ABSTRACT

Title of dissertation: UNDERSTANDING THE RISK OF DRUG OVERDOSE AND ALCOHOL-INDUCED DEATHS AMONG ADULTS WITH DIFFERENT TYPES OF DISABILITIES

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Background: Disability is associated with drug and alcohol morbidity and mortality, which have reached high levels in recent years. Previous disability studies often combine all disabilities into a single category or focus on a single type of limitation. This dissertation characterizes different types of disabilities among U.S. adults and assesses associations with drug and alcohol morbidity and mortality.

Methods: Using the 2018-2019 National Survey on Drug Use and Health (NSDUH, Aim 1), a nationally representative cross-sectional survey (n=83,485), different individual disabilities and co-occurring disabilities were identified. Multivariable logistic regression was used to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for associations between disability type and prevalence of drug and alcohol use disorders. Disabilities were also characterized within the Mortality Disparities in American Communities Study (Aims 2 and 3), a nationally-representative prospective cohort with baseline data collected in 2008 and mortality follow-up through 2019 (n=3,324,000). Multivariable Cox proportional hazards regression was used to estimate adjusted hazard ratios (aHRs) and CIs for associations between disability type and drug overdose death (OD, Aim 2) and alcohol-induced death (AID, Aim 3).

Results: Within the NSDUH analysis, adults with cognitive disability had increased odds of drug (aOR=3.3; 95% CI=2.9–3.8), and alcohol use disorder (aOR=2.3; 95% CI=2.0–2.6), compared to adults without disability. Positive associations of lesser magnitude were observed between hearing/seeing and ambulatory disabilities and drug use disorder. In MDAC analyses, OD risk was elevated among adults with cognitive (aHR=2.6; 95% CI=2.4–2.9), ambulatory (aHR=2.8; 95% CI=2.6–3.1), ambulatory and hearing/seeing (aHR=2.5; 95% CI=2.0–3.1), and hearing/seeing disability (aHR=1.6; 95% CI=1.4–1.9), compared to adults without disability. The risk of AID was elevated for adults with co-occurring ambulatory and hearing/seeing disability (aHR=1.8; 95% CI=1.5–2.2), ambulatory disability only (aHR=1.5; 95% CI=1.3–1.7), and hearing/seeing disability only (aHR=1.2; 95% CI=1.0–1.4).

Conclusions: The examination of specific disability categories reveals unique associations that are not apparent when all disabilities are combined. These findings can be used to improve access to recovery support services. Expansion of educational and occupational opportunities for adults with disabilities should be considered as strategies to reduce drug and alcohol morbidity and mortality.

UNDERSTANDING THE RISK OF DRUG OVERDOSE AND ALCOHOL-INDUCED DEATHS AMONG ADULTS WITH DIFFERENT TYPES OF DISABILITIES

BY

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List of Abbreviations

ACA, Affordable Care Act

ACS, American Community Survey

ACASI, Audio computer-assisted self-interviewing

ADA, Americans with Disabilities Act

ADL, Activities of daily living

AID, Alcohol-induced death

CI, Confidence Interval

CDC, US Centers for Disease Control and Prevention

CPS, Current Population Survey

DAG, Directed acyclic graph

DEA, Drug Enforcement Administration

DSM, Diagnostic and Statistical Manual of Mental Disorders

HEAL, Helping to End Addiction Long-term

HHS, US Department of Health and Human Services

HR, Hazard Ratio

IADL, Instrumental activities of daily living

ICD, International Classification of Disease

IQ, Intelligence Quotient

MDAC, Mortality Disparities in American Communities Study

MeSH, Medical Subject Heading

NDI, National Death Index

NHANES, National Health and Nutrition Examination Survey

NHIS, National Health Interview Survey

NSDUH, National Survey on Drug Use and Health

OD, Overdose

OMB, Office of Management and Budget

OR, Odds ratio

POV, Poverty status

SAMHSA, Substance Abuse and Mental Health Services Administration

SSN, Social Security Number

SUD, Substance use disorder

TDD, Telephone Device for the Deaf

US, United States

Chapter 1: Introduction

Drug and alcohol use caused 1.6 million deaths in the United States (US) between 1999 and 2020.[1] During this same period, the age-adjusted rate of drug overdose (OD) death more than quadrupled, from 6.1 to 28.3 per 100,000,[1] while the rate of alcohol-induced death (AID) increased 85%, from 7.1 to 13.1 per 100,000.[1] The presence of any reported disability has been established as a risk factor for drug OD[2–4] and AID,[5] but little is known about the differential risk among adults with specific types of disabilities.

US adults with disabilities are a highly diverse population that includes persons with sensory, ambulatory, cognitive, self-care, and other types of limitations.[6] Prior drug OD and AID research has defined disability as work limitations,[4,5] receipt of Medicare disability benefits,[2] or the presence of one or more specific conditions,[3] thus combining individuals with distinct limitations into a single category. At present, it is unknown whether the risk of drug OD and AID is elevated among all adults with disabilities, or if pooled results are inflated by one or two high-risk groups. Alternatively, the association could be due to confounding, as many of the socioeconomic characteristics associated with disability are also associated with drug OD and AID. Additionally, existing research largely predates the increase in illicitly-manufactured fentanyl OD deaths that has occurred in recent years. The purpose of the present studies is to improve knowledge of the risk of drug OD and AID among US adults with different types of disabilities.

The Burden of Substance Use in the United States

The steady rise in drug OD deaths over the last two decades has made drug-related mortality a leading cause of potential life years lost,[7] and a major contributor to decreasing life expectancy in the US.[8] In 2020, drug deaths caused an estimated loss of 3.0 million life years before age 75.[7] For comparison, COVID-19 caused an estimated loss of 1.8 million life years, and cancer caused an estimated loss of 4.1 million life years before age 75 during 2020.[7] These premature deaths are a hardship for the families of the decedents, and they deplete vital human capital from communities. A well-informed public health response is needed to reduce both drug OD and AID.

A nuanced description of high-risk populations is an important element of the public health response to emerging health threats, such as drug OD and AID. Prior studies have described the socioeconomic and demographic characteristics of persons at increased risk for drug OD and AID.[3,5,9–12] For example, deaths from both causes are more than twice as common among men compared to women.[12,13] Comparisons by state reveal death rates that are three times higher in the most-affected state of West Virginia, compared to the least-affected state of Texas.[1] History of work-related injury is also associated with drug OD and AID,[9] and occupations like construction and extraction (e.g. mining) are especially impacted.[10] Drug OD deaths are also more common among persons who are unemployed and persons with low income.[3] Notwithstanding the insights these and other studies provide, drug OD and AID rates remain high. Consequently, there is a need to identify additional characteristics associated with drug- and alcohol-related morbidity and mortality in order to recognize and reach high-risk individuals with prevention interventions and address the underlying conditions that put some persons at increased risk for drug OD and AID.

Overview of Disability Among Adults in the United States

There is growing evidence that disability status is strongly associated with increased risk of drug and alcohol mortality.[2–5] Rather than being an inherent characteristic of an individual, disability is the result of an interaction between an individual's abilities and their environment, which limits participation in a range of activities.[14] In the US, the civil rights of persons with disabilities are protected under the Americans with Disabilities Act (ADA), which, for implementation purposes, defines disability using an extensive list of specific types of limitations, including physical and mental impairments.[15] Importantly, illegal drug use is not considered a disability under the ADA.[15]

The passage of the ADA heightened the need for valid, population-based measures that could be used to evaluate people with disabilities' access to opportunities, which the act was intended to equalize. In 1997, the US Office of Management and Budget (OMB) convened a workgroup to develop a set of six disability questions that would align with the ADA and meet the needs of agencies involved in the ADA's implementation.[16] The workgroup agreed to create and validate questions focused on three specific disability domains, which are sensory, physical, and mental/emotional/cognitive, and general limitations in performing self-care activities, defined as activities of daily living (ADLs) and instrumental activities of daily living (IADLs).[16] After extensive cognitive testing and evaluations of test/re-test reliability, the six questions were finalized and included in the 2008 American Community Survey (ACS), the data source used in Aims 2 and 3 of this dissertation.

The standardization of disability surveillance methods was extended further with the passage of the Affordable Care Act (ACA) in 2010. Under the ACA, the Secretary of the US Department of Health and Human Services (HHS) must establish minimum data collection standards for the monitoring of health disparities, including disparities by race, ethnicity, language and disability status.[17] In 2011, HHS issued guidance that endorsed the use of the ACS disability questions, henceforth referred to as the "HHS disability questions," for monitoring disability-related health disparities.[17] In 2015, the HHS questions were added to the National Survey on Drug Use and Health (NSDUH),[18] which is sponsored by HHS through the Substance Abuse and Mental Health Services Administration (SAMHSA).

Despite efforts to standardize the definition of disability, estimates of disability prevalence vary across data sources. For example, the 2010 ACS reports that approximately 33.9 million adults aged 16 or older have one or more disabilities, as defined by the 6 HHS questions[19]; while the 2010 Current Population Survey (CPS), which was also implemented by the US Census Bureau and used the 6 HHS questions, reports that 26.6 million adults aged 16 or older have one or more disabilities.[20] These differences are likely attributable to differences in survey mode and context, which will be discussed further in Chapter 3 of this dissertation.

