984 | 126,351,496 | 81.51 | |
| | *n* | Mean | SE | *n* | Mean | SE | $P^d$ |
| Age first tried cannabis | 73 | 16.12 | 0.60 | 1916 | 17.29 | 0.11 | .090 |
| Age started regularly using cannabis | 45 | 16.43 | 0.72 | 907 | 17.70 | 0.19 | .101 |

[a]*n* does not add up to the total number due to missing data.
[b]Regular cannabis use is defined as ever using cannabis or hashish 1 time or more per month for more than 1 year.
[c]Rao-Scott modified chi-square test.
[d]*t* test.

(Table 3). Although D/HH respondents reported first use of cannabis (mean age: 16.1 vs. 17.3 years; Table 3) and regular use of cannabis (mean age: 16.4 vs. 17.7 years; Table 3) more than 1 year earlier than hearing respondents, these differences were not statistically significant at the $P < .05$ level (Table 3). This conclusion remained after adjusting for demographic characteristics.

A significantly higher percentage of D/HH respondents endorsed regular cannabis use compared with their hearing counterparts (36% vs. 27%, $P = .007$; Table 3). Logistic regression results indicated that D/HH respondents were more likely to be regular cannabis users than hearing respondents, even after adjusting for demographic characteristics (adjusted OR = 1.30, 95% CI = 1.01–1.67, $P = .045$).

## Discussion

The current article reports findings from a secondary analysis of the 2013–2014 NHANES administration, in which we compared alcohol and drug use between 133 D/HH respondents and 4006 hearing respondents. Prior to this analysis, little research had been conducted on the epidemiology of SUD in the D/HH population. The existing literature reported highly mixed results, likely due to inaccessible research procedures and methodological discrepancies between studies (e.g., inconsistent approaches for separating participants into deaf, hard-of-hearing, and non-deaf subgroups). Although the current analysis overcame some of these challenges, other limitations remain and are described in detail below.

### *Summary of findings*

We first hypothesized that D/HH participants would report higher lifetime rates of alcohol and drug use, i.e., "ever use," than hearing participants. This hypothesis was not supported. Rather, the prevalence of lifetime alcohol use was nearly identical across hearing status (D/HH = 87.86%; hearing = 86.46%), as was the prevalence of lifetime cannabis use (D/HH = 62.88%; hearing = 59.04%) and lifetime drug use (D/HH = 23.00%; hearing = 18.49%).

Our second hypothesis was that D/HH participants would report an earlier age of first drug use and age of first regular drug use than hearing participants. This hypothesis was not supported. After adjusting for age, gender, race, and education, there was no significant difference between D/HH and hearing respondents. Both groups initiated cannabis use around the ages of 16–17 and quickly became regular users.

Third, we hypothesized that D/HH participants would report a higher frequency and greater quantity of alcohol and drug use than hearing participants. This hypothesis was partially supported. Past-year number of drinking days and total quantity of drinks were not significantly different between groups. However, regarding patterns of use, D/HH participants were more likely to have used cannabis on a regular basis—once a month for more than a year—than their hearing counterparts (D/HH = 35.77%; hearing = 26.68%). Additionally, compared with just 12.35% of the hearing subgroup, one third (32.99%) of deaf respondents reported a lifetime history of heavy alcohol use—i.e., a period in time when they consumed 4 drinks (for women) or 5 drinks (for men) per day "almost every day."

Together, these findings suggest that the overall lifetime prevalence of alcohol and drug use does not differ based on hearing status, and that D/HH and hearing adolescents begin using cannabis on a similar timeline. On the surface, such findings give the impression that substance use is equivalent regardless of whether one is D/HH or hearing. These particular statistics, however, oversimplify and obscure the details of one's use and, therefore, fail to capture concerning patterns of drinking and cannabis use that appear to be more typical of D/HH individuals than hearing individuals.

Specifically, findings indicate that D/HH respondents were more likely to have been heavy alcohol users than their hearing counterparts. In other words, when D/HH individuals drink, they tend to drink heavily. To illustrate, let us consider 2 individuals who each consume 365 alcoholic beverages per year. The first individual consumes 1 alcoholic beverage per day, which falls within the bounds of "moderate drinking" as defined by the National Institute on Alcohol Abuse and Alcoholism (NIAAA). The second individual drinks only once per week, but consumes 7 drinks at a time—a pattern of use classified by NIAAA as "binge drinking," which has a number of affiliated health problems (e.g., injuries, suicide, hypertension, acute myocardial infarction, gastritis, pancreatitis, sexually transmitted infections, and meningitis) and social consequences (e.g., interpersonal violence, including homicide, assault, domestic violence, rape, and child abuse).[26] This issue becomes even more relevant given previous findings that deaf individuals experience higher rates of obesity, suicide, physical abuse, and forced sex than the general population.[1,27,28] Although it could not be directly investigated as part of this analysis, it is possible that heavy alcohol use may be one link in the causal chain between hearing status and these other behavioral health disparities.

Additionally, our findings indicated that D/HH individuals were more likely to be regular cannabis users than hearing individuals. These findings also have public health relevance, given effects of regular cannabis use reported in recent meta-analyses (e.g., increased risk of respiratory problems, cardiovascular disease, activation of mood or psychotic disorders).[8,9] Together, these findings stress the importance of directing resources to the prevention and treatment of heavy alcohol use and regular cannabis use in the D/HH population.

### *Study strengths and limitations*

One of the primary strengths of the current secondary analysis was our use of a large, national epidemiological database to draw comparisons between D/HH and hearing respondents. Because NHANES data are collected on an annual basis, this will allow researchers to analyze changes in alcohol and drug use patterns within the D/HH population over time, a critical consideration given recent legislative changes regarding the recreational use of cannabis. Additionally, the use of this database resulted in a relatively large sample of D/HH individuals, a rare occurrence for

most deaf-behavioral health researchers.[29] The size of our sample allowed us to adjust for demographic characteristics of age, gender, race, and education with sufficient numbers of participants in each cell, suggesting that our findings are not due to confounding demographic differences between the D/HH and hearing subgroups.

Interpretation of our findings must also take into consideration the following limitations. Similar to previous analyses with D/HH participants,[21] the only available NHANES variable that could be used to separate participants into D/HH and hearing subgroups was not ideal. Those who identified as "deaf" and those who identified as having "serious difficulty hearing" likely represent a diverse group of individuals with hearing loss, with varied language and communication preferences, sociocultural norms, and community affiliations. It is for this reason that we labeled this subgroup as "deaf/hard-of-hearing"—because we recognize that this is not a homogeneous group. Such heterogeneity within our target subsample makes generalization to the US D/HH population difficult, and, as such, our findings should be interpreted with caution until future researchers are able to corroborate our findings with more specific, definitive diversity variables.

In a similar vein, it remains unclear how individuals within the D/HH subsample were accommodated during data collection procedures. NHANES 2013–2014 documentation indicates that interviewers participated in cultural competency training and "local interpreters were hired when necessary and were provided with translated glossaries of terms, hand cards, and exam scripts to minimize errors in interpretation." Additionally, the NHANES Interviewer Procedure Manual notes that interviewers could record "special considerations" for a respondent, including whether the individual had a level of hearing loss that could influence the interview or examination process. Yet, no information is available that specifies how D/HH participants were accommodated throughout the interview and examination process, with the exception of using a "proxy respondent" from the participant's household. Without this information, it is impossible to evaluate the reliability of the data collected from the D/HH subgroup.

### *Future directions*

Despite these limitations, our study provides preliminary evidence that heavy alcohol use and regular cannabis use are more prevalent among D/HH individuals than hearing individuals. Future research, with more appropriate disability variables and inclusion of disability accommodations, is needed to replicate this finding, as well as to determine if this pattern of substance use is a mediator of outcome between hearing status and other behavioral health problems that are more prevalent in the D/HH population (e.g., interpersonal violence, suicide).

The continuation of this work is rather urgent, especially given recent legislative changes regarding cannabis use. D/HH individuals possess a number of risk factors for substance use disorder, including less access to health-related information and low rates of behavioral health literacy, and, as such, may be more greatly impacted by these legislative changes than individuals from the general US population. It is imperative that this impact be captured by future research efforts in order to inform the development of prevention and intervention efforts for the traditionally underserved D/HH population.

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## Author contributions

Melissa L. Anderson contributed to the research conception and design, interpretation of results, writing, and revision of this article; Bei-Hung Chang contributed to the research conception and design, data analysis, interpretation of the results, writing, and revision; Nisha Kini contributed to the data analysis, interpretation of results, and writing.

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