Despite differences related to survey mode and other factors, there are many consistent findings across surveys that examine the distribution of disability among US adults. For example, disability is reported more often by older adults relative to younger adults, and women relative to men.[6] Despite the requirements of the ADA, disability is also associated with lower income[21] and lower educational attainment.[22] Grouping disabilities by domain shows some types of disabilities are more common than others. In descending order, the prevalence among adults aged 15 years or older is: physical (17%), cognitive (7%), and communicative (6%).[6] Importantly, many individuals have disabilities in more than one domain. Specifically, 6% of adults aged 15 years or older have a disability in two domains and 2% have a disability in three domains.[6]

Many US disability studies[3,6,23–26] use the ADA disability paradigm, which *does not* consider substance use itself to be a disability, and the same approach is used in this dissertation. This stands in contrast to other conceptualizations of disability, in which substance use *is* considered a disability. This alternative view can be seen in the WHO Global Burden of Disease paradigm, which considers drug and alcohol use disorders to be disabilities, and even attempts to quantify the diminishment of health these conditions cause.[27]

Overview of Existing Evidence Linking Disability with Substance Use

Prior studies show a consistent association between disability and drug- and alcohol-related health problems.[2–5,28] A 20% sample of adults whose initial Medicare eligibility was due to disability reported an opioid OD death rate of 77.6 per 100,000 in 2016. This indicates opioid OD rates are 4.8 times higher among disabled adults compared to the general population.[2] A positive association of similar magnitude was also reported in a study of 2008 ACS participants whose survey records were linked to the National Death Index (NDI). The unadjusted hazard ratio comparing the risk of opioid OD death among disabled and non-disabled adults was 4.0 (95% CI = 3.7 – 4.3). Importantly, partially- and fully-adjusted models suggested that demographic and socioeconomic covariates acted as both positive and negative confounders of the association between disability and opioid OD death, but a statistically-significant hazard ratio of 2.8 (95% CI = 2.6 – 3.0) remained in the fully-adjusted model.[3] Analysis of a nationally representative sample from 1990 – 2011 found that among adults who are unable to work because of disability the crude alcoholic liver disease hazard ratio was 3.8 (95% CI = 3.2 – 4.4), when working adults were used as the comparison group.[5] Research has also demonstrated an association between *non-fatal* alcohol dependence, which is an important risk factor for some types of AID, and disability. Nationally-representative NSDUH data from 2002 show that 7.9% of adults with disabilities were alcohol dependent, compared to only 3.1% of adults who were not disabled.[29] The existing literature does not include examinations of the risk of drug OD and AID by disability type.

Specific Aims and Hypothesis

In light of the burden of drug and alcohol mortality in the US, and the salience of disability status as a population-level influence on health, this dissertation furthers knowledge on the epidemiology of drug OD and AID by disability types by addressing the following **specific aims:**

1. To examine the associations between measures of any reported disability, different types of reported disabilities, and self-reported drug and alcohol use disorders among adult participants in the National Survey on Drug Use and Health.
2. To estimate the associations between different types of reported disabilities and <u>drug overdose</u> deaths among adult participants in the Mortality Disparities in American Communities (MDAC) Study.
3. To estimate the associations between different types of reported disabilities and <u>alcohol-induced deaths</u> among adult MDAC participants.

Based on the current literature and the theoretical framework presented below, the **hypothesis** is that there will be a positive association between measures of any reported disability and self-reported substance used disorders (SUDs), drug OD and AID; and heterogeneity in the association between different types of reported disabilities and these same indicators of substance use. Specifically, cognitive disabilities, which include mental health conditions, will be positively associated with substance use.

Aim 1 uses nationally-representative cross-sectional data from approximately 83,000 US adults who participated in the NSDUH. Aims 2 and 3 utilize data from a nationally-representative cohort that includes 3.3 million participants in the American Communities Survey (ACS) whose responses have been linked to the NDI. Both data sources include the six standard disability questions recommended by the US HHS for identifying disabilities in survey research, which are discussed above. The six questions have been used extensively in public health and public policy research to identify ambulatory, cognitive, sensory and self-care disabilities. This research furthers efforts to prevent drug- and alcohol-related mortality by highlighting the specific types of disabilities that are most associated with deaths from these causes.

Theoretical Framework

The framework for this dissertation is rooted in ecosocial theory which seeks to explain differences in the health of socially-defined groups by examining influences experienced at multiple levels, from individual to societal.[30] Key constructs in the ecosocial theory include embodiment; pathways to embodiment; cumulative interplay of exposure, susceptibility, and resistance; and agency and accountability. Each of these four constructs is useful for understanding the association between disability, drug OD, and AID.

In ecosocial theory, the term embodiment refers to how the social and biological world is "incorporated into the bodies" of persons in different social groups. In the case of adults with disabilities, this might involve limited opportunities to participate in work and other rewarding activities.[6] This lack of opportunity, in turn, might lead to feelings of isolation. Society might also undervalue the contributions of adults with disabilities who participate in work. If these sentiments are internalized, some adults with disabilities might use drugs and alcohol as maladaptive strategies to cope with painful emotions.[31] Importantly, alcohol and drug use can also precede the onset of certain types of disabilities. For example, mental health problems can be the result of drug and alcohol use, not simply the trigger.

Pathways to embodiment, as an ecosocial construct, are the conduits through which "social, environmental and biological forces interact with the bodies" of persons with disabilities.

For disabled adults, pathways to embodiment could include built environments and transportation systems that require adults to drive themselves to social activities, workplaces and other local amenities. For those who can overcome transportation barriers, social norms could still limit participation in work, recreation, and socializing. For example, the expectation that participants in social activities will all have typical seeing, hearing, walking and cognitive abilities could be a nexus between social attitudes and feelings of isolation among disabled adults.

There are several ways in which the ecosocial theory construct of "cumulative interplay of exposure, susceptibility, and resistance" to the harmful effects of drugs and alcohol might differ by disability status. First, adults with painful disabilities might be prescribed opioids at higher rates than non-disabled adults.[26] Second, adults with disabilities related to anxiety might be prescribed benzodiazepines (e.g. Xanax) at higher rates than non-disabled adults.[32] Third, disabilities that lead to feelings of isolation might also decrease resistance to the harmful effects of drugs and alcohol.[31] Fourth, people with disabilities and Substance Use Disorders (SUDs) might face barriers when accessing SUD treatment.[33,34]

The construct of "agency and accountability" examines how institutions and the state might affect the distribution of SUDs among socially-defined groups. Of the four constructs in ecosocial theory, that of agency and accountability is the most well-documented with regards to healthcare regulations and law enforcement. A lack of regulation has allowed pharmaceutical firms to aggressively market opioids directly to prescribers. Between 2013 and 2015, pharmaceutical companies provided 1 in 12 US physicians with speaking fees, honoraria, food, or other payments related to prescription opioids. The median value of payments was $15.[35] There is also evidence that pharmaceutical industry marketing of opioids is associated with OD deaths at the county level.[36] Despite increasing rates of opioid use disorders, there is a large gap between the number of people with these conditions and the number of clinicians who prescribe buprenorphine, a medicine that treats opioid use disorders.[37] Barriers to insurance reimbursement and stigma might contribute to this gap. Law enforcement has struggled to prevent highly-potent illicit fentanyl from entering US drug markets. Recent data show that despite significant interdiction efforts by the US Drug Enforcement Administration (DEA), illicit fentanyl is highly available in the US.[38]

Significance and Innovation

Relative to core socioeconomic and demographic characteristics, disability status is an understudied attribute in substance use research.[39] A number of published disability studies used very general definitions of disability, for example being unable to work.[3,5,29] Such broad definitions limit the ability of the current literature to parse the risks of drug OD and AID in disabled adults; a heterogeneous population that includes persons with distinct types of difficulties and employment statuses. This dissertation expands knowledge of relationships between disability, drug OD and AID by quantifying the risk of both outcomes by disability type using nationally-representative data sources and longitudinal study designs for aims 2 and 3. Specifically, the dissertation examines the five most common disabilities and disability combinations identified by both data sources, and comparisons are made using non-disabled adults as the reference group. The findings provide clarity on which disability types, ambulatory, cognitive and communicative, and their combinations, are most strongly associated with drug OD and AID. This knowledge informs efforts to prevent SUDs, drug OD and AID by identifying high-risk populations that could benefit from primary, secondary and tertiary prevention.

In addition to identifying the specific types of disabilities most strongly associated with substance use, it is important to understand which substances are most often used by different subpopulations of people with disabilities. Substances with use potential can be categorized as drugs and alcohol. This delineation can help policy makers and public health authorities identify the distinct strategies most likely to reduce the burden of substance use among people with disabilities. Examples of prevention strategies include opioid prescribing guidelines, regulation of alcohol outlet density and hours of sale, and interdiction of illicit drugs. Understanding the types of disabilities most associated with the use of drugs and alcohol enables more tailored interventions to reduce morbidity and mortality caused by substance use.

Key Terms

Terminology related to drug and alcohol use has changed over time. For clarity, key terms used in this dissertation are defined here.

Alcohol Abuse – A diagnosis in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Revision (DSM-IV) which reflects social, legal, educational or other problems caused by alcohol use. In DSM-V, alcohol abuse and alcohol dependence are combined into a single diagnosis called "Alcohol Use Disorder" (see below).[40] An in-depth discussion of drug abuse/dependence is included in chapter 2.

Alcohol Dependence - A diagnosis in the DSM-IV which reflects an inability to control escalating alcohol use and its negative repercussions. In DSM-V, alcohol abuse and alcohol dependence are combined into a single diagnosis called "Alcohol Use Disorder" (see below).[40] An in-depth discussion of alcohol abuse/dependence is included in chapter 2.

Alcohol-Induced Death – Deaths caused by the physiological effects of alcohol on the body. The International Classification of Disease 10th Revision (ICD-10) codes are mental and behavioral disorders due to the use of alcohol (i.e. dependence, withdrawal, and psychosis) (F10.1 – F10.9), nervous and muscular system disorders due to alcohol (i.e. neuropathies and myopathies) (G31.2, G62.1, G72.1, I42.6), alcoholic diseases of the digestive system (i.e. cirrhosis of the liver, hepatitis and pancreatitis) (K29.2, K70.0 - 70.4, 70.9, K85.2, K86.0), acute alcohol poisoning (R78.0, X45, X65, Y15). An in-depth discussion of alcohol-induced deaths is included in chapter 2.

Alcohol Misuse - "Alcohol consumption that puts individuals at increased risk for adverse health and social consequences."[41]

Alcohol Use – Any alcohol consumption, including drinking in moderation, binge drinking and heavy alcohol use.

Alcohol Use Disorder – A diagnosis in the DSM-V which reflects alcohol use that interferes with roles and responsibilities, and leads to tolerance, withdrawal symptoms, and risky behavior. The severity of alcohol use disorder ranges from mild to severe.[40]

Drug Abuse - A diagnosis in the DSM-IV which reflects social, legal, educational or other problems caused by drug use.[42] An in-depth discussion of drug abuse/dependence is included in chapter 2.

Drug Dependence – Also called "addiction," is drug use that escalates and causes withdrawal symptoms. An in-depth discussion of drug abuse/dependence is included in chapter 2.

Drug Misuse – An umbrella term for opioid use disorder, stimulant use disorder, and other problematic patterns of drug use that cause impairment and distress.

Drug Overdose Death – Acute poisoning deaths caused by drugs identified with the following ICD-10 underlying cause of death codes: accidental drug OD death (X40-X44), intentional drug OD (i.e., suicide) (X60-X64), drug OD homicide (i.e., assault by drugs) (X85), and drug OD of undetermined intent (Y10-Y14). An in-depth discussion of drug OD deaths is included in chapter 2.

Drug Use – Any use of illegal substances such as cocaine, heroin, or methamphetamine. Drug use also includes the use of prescription medications, such as opioids, in a manner inconsistent with the prescriber's instructions.[43]

Substance Misuse - "The use of alcohol or drugs in a manner, situation, amount, or frequency that could cause harm to the user or to those around them."[44]

Chapter 2: Background

Existing evidence linking disability and substance use includes research focusing on non-fatal use, fatal drug overdose (OD) death, and alcohol-induced death (AID), which correspond to the three aims of this dissertation. Prior literature for these substantive areas is summarized below and organized by Dissertation Aim. Also included is a brief summary of disability categories used in recent research.

Disability Categories Used in Recent Population-Based Drug Use and Mental Health Research

A large share of recent disability research focusing on drug use and mental health has been published by researchers at the University of Florida (UF) Gainesville, while researchers from a number of other institutions have also contributed to this area of study.

Research Conducted at the University of Florida Gainesville

Since 2021, UF researchers have published five disability studies using National Survey on Drug Use and Health (NSDUH) data which focus on drug use,[45] suicidality,[46,47] and mental illness.[48,49] The UF researchers used the US Department of Health and Human Services (HHS) disability questions to create seven mutually exclusive categories: no disability, hearing only, vision only, cognitive only, mobility only, complex activity only, and two or more disabilities. Complex activity was defined as difficulty bathing or dressing, or difficulty shopping or visiting a doctors' office without assistance. These seven categories provide more detail than much of the existing literature and are conceptually easy to understand. The main disadvantage of the UF researcher's approach is the grouping of all persons with two or more disabilities into a single category, which does not distinguish between common co-occurring disabilities, like mobility and hearing/vision limitations, and less common combinations, like mobility and cognitive limitations.

Other Research Using the National Survey on Drug Use and Health

Since the six HHS disability questions were added to the survey in 2015, various other methods have been used to categorize disabilities in research conducted using the NSDUH. All six questions have been combined to form a binary measure of the presence or absence of any disability.[24,26] Survey participants answering "no" to all six questions were classified as not having a disability, and survey participants answering "yes" to one or more of the questions were classified as having a disability.[24,26] Other research has used just four the six questions to create binary measures of activities of daily living (ADL) and instrumental activities of daily living (IADL) disabilities.[25] Survey participants answering "no" to all four questions were classified as not having a disability; survey participants answering "yes" to the cognitive, mobility, and dressing questions were classified as having ADL disability; and survey participants answering "yes" to the shopping or visiting a doctors' office without assistance question were classified as having IADL disability.[25] To summarize, various methods have been used to classify adults with disabilities in recent, population-based drug use and mental health research. The six HHS questions can be combined in different ways to suit the needs of researchers, and there are not firm conventions for grouping disabilities.

Disability and Substance Use Disorder (Aim 1)

Research Using the National Survey on Drug Use and Health

Since 2007, six studies have examined disability and substance use using data from the NSDUH.[24–26,29,45,50] A summary of these studies is presented in Table 1. Research has been carried out among populations of college students,[24] working-age adults,[29,50] and all NSDUH participants age 18 and older.[26,45] Within each of these distinct populations, positive associations between disability and substance use have been reported.

NSDUH studies have defined disability as any one of the six HHS disability questions,[24,26] only one or two of the HHS questions,[45] a limitation in ADLs or IADLs,[25] ability to work,[29] or receipt of Medicare benefits before age 65.[50] Just as prior NSDUH studies have used a variety of methods to identify adults with disabilities, this literature also includes several different measures of substance use, including any prior use of illicit drugs, misuse of prescription drugs, or current substance use disorder,[24] opioid use disorder,[26,45] opioid and benzodiazepine misuse,[25] drug and alcohol dependence,[29] and heroin and oxycodone use.[50] The consistent finding of a link between disability and substance use across study populations, disability measures and outcomes, suggests that the two constructs are positively associated in the NSDUH source population of US adults. Less is known about the magnitude of the association, which differs considerably across studies.

The magnitude of the associations reported in the NSDUH literature range from modest for the outcome of past year alcohol abuse (OR = 1.3; $p < 0.001$),[29] to large for the outcome of past month heroin abuse (OR = 4.7; 95% CI: 2.6 – 8.6).[50] The measures of association reported in other NSDUH studies fall within this range. In general, prior NSDUH studies have also controlled for major demographic and socioeconomic characteristics[29,50] and health status,[24,25] in order to minimize potential confounding due to these covariates. The exception, Lauer et al., includes only unadjusted results and reports a moderately-strong association of approximately three times the risk (RR = 2.8; 95% CI = 2.2 – 3.7) of opioid use disorder among disabled adults, compared to adults without disability.[26] All NSDUH studies also report at least one non-significant result, which is likely a consequence of insufficient statistical power, rather than the absence of an association in the base population. In contrast to the majority of results reported in NSDUH studies, Glazier et al. found a significantly lower risk of one type of substance use among disabled adults. Using pooled data from the 2002 – 2010 NSDUH, lower odds (OR = 0.8; 0.7 – 0.8) of past month binge drinking were identified among disabled adults, compared to adults without disability.[50] The conflicting results reported by Brucker et al., which are referenced above, might be due to differences in the outcomes assessed (i.e. past year alcohol dependence and past month binge drinking).

Despite using different measures of disability and focusing on different substances, prior research which utilized NSDUH data report a consistent positive association between disability and substance use. Regardless of whether disability is defined based on the six HHS disability questions, performing ADLs or IADLs, ability to work, or receiving Medicare benefits before age 65, or whether the outcome is misuse or abuse of prescription or illicit drugs, disabled adults reported increased prevalence of substance use compared to non-disabled adults. The main shortcoming of this literature is the failure of most studies to distinguish between different types of disabilities, each of which might display a unique association with substance use.

Single Disability Research

The association between specific disabilities and substance use has been examined by five original research studies[31,51–54] and one review article,[55] which examine some, but not all, major types of disabilities reported by US adults. A summary of these studies is presented in Table 1. A review of the literature did not identify research focusing on substance use among adults with ambulatory disabilities. Despite these gaps, the information presented below complements research conducted using binary disability measures by illustrating the differences in substance use reported by persons with different types of disabilities.

Prior research focusing on intellectual disabilities, which are a type of cognitive disability, and substance use among adults has been limited.[31,53,55] The most recent was conducted between 2010 and 2011 in Holland using a sample of 419 adults with intellectual disabilities who were served by 16 social services providers. Study participants were randomly selected within institutions, but the institutions were not randomly selected and might not be representative of all social service providers.[53] Using a questionnaire designed specifically for people with intellectual disabilities, the investigators concluded that 14.6% of study subjects currently used cannabis, and 1.2% currently used illicit stimulants, which are much higher rates than the Dutch general population.[53] Interestingly, the investigators reported lower rates of alcohol use among adults with intellectual disabilities than in the Dutch general population.[53]

In addition to the original research conducted by VanDerNagel et al., review articles have summarized the findings of multiple investigations of cognitive disabilities in relation to drug and alcohol use.[55,56] The most recent such article was published in 2006 by McGillicuddy et al.. Synthesizing the results of five previous studies, McGillicuddy et al. report slightly lower rates of substance use (which is a broad category that includes both occasional, lower-risk use, and frequent, higher-risk use) among adults with intellectual disability. However, a subset of studies reports that adults with intellectual disabilities are likely to experience negative consequences from substance use, which are the criteria used to identify the narrower category of substance use/abuse. The review article did not include well-defined comparison groups of non-disabled adults.[55]

Substance use among adults with intellectual disabilities has also been studied using qualitative methods, which provide insights into the reasons why some in this population use drugs and alcohol.[31] Ten adults with intellectual disabilities who also used drugs and/or alcohol were purposively sampled and interviewed by Taggart et al. and they reported using drugs and alcohol to cope with loss, trauma and isolation.[31]

This prior research provides insights into the prevalence of substance use among adults with intellectual disabilities as well as possible reasons for misusing drugs and alcohol. Within the prevalence literature two studies report mixed results.[53,55] VanDerNagel et al. reports *higher* drug use and lower alcohol use among adults with intellectual disability, compared to the Dutch general population; while McGillicuddy et al., a review article, reports *lower* rates of drug and alcohol use among adults with intellectual disability. McGillicuddy et al. also reports higher rates of excess alcohol use within this population, an outcome that is not examined by VanDerNagel et al., who only focused on substance *use*. Taggert et al. did not attempt to evaluate substance use among adults with intellectual disability, compared to those without. Instead, it focused on the reasons some adults with intellectual disabilities use drugs and alcohol. The reported reasons include loss, trauma and isolation.[31]

Just as cognitive impairment can contribute to the unsafe use of drugs and alcohol, substance use disorders (SUDs) can cause cognitive impairment. High blood alcohol levels can have direct neurotoxic effects, and damage the brain indirectly by producing thiamine deficiency,[57] and alcohol use disorder has been linked to deficits in memory, decision making, and focus.[58] Drug use disorders are associated with impaired impulse control and problem solving.[58]

Substance use has also been examined among persons with hearing and vision disabilities.[51,52,59] The most recent investigation, which is by Hinson-Enslin et al., used the nationally-representative cross-sectional National Health and Nutrition Examination Survey (NHANES) to examine lifetime drug use among a sample of 9,367 participants in the 2013-2018 NHANES who had vision and/or hearing loss. Results show elevated odds of lifetime drug use among adults with hearing loss (OR = 1.4; 95% CI = 1.0 – 1.9), and vision loss (OR = 1.4; 95% CI = 1.0 – 1.9), compared to non-disabled adults. Despite this, the research also found that persons with these disabilities were no more likely to have gone to drug rehabilitation, which might account for the higher rates of drug-related morbidity observed in this population.[59]

A second NHANES study, which was by Anderson et al., examined 4,139 participants in the 2013-2014 wave of the survey. The results showed elevated odds of regular cannabis use (OR = 1.3; 95% CI = 1.0 – 1.7) and heavy alcohol use (OR = 2.5; 95% CI = 1.5 – 4.2) among deaf and hard of hearing survey participants, compared to their hearing counterparts. Importantly, the study also found *similar* prevalence of lifetime drug and alcohol *use* among those with and those without hearing difficulties. Thus, "when deaf and hard of hearing individuals use substances, they tend to be heavy users."[51]

Additional information about substance use among hearing-impaired individuals was reported by Moore & McAweeney, who analyzed 98,932 unique records entered in 1998 in the New York State Substance Abuse Treatment Database. The investigators determined that 1.8% of persons in treatment for substance use disorder were deaf or hard-of-hearing, a percentage that is similar to that of the general population. The investigators also report hearing-impaired participants progress towards recovery goals at the same rate as persons who are not hearing impaired.[52]

Research by Yu makes a unique contribution to this area of study by examining multiple disabilities within the same sample and disaggregating disabilities into different types. Data come from the 2000-2001 National Longitudinal Transition Study, a nationally-representative study of students who have received special education services. Substance use information was gathered from 2,640 study participants who were at least 18 years old at the time of the study. The results indicate that when all disabilities are combined, disabled students report *lower* rates of substance use than their non-disabled peers. However, when disabilities are disaggregated, significant differences between disability types become evident. The students with the highest rates of substance use had disabilities related to emotional disturbances, 36% of whom reported use of illegal drugs, and 54% of whom reported alcohol use in the 30 days prior to the survey. This study shows the potential value of disaggregating disabilities by type. It also shows the potential for one disproportionately-affected subgroup to inflate the association between substance use and binary measures of the presence of any type of disability.[54]

To summarize, there is considerable evidence of increased drug and alcohol use among adults with certain disabilities. Investigations focusing on adults with hearing, seeing and intellectual difficulties all report increased prevalence of drug and alcohol use among disabled adults. Importantly, several studies report similar rates of drug and alcohol *use*, which included both moderate and heavy consumption, among persons with and without disabilities. Yu et al. examined substance use within a single study population using both a binary measure of any disability, and specific disability categories. It found higher rates of alcohol and illegal drug use among individuals with emotional disturbances compared to those with learning, visual and hearing disabilities.

Table 1. Summary of Studies Related to Disability Status and Substance Use

Author, Year of Publication	Study Name (Design), Year(s)	Sample Size	Exposure	Outcome	Key Findings
Anderson, 2018	NHANES (Cross-sectional Survey) 2013 – 2014	4,139	Deafness or serious hearing difficulty	Drug and alcohol use	Deaf and hard of hearing survey participants had elevated odds of regular cannabis use (OR = 1.3; 1.0 – 1.7) and heavy alcohol use (OR = 2.5; 1.5 – 4.2), compared to their hearing counterparts. However, deaf and hard of hearing adults did not have higher prevalence of drug or alcohol use.
Brucker, 2007	NSDUH (Cross-sectional Survey) 2002	54,079	Disability (defined as general, physical or serious mental illness)	Drug and alcohol use	Adults with a disability had higher odds of illicit drug use (OR = 1.7; p < 0.001), illicit drug dependence (OR = 2.1; p < 0.001), and alcohol dependence (OR = 1.3; p < 0.001), compared to non-disabled adults.
Casseus, 2021	NSDUH (Cross-sectional Survey) 2017	6,189	Disability (defined as a binary measure of one or more of the 6 HHS disability categories)	Past use of an array of drugs; current substance use	There were significant associations between disability and lifetime history of drug use (aOR = 1.47; 1.20 – 1.79), and past-year dependence or abuse of illicit drugs (aOR = 3.01; 2.06 – 4.40).
Ford, 2018	NSDUH (Cross-sectional Survey)	43,561	ADL and IADL disability	Opioid and benzodiazepine misuse	Adults with ADL disability had 1.6 times the risk (RR = 1.6; 1.2 – 2.2) of opioid use disorder

	2015				compared to those without ADL disability, and adults with IADL disability had 2.2 times the risk (RR = 2.2; 1.3 – 3.7) of benzodiazepine misuse compared to those without IADL disability.
Glazier, 2013	NSDUH (Cross-sectional Survey) 2002 - 2010	337,650	Disability (defined as inability to work or Medicare before age 65)	Substance abuse	Adults with a disability had higher odds of heroin use (OR = 4.7; 2.6 – 8.6)), oxycodone use (OR = 3.0; 1.8 – 5.2), and sedative use (OR = 3.0; 1.8 – 5.0), compared to those without disabilities.
Hinson-Enslin, 2021	NHANES (Cross-sectional Survey) 2013 – 2018	9,367 (Drug use); 5,171 (rehabilitation)	Vision and/or hearing loss	Lifetime drug use and rehabilitation	Lifetime drug use was more common among persons with hearing loss (OR = 1.36; 1.01 – 1.85) and vision loss (OR = 1.37; 0.97 – 1.90), compared to non-disabled adults, but they were not more likely to have gone to rehabilitation.
Hong 2022	NSDUH (Cross-sectional Survey) 2015 – 2019)	201,376	Disability (defined as a binary measure of one or more of the 6 HHS disability categories; and hearing, vision, cognitive, mobility, complex activity	Opioid use disorder	Compared to non-disabled adults, the adjusted odds of opioid use disorder were elevated among adults with vision (aOR = 1.60; 1.07 – 2.40), cognitive (aOR = 1.54; 1.19 – 1.99), and 2 or more limitations (aOR = 1.79; 1.40 – 2.29). Models were adjusted for 18 covariates, including possible

			limitation, and 2 or more		mediators, such as non-opioid drug use disorder.
Lauer, 2019	NSDUH (Cross-sectional Survey) 2015 – 2016	84,633	Disability (defined as a binary measure of one or more of the 6 HHS disability categories)	Opioid use disorder	The six HHS disability questions were used to create a binary measure of any disability. The outcome was opioid use disorder among disabled vs non-disabled adults. Results showed 2.8 times the risk (RR = 2.8; 2.2 – 3.7) among those with disability.
McGillicuddy, 2006	Review of 5 prevalence studies published between 1983 and 1999	7 - 136	Intellectual disability	Drug and alcohol use	Adults with intellectual disability report slightly lower rates of substance use, compared to those without intellectual disability. However, adults with intellectual disability are more likely to report negative consequences from substance misuse, compared to adults without intellectual disability.
Moore, 2006	New York State Substance Abuse Treatment Database 1998	98,932	Hearing status	Participation in treatment for substance use disorder	1.8% of persons in treatment for substance use disorder were deaf or hard-of-hearing, similar to the prevalence of these disabilities in the general population. Deaf or hard-of-hearing participants progress towards recovery goals at the same rate as persons who are not hearing impaired.

Taggart, 2007	Interviews with adults with intellectual disabilities and substance use disorder 2006	10	Motivation	Drug and alcohol use	Self-medicating against life's negative experiences was the overarching theme that emerged from the interviews. Subthemes were psychological trauma, like loss of close family members, physical and sexual abuse. And social distance from their community, like lack of friends and companions.
VanDerNagel, 2017	16 Organizations of the Dutch Assoc. Of Healthcare Providers for People with Disabilities 2010 - 2011	419	Intellectual disability	Drug and alcohol use	14.6% of study subjects currently used cannabis, and 1.2% currently used illicit stimulants, which are much higher rates than the Dutch general population. Reported rates of alcohol use were lower among adults with intellectual disabilities than the Dutch general population.
Yu, 2008	National Longitudinal Transition Study-2 2000 - 2001	2,640	Disability type (learning, speech, emotional, visual, hearing, brain injury)	Drug use	When all disabilities are combined, disabled students report lower rates of substance use. Students with specific disabilities have significantly elevated rates of substance use, for example, 36% used illegal drugs and 54% used alcohol in the last 30 days among those with emotional disturbances.

Disability and Drug Overdose (Aim 2)

Prior studies which examined disability status in relation to drug OD have relied on various data sources including Medicare data, linked survey data, pension data, and cross-sectional health surveys. A summary of these studies is presented in Table 2.

Research Using Medicare Data

Medicare data are a major source of information on the risk of OD death by disability status. Prior research has used Medicare data to investigate OD deaths directly, through the use of death certificates,[2] or indirectly by focusing on risk factors like prior non-fatal OD or prescription opioid use.[60–62] The most relevant of these studies, three of which utilized a cohort study design,[2,60,61] and one of which was cross-sectional,[62] are reviewed below. Findings from this research supports a strong association between disability and OD death.

In a prospective cohort study of approximately 1.8 million Medicare-disability beneficiaries conducted by Kuo et al., the rate of OD death estimated in 2016 was 77.6 per 100,000, which was four times higher than the general population.[2] Intuitively, disabled adults who also reported substance use where at particularly high risk, as were those with psychiatric diseases and chronic pain. Among Medicare beneficiaries with all three conditions, the OD rate was 363.7 per 100,000.[2] For reference, the rate in the general population was 19.7 per 100,000.[1]

Medicare data also show that, in addition to OD deaths, adults with disabilities are disproportionately affected by *non-fatal* OD. Peters et al. examined 1,766,790 Medicare beneficiaries as in a retrospective cohort study and reported that, in 2013, 24.5% of patients treated for non-fatal OD were disabled. Results also showed that the proportion of non-fatal OD patients who are disabled more than doubled compared to 1998.[61] Similarly, Song et al. analyzed more than 160 million hospital discharge records collected from 1993-2014 and found that patients with opioid poisoning were more likely to be disabled compared to patients hospitalized for other indications. Opioid poisoning patients were also more likely to be white, and middle aged.[62] Strengths of the study include the use of weighting to produce results that are nationally-representative.

Although it is difficult to know the source of the drugs involved in an OD, it is likely that many disabled adults receive opioids from their healthcare providers. In a retrospective cohort study of more than 2.2 million Medicare beneficiaries, Meara et al. found that 47% of those with disability filled opioid prescriptions in 2012. Furthermore, approximately 5% of disabled beneficiaries filled high-dose (>120 mg/day) opioid prescriptions.[60]

Taken together, research using Medicare data consistently reports two key findings. First, adults receiving Medicare disability benefits are disproportionately affected by both fatal and non-fatal OD.[2,61,62] Second, disabled Medicare beneficiaries are likely to be prescribed opioids, and in some cases prescriptions are for large daily doses.[60]

Research Using Linked Survey Data

Linked survey data are another important source of information on the risk of drug OD death by disability status. This research includes baseline information from carefully defined study populations and mortality outcome information assessed longitudinally using the National Death Index (NDI), which is a design that can best be described as a cohort study. Altekruse et al. used the 2008 American Community Survey (ACS) linked to the 2015 NDI to estimate the risk of opioid OD death by disability status using a sample of 3,934,000. The HHS disability questions were used to create a dichotomous (Y/N) disability variable that indicated the presence of any disability. The outcome was defined as *opioid* OD, which, as described in the case definitions section below, is a narrower category than drug OD. The results show that disabled adults had approximately three times the risk (HR = 2.8; 95% CI = 2.6 – 3.0) of opioid OD death compared to non-disabled adults controlling for a range of demographic and socioeconomic covariates.[3]

A different national survey linked to the NDI was also used by Aram et al. to estimate OD risk by disability status. Using a sample of 438,739 participants in the Current Population Survey (CPS) and a dichotomous disability variable based on respondents' ability to work, the risk of poisoning death was estimated. Results showed that disabled adults had approximately seven times the risk (HR = 7.0; 95% CI = 6.8 – 7.1) of poisoning death compared to employed adults, independent of demographic and socioeconomic covariates.[4]

Pension Data Research

A retrospective cohort study conducted using pension data from Norway also suggests that adults with disabilities are at increased risk of drug OD. Using a sample of 1,628 Norwegian Cause of Death Registry records linked to research registers, Amundsen et al. found that prior receipt of a disability pension was more than three times higher among OD decedents compared to the general Norwegian population. OD decedents also were found to have lower levels of educational attainment and lower marriage rates, compared to other Norwegians.[28]

Research Using Cross-Sectional Health Survey Data

Research that uses self-reports of *non*-fatal drug use also provides insights into the risk of drug OD death among adults with disabilities. Several such studies have been completed using cross-sectional health survey data. Specifically, the NSDUH, and surveys of adults in vocational rehabilitation programs or college students. Although each study used a different definition of disability and focused on the use of different drugs, all report a positive association between disability and self-reported substance use. Because the NSDUH research is described in greater detail above, information about the sample size, and study years are omitted here, and only key findings are presented.

NSDUH research has found that adults with any disability have increased prevalence of lifetime drug use, and past-year illicit drug dependence or abuse,[24] opioid use disorder,[25,26] illicit drug use and illicit drug dependence,[29] and past-month heroin abuse.[50] This research demonstrates a strong cross-sectional association between disability and substance use in several waves of a nationally-representative survey.

Similar results were obtained from a random sample of 1,876 disabled adults in vocational rehabilitation in 1994 - 1995. An analysis by Moore (1998), reported a high prevalence of illicit drug use among disabled adults relative to the general population.[56] Importantly, adults in vocational rehabilitation might not be representative of all US adults with disability, and are likely higher functioning than adults whose disability precludes paid work. The research conducted by Moore et al. indicates that the association between disability and substance use is present in the sub-population of disabled adults who are able to work.

Bernert et al. used a national survey of 61,140 undergraduate students surveyed in 2009 and found higher odds of drug use among students who self-identify as disabled.[63] Unlike many other disability studies, Bernert et al. differentiated between students with one disability, and those with two or more disabilities, and results showed increased prevalence of substance use in the latter category. Using non-disabled students as the reference, students with one disability reported somewhat elevated odds of unprescribed use of prescription drugs (OR = 1.9; 95% CI =

1.7 – 2.0), while students with two or more disabilities reported considerably higher odds (OR = 2.7; 95% CI = 2.4 – 3.0).[63]

To summarize, this research using cross-sectional surveys collected self-reported disability and drug use information. Despite using different definitions of disability and focusing on the use of different substance, each study reports a positive cross-sectional association between disability and substance use.

Single Disability Research

The elevated risk of fatal drug OD among some populations of disabled adults is also demonstrated by several studies that have focused on substance use among persons with specific types of disabilities, such as difficulty seeing, difficulty hearing, and intellectual disability.[31,51,53,54] Key aspects of this research, including study designs, sample sizes and study years are included in the previous section, and Tables 1 and 2, and are not repeated here. Instead, only the results are restated to demonstrate that many adults with specific disabilities have increased prevalence of substance use, which is an important risk factor for drug OD death. Single disability studies report an association between deafness and regular cannabis use,[51] intellectual disability and illicit drug use[53] and cognitive disabilities related to emotional disturbances and illicit drug use.[54]

In summary, the association between disability and drug OD deaths has been studied using a variety of research methods and definitions of disability that range from inability to work to the presence of one or more specific disabling conditions, like deafness, blindness, difficulty walking, cognitive impairment or difficulty performing ADLs. Major data sources in the disability and substance use literature include Medicare data, population-based surveys linked to death certificates, and cross-sectional surveys. Whether the outcome studied is death or non-fatal substance use, the existing evidence demonstrates a positive association between disability and drug-related health problems.

Table 2. Summary of Studies Related to Disability Status and Drug Overdose Death

Author, Year of Publication	Study Name (Design), Year(s)	Sample Size n	Exposure	Outcome	Key Findings
Altekruse, 2020	MDAC (Prospective cohort) 2008 – 2015	3,934,000	Disability (defined as a binary measure of one or more of the 6 HHS disability categories)	Opioid OD death	Adults with disability had approximately three times the risk (HR = 2.8; 2.6 – 3.0) of opioid OD death, compared to non-disabled, controlling for demographic and socioeconomic covariates.
Amundsen, 2015	Norwegian Cause of Death Registry linked to research registers (Retrospective cohort) 2003 – 2009	1,628	Disability pension, socioeconomic status, occupation	Drug-related death	Forty percent (40.0%) of female OD decedents received a disability pension within 5 years of drug OD death, compared to 11.5% of the general population. 30% of male OD decedents received a disability pension within 5 years of drug OD death, compared to 8.5% of the general population.
Anderson, 2018	NHANES (Cross-sectional Survey) 2013 – 2014	4,139	Deafness or serious hearing difficulty	Drug and alcohol use	Deaf and hard of hearing survey participants had elevated odds of regular cannabis use (OR = 1.3; 1.0 – 1.7) and heavy alcohol use (OR = 2.5; 1.5 – 4.2), compared to their hearing counterparts. However, deaf and hard of hearing adults did not have higher prevalence of drug or alcohol use.
Aram, 2020	NLMS (Prospective cohort)	438,739	Disability (defined as inability to work)	Drug OD death	Adults who were disabled (HR = 7.0; 6.8 – 7.1), unemployed (HR = 4.2; 4.1 – 4.3) and retired (HR =

	2000 – 2006				2.9; 2.9 – 3.0) were at higher risk of OD death relative to those who were employed.
Bernert, 2012	NCHS-NCHA II 2009	61,140	Disability (defined as 1,2 or more conditions from a 9-item list)	Unprescribed use of prescription drugs	Compared to non-disabled students, those with one disability had modestly (OR = 1.9; 1.7 – 2.0), and those with two or more disabilities had considerably higher (OR = 2.7; 2.4 -3.0) odds of unprescribed use of prescription drugs.
Brucker, 2007	NSDUH (Cross-sectional Survey) 2002	54,079	Disability (defined as general, physical or serious mental illness)	Drug and alcohol use	Adults with a disability had higher odds of illicit drug use (OR = 1.7; $p < 0.001$), illicit drug dependence (OR = 2.1; $p < 0.001$), and alcohol dependence (OR = 1.3; $p < 0.001$), compared to non-disabled adults.
Casseus, 2021	NSDUH (Cross-sectional Survey) 2017	6,189	Disability (defined as a binary measure of one or more of the 6 HHS disability categories)	Past use of an array of drugs; current substance use	There were significant associations between disability and lifetime history of drug use (aOR = 1.47; 1.20 – 1.79), and past-year dependence or abuse of illicit drugs (aOR = 3.01; 2.06 – 4.40).
Ford, 2018	NSDUH (Cross-sectional Survey) 2015	43,561	ADL and IADL disability	Opioid and benzodiazepine misuse	Adults with ADL disability had 1.6 times the risk (RR = 1.6; 1.2 – 2.2) of opioid use disorder compared to those without ADL disability, and adults with IADL disability had 2.2 times the risk (RR = 2.2; 1.3 – 3.7) of benzodiazepine misuse compared to those without IADL disability.

Glazier, 2013	NSDUH (Cross-sectional Survey) 2002 - 2010	337,650	Disability (defined as inability to work or Medicare before age 65)	Substance abuse	Adults with a disability had higher odds of heroin use (OR = 4.7; 2.6 – 8.6)), oxycodone use (OR = 3.0; 1.8 – 5.2), and sedative use (OR = 3.0; 1.8 – 5.0), compared to those without disability.
Kuo, 2019	CMS 20% random sample linked to the National Death Index (Prospective cohort) 2012 – 2016)	1,766,790	Disability (defined as qualification for Medicare disability benefits)	Opioid overdose death	Medicare disability enrollees represent 14.9% of beneficiaries younger than 65, but account for 80.8% of opioid overdose deaths within the Medicare population younger than 65 (77.6 deaths per 100,000)
Lauer, 2019	NSDUH (Cross-sectional Survey) 2015 – 2016	84,633	Disability (defined as a binary measure of one or more of the 6 HHS disability categories)	Opioid use disorder	The six HHS disability questions were used to create a binary measure of any disability. The outcome was opioid use disorder among disabled vs non-disabled adults. Results showed 2.8 times the risk (RR = 2.8; 2.2 – 3.7) among those with disability.
Meara, 2016	Medicare administrative data for fee-for-service disabled beneficiaries (Cross-sectional) 2006 - 2012	2.2 million	Descriptive study - prevalence of opioid prescribing to disabled Medicare beneficiaries	Descriptive study - prevalence of opioid prescribing to disabled Medicare beneficiaries	Forty-seven percent (47%) of disabled Medicare beneficiaries filled opioid prescriptions in 2012, and approximately 5% of disabled beneficiaries filled high-dose (>120 mg/day) opioid prescriptions.
Moore, 2006	New York State Substance Abuse Treatment Database	98,932	Hearing status	Participation in treatment for substance use disorder	1.8% of persons in treatment for substance use disorder were deaf or hard-of-hearing, similar to prevalence of these disabilities in

	(Cross-sectional) 1998				the general population. Deaf or hard-of-hearing participants progress towards recovery goals at the same rate as persons who are not hearing impaired.
Peters, 2018	HCUP National Inpatient Sample (Retrospective cohort) 1998 - 2013	Approx. 800,000	Disability (Defined as Medicare disability insurance coverage)	Hospitalization for non-fatal prescription opioid OD	The share of non-fatal OD patients who were Medicare Disability Beneficiaries increased from 11.7% to 24.5% between 1998 and 2013.
Song, 2017	HCUP National Inpatient Sample (Cross-sectional) 1993-2014	>160 million hospital records	Medicare disability insurance coverage	Opioid/heroin OD	Compared to those hospitalized for other indications, patients admitted for opioid/heroin poisoning were more likely to be white, ages 50–64, Medicare beneficiaries with disabilities, and residents of lower-income areas.
Taggart, 2007	Interviews with adults with intellectual disabilities and substance use disorder 2006	10	Motivation	Drug and alcohol use	Self-medicating against life's negative experiences was the overarching theme that emerged from the interviews. Subthemes were psychological trauma, like loss of close family members, physical and sexual abuse. And social distance from their community, like lack of friends and companions.
VanDerNagel, 2017	16 Organizations of the Dutch Assoc. Of Healthcare Providers for	419	Intellectual disability	Drug and alcohol use	Approximately fifteen percent (14.6%) of study subjects currently used cannabis, and 1.2% currently used illicit stimulants, which are much higher rates than

	People with Disabilities 2010 - 2011				the Dutch general population. Reported rates of alcohol use were lower among adults with intellectual disabilities than in the Dutch general population.
Yu, 2008	National Longitudinal Transition Study-2 (Prospective cohort) 2000 - 2001	2,640	Disability type (learning, speech, emotional, visual, hearing, brain injury)	Drug use	When all disabilities are combined, disabled students report lower rates of substance use. Students with specific disabilities had significantly elevated rates of substance use, for example, 36% used illegal drugs and 54% used alcohol in the last 30 days among those with emotional disturbances.

Disability and Alcohol-Induced Death (Aim 3)

Prior studies have not directly examined disability status in relation to the risk of AID. The existing evidence related to this topic consists of descriptive AID statistics generated using death certificates, and various surveys that capture disability and *non-fatal* alcohol use. Two longitudinal studies[64,65] that focus on *non-fatal* alcohol use as a potential risk factor for disability are also included below to demonstrate the potential for a bidirectional relationship between substance use and disability, and a possible pathway that might lead some non-disabled adults to become disabled.

General Information Obtained from Death Certificates

General information about AID is available in published summaries of death certificate data. These sources report that AIDs vary by sex, age, race and urbanization.[1,12,66] An analysis by Spencer et al. included more than 48 million US death certificates reported to the CDC between 2000 and 2018 for all causes combined. Results show that the AID rate for males was 3.6 times the rate for females and that the rate was also higher in rural areas of the US.[12] Ad-hoc queries of the CDC's online WONDER database can also be used to compare AID rates by racial group. For example, of the 37,329 AIDs reported in the US in 2018, 1,437 were among American Indian or Alaska Native persons, and the age-adjusted rate of AIDs within this group was more than three times higher than that of whites, the next highest group.[1] A published analysis by White et al. analyzed death certificates from 944,880 alcohol-related deaths that occurred in the US between 1999 and 2017. The results show that alcohol-related deaths vary by age and were highest among persons aged 45 to 74 years.[66] For additional information about the populations at greatest risk for AID, it is useful to examine other data sources which ascertain both core demographics and detailed health and disability information.

Research Using Cross-Sectional Health Survey Data

Surveys are one of the primary sources of information on disabilities and alcohol use. In substance use research, the NSDUH, which is described in greater detail earlier in this chapter, is a key source of information. However, only two studies use NSDUH data to study alcohol use by disability status.[29,50] Because the study years, sample size, and other details are described above, this information is not repeated here, and only results pertinent to AID are included.

Despite using the same data source, the two NSDUH studies report findings that appear contradictory. Brucker (2007) studied a sample of 54,079 Social Security Disability benefit recipients to estimate the prevalence of substance use among them. The study found that 7.9% of adults with disabilities, compared to only 3.1% of adults who were not disabled, were alcohol dependent.[29] Conversely, a study by Glazier & Kling (2013) found that those with disability had significantly lower odds of binge drinking in the last month, compared to adults without disability.[50] One explanation for this discrepancy is the way disabled adults were identified in the two studies. Brucker (2007), differentiated disabled and non-disabled individuals with a survey question about Social Security Insurance Benefits and self-reported ability to perform work. Glazier (2013) used self-report of a work disability and Medicare eligibility prior to age 65. A second explanation for the discrepancy in findings could be differences in the studied outcome, i.e., self-reported alcohol dependence (Brucker, 2007) and self-reported binge drinking (Glazier, 2013). Alcohol dependence is characterized physiologically and behaviorally and it involves increasing tolerance, the onset of withdrawal symptoms and failure to perform socially-defined roles due to alcohol use. In contrast, binge drinking is characterized by episodic excessive alcohol use, and it does not account for the impact of alcohol use on the lives of individuals. Results from a related survey also provide information on disability and alcohol use. The

National Comorbidity Survey was a cross-sectional study of behavioral health disorders in the US population.[67] In one analysis of the survey data, which had a sample size of 4,883, a single question was used to identify disabled adults. The results show that disabled adults had higher odds of lifetime alcohol dependence (OR = 2.2; 95% CI = 1.4 – 3.4) relative to nondisabled adults.[67]

Although these survey studies provide insights into the burden of alcohol use among disabled adults, they use broad and inconsistent definitions of disability and focus only on alcohol use, rather than alcohol-related death. Furthermore, the results are far from conclusive, with one reporting a negative association between disability and alcohol use and two reporting a positive association. Additionally, the cross-sectional design of these three studies makes it difficult to determine the temporal relationship between alcohol use and disability.

Longitudinal Research

Several longitudinal studies have focused on disability and alcohol use.[64,65] Unlike the research proposed in this dissertation, these studies defined alcohol use as the exposure, and the receipt of a disability pension as the outcome. The studies are included here to demonstrate the potential for a bidirectional relationship between <u>non-fatal</u> substance use and disability, and to highlight one of the pathways that might lead some non-disabled adults to become disabled. Mansson et al. studied 3,751 men residing in Malmo, Sweden who participated in a health survey in the mid-1970's. This cohort was followed for 11 years to determine how many went on to receive a disability pension. The results show that both heavy drinking (RR = 1.3; 95% CI = 1.1 – 1.6) and abstaining from alcohol (RR = 1.8; 1.3 – 2.4) are associated with increased risk of receiving a disability pension, relative to low alcohol consumption.[65] A study conducted in Finland focused on a similar topic and reported similar results. Both heavy drinkers (OR = 1.4; p

< 0.01) and abstainers (OR = 2.7; $p < 0.01$) had increased odds of receiving a disability pension, relative to moderate drinkers. Importantly, the Finnish study population was made up of 12,502 monozygotic and dizygotic twins, which largely controls for environmental and genetic confounders.[64] These studies demonstrate the potential for alcohol use to affect disability. Considering other research showing that disabilities might affect alcohol use, a cyclical might be an appropriate model for the relationship between these two phenomena. However, it is important to point out that no bidirectional relationship is possible between disability and AID, which is a singular event, and is the focus of aim two of this dissertation.

Surveys of Students

Health surveys of students also provide insights into the cross-sectional association between disability and substance use. Using results from the National College Health Assessment survey, Bernert et al. examined self-reported alcohol use among a sample of 60,940 students with disabilities. Unlike other similar studies, a distinction was made between students with one disability and students with two or more disabilities. Relative to non-disabled students, only students with two or more had significantly higher odds (OR = 1.2) of heavy drinking in the past week, compared to non-disabled students. The most common disabilities in the study population were ADHD, psychiatric conditions, and learning disabilities. Because institutions self-selected to participate in the survey, the results are not generalizable to all undergraduate students across all institutions.[63]

Another survey, the National Longitudinal Transitions Study-2, which is described in greater detail in a previous section, provides nationally representative estimates of alcohol use among students. Results of an analysis by Yu et al. show that when all disabilities are combined, disabled students report lower rates of alcohol use than their non-disabled peers. However, when individual disabilities are examined, large differences come to light. For example, 54% of young adults with emotional disturbances reported alcohol use, compared to 36% of young adults with hearing impairments.[54] These results underscore the importance of disaggregating disabilities by type. The results also suggest that disabilities related to mental health conditions might be a driver of the association between disabilities and AID.

Single Disability Research

Prior research, the details of which has already been described above, has examined alcohol use among adults with intellectual disabilities.[31,53,55,68] The results suggest that adults with disabilities use alcohol at rates that are the same or lower than the general population, but when adults with intellectual disabilities use alcohol, they might drink in riskier ways. VanDerNagel, et al. reported lower rates (64%) of current alcohol use among Dutch adults with intellectual disabilities, relative to the Dutch general population (77%). Importantly, the study used a questionnaire designed specifically for persons with intellectual disabilities, which might have produced more accurate results than survey instruments designed for the general population [53]. A review article published in 2000 summarized six empirical studies of drug and alcohol use among adults with intellectual disabilities. The studies were conducted between 1981 and 1995, and used primarily convenience samples ranging in size from 55 - 377. The review reported comparable rates of alcohol abuse among adults with intellectual disabilities compared to their non-cognitively-impaired peers [68]. McGillicuddy (2006) summarized 5 studies of drug and alcohol use by disability status. The results show less alcohol use among adults with intellectual disabilities, relative to a nondisabled comparison group. However, like VanDerNagel, at al. (2017) it found that adults with intellectual disabilities that use drugs and alcohol might do so in riskier ways [55]. And in Taggart's qualitative study of 10 adults with intellectual disabilities and substance use disorders, participants reported being motivated to use drugs and alcohol as a way to cope with loss, trauma and isolation [31]. These studies highlight the inconclusiveness of this area of study and the need for higher quality research.

Another area of disability-specific research focuses on hearing difficulty. Like the studies of adults with intellectual disabilities, these investigations report similar rates of alcohol use and similar treatment outcomes for disabled adults treated for substance use. Anderson et al. which is described in greater detail above, reports little difference in alcohol use by hearing status. However, when adults who are deaf or hard of hearing do use alcohol, they have higher odds (OR = 2.5; 95% CI: 1.5 – 4.2) of heavy use, compared to hearing adults. These findings indicate that when deaf or hard of hearing adults use alcohol, they tend to be heavier users [51].

In summary, AID rates vary by age, sex and race, but no studies were identified that examined AID by disability status. A pair of cross-sectional health surveys[29,50] used a dichotomous disability variable and two different measures of alcohol use, and report seemingly contradictory findings. Longitudinal studies show that heavy alcohol use could be an early stage in a disease process that also includes a period of disability and might culminate in AID.[64,65] It also suggests a potential bidirectional relationship between disability and ongoing alcohol use. Single disability studies show the importance of disaggregating disabilities by type.[31,53,55] A survey of students found that disabilities involving emotional disturbances, which fall under the category of cognitive disabilities, are associated with alcohol use.[54] Finally, intellectual and hearing disabilities were not consistently associated with alcohol *use,* but they are associated with alcohol use disorder.[51,53,55]

Table 3. Summary of Studies Related to Disability Status and Alcohol-Induced Death

Author, Year of Publication	Study Name (Design), Year(s)	Sample Size	Exposure	Outcome	Key Findings
Anderson, 2018	NHANES (Cross-sectional Survey) 2013 – 2014	4,139	Deafness or serious hearing difficulty	Drug and alcohol use	Deaf and hard of hearing survey participants had elevated odds of regular cannabis use (OR = 1.3; 1.0 – 1.7) and heavy alcohol use (OR = 2.5; 1.5 – 4.2), compared to their hearing counterparts. However, deaf and hard of hearing adults did not have higher prevalence of drug or alcohol use.
Anderson, 2014	National Comorbidity Study Replication (Cross-sectional Survey) 2001-2003	4,883	Physical disabilities	Substance use disorder	Disabled adults had higher odds of lifetime alcohol dependence (OR = 2.2; 1.4 – 3.4) relative to nondisabled adults
Bernert, 2012	NCHS-NCHA II 2009	61,140	Disability (defined as 1,2 or more conditions from a 9-item list)	Unprescribed use of prescription drugs	Compared to non-disabled students, those with one disability had modestly (OR = 1.9; 1.7 – 2.0), and those with two or more disabilities had considerably higher (OR = 2.7; 2.4 -3.0) odds of unprescribed use of prescription drugs.
Bockerman, 2016	Older Finnish Twin Cohort Study (Prospective Cohort) 2016	12,502	Disability pension	Alcohol use	Both heavy drinkers (OR = 1.4; p < 0.01) and abstainers (OR = 2.7; p < 0.01) had increased odds of receiving a disability pension, relative to moderate drinkers.
Brucker, 2007	NSDUH (Cross-sectional Survey)	54,079	Disability (defined as general,	Drug and alcohol use	Adults with a disability had higher odds of illicit drug use (OR = 1.7; p < 0.001), illicit drug dependence (OR = 2.1; p < 0.001), and alcohol

	2002		physical or serious mental illness)		dependence (OR = 1.3; p < 0.001), compared to non-disabled adults.
Burgard, 2000	Review article 1981 – 1995	Review of 6 Prevalence Studies	Intellectual disability	Drug and alcohol use	Alcohol abuse rates were similar among adults with and without intellectual disability.
Glazier, 2013	NSDUH (Cross-sectional Survey) 2002 - 2010	337,650	Disability (defined as inability to work or Medicare before age 65)	Substance abuse	Adults with a disability had higher odds of heroin use (OR = 4.7; 2.6 – 8.6), oxycodone use (OR = 3.0; 1.8 – 5.2), and sedative use (OR = 3.0; 1.8 – 5.0), compared to those without disabilities.
Mansson, 1999	Malmo, Sweden Birth Cohort Study (Prospective cohort) 1970's to 1980's	3,751	Alcohol use	Disability pension	Both heavy drinking (RR = 1.3; 1.1 – 1.6) and abstaining from alcohol (RR = 1.8; 1.3 – 2.4) are associated with increased risk of receiving a disability pension, relative to low alcohol consumption.
McGillicuddy, 2006	Review of 5 prevalence studies published between 1983 and 1999	7 - 136	Intellectual disability	Drug and alcohol use	Adults with intellectual disability report slightly lower rates of substance use, compared to those without intellectual disability. However, adults with intellectual disability are more likely to report negative consequences from substance use, compared to adults without intellectual disability.
Spencer, 2020	Vital Statistics 2000-2018	>48 million death certificates	Descriptive study of the annual AID rate	Descriptive study of the annual AID rate	AID rates are 3.6 times higher among men, compared to women.

Taggart, 2007	Interviews with adults with intellectual disabilities and substance use disorder 2006	10	Motivation	Drug and alcohol use	Self-medicating against life's negative experiences was the overarching theme that emerged from the interviews. Subthemes were psychological trauma, like loss of close family members, physical and sexual abuse. And social distance from their community, like lack of friends and companions.
VanDerNagel, 2017	16 Organizations of the Dutch Assoc. Of Healthcare Providers for People with Disabilities 2010 - 2011	419	Intellectual disability	Drug and alcohol use	14.6% of study subjects currently used cannabis, and 1.2% currently used illicit stimulants, which are much higher rates than the Dutch general population. Reported rates of alcohol use were lower among adults with intellectual disabilities than in the Dutch general population.
White, 2020	Vital Statistics 1999 – 2017	944,880	Descriptive study of the annual AID rate	Descriptive study of the annual AID rate	AID rates are highest among persons aged 45 to 74 years.
Yu, 2008	National Longitudinal Transition Study-2 2000 - 2001	2,640	Disability type (learning, speech, emotional, visual, hearing, brain injury)	Drug use	When all disabilities are combined, disabled students report lower rates of substance use. Students with specific disabilities have significantly elevated rates of substance used, for example, 36% use illegal drugs and 54% used alcohol in the last 30 days among those with emotional disturbances.

Discussion of Case Definitions

Drug/Alcohol Abuse

The definitions of both drug and alcohol abuse are based on the Diagnostic and Statistical Manual of Mental Disorders, Fourth Revision (DSM-IV), which uses behavioral criteria, rather than blood tests or estimates of the amounts of drugs and alcohol a person uses. Under this paradigm, substance *use* becomes substance *abuse* when it interferes with work, family and other roles; requires substantial time to acquire substances or recover from substance use; places people in danger when they are under the influence of substances; and continues despite negative consequences. The complete list of criteria for DSM-IV drug/alcohol abuse, which is available online from the National Library of Medicine [42], is presented here:

- Recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home (e.g., repeated absences or poor work performance related to substance use; substance-related absences, suspensions, or expulsions from school; neglect of children or household)
- Recurrent substance use in situations in which it is physically hazardous (e.g., driving an automobile or operating machinery when impaired by substance use)
- Recurrent substance-related legal problems (e.g., arrests for substance-related disorderly conduct)
- Continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance (e.g., arguments with spouse about consequences of intoxication, physical fights)

Drug/Alcohol Dependence

Drug/alcohol dependence is identified using behavioral and physiological criteria. The criteria for drug/alcohol dependence gauge tolerance, withdrawal and failed attempts to reduce substance use. The complete list of criteria for DSM-IV drug/alcohol dependence, which is available online from the National Library of Medicine [42], is presented here:

- Tolerance, as defined by either of the following: (a) a need for markedly increased amounts of the substance to achieve intoxication or desired effect, or (b) markedly diminished effect with continued use of the same amount of the substance
- Withdrawal, as manifested by either of the following: (a) the characteristic withdrawal syndrome for the substance, or (b) the same (or closely related) substance is taken to relieve or avoid withdrawal symptoms
- The substance is often taken in larger amounts or over a longer period than intended
- There is a persistent desire or unsuccessful efforts to cut down or control substance use
- A great deal of time is spent in activities necessary to obtain the substance, use the substance, or recover from its effects
- Important social, occupational, or recreational activities are given up or reduced because of substance use
- The substance use is continued despite knowledge of having a persistent physical or psychological problem that is likely to have been caused or exacerbated by the substance (e.g., current cocaine use despite recognition of cocaine-induced depression, continued drinking despite recognition that an ulcer was made worse by alcohol consumption)

Drug Overdose Death

The definition of drug OD death was developed by the Council of State and Territorial Epidemiologists and later endorsed by the US Centers for Disease Control (CDC) (Gabella, 2014). Under this definition, drug OD deaths are identified using ICD-10 underlying cause of death and include accidental drug OD death (X40-X44), intentional drug OD (i.e., suicide) (X60-X64), drug OD homicide (i.e., assault by drugs) (X85), and drug OD of undetermined intent (Y10-Y14). Death certificates filed nationally during the timeframe covered in aim two of this dissertation, which is 2008-2019, indicate that the majority of drug OD deaths were accidental, a smaller share were suicides, and very few were homicides **(Table 4)**. Importantly, the case definition does not incorporate multiple cause of death information, which is needed to distinguish between deaths related to heroin, fentanyl, cocaine, and other specific drugs. Thus, chapter five of this dissertation focuses on all drug OD deaths, rather than opioid OD deaths only. In the view of the author, this is a pragmatic solution to a widespread problem with OD mortality statistics: that the death investigation process, including toxicology testing, varies across US jurisdictions and the specific drugs involved are often missing from death certificates, and limiting the research to cases that list specific drugs would likely omit many drug OD deaths. Furthermore, many drug OD deaths involve multiple drugs or alcohol [69] the pharmacological interactions of which make it difficult to attribute the death to a single substance.

Table 4. Underlying Cause of Drug Overdose Death, United States – 2008-2019

Cause of death	ICD-10 Code	Percent of Deaths
Accidental poisoning by exposure to drugs	X40-44	84%
Intentional self-poisoning by exposure to drugs	X60-64	10%
Assault by drugs	X85	<1%
Poisoning by drugs, undetermined intent	Y10-14	6%

Source: CDC WONDER

Alcohol-Induced Death

Alcohol-induced death (AID) is a case definition developed by the CDC to capture deaths caused by the physiological effects of alcohol on the body. The ICD-10 case definition is mental and behavioral disorders due to the use of alcohol (i.e. dependence, withdrawal, and psychosis) (F10.1 – F10.9), nervous and muscular system disorders due to alcohol (i.e. neuropathies and myopathies) (G31.2, G62.1, G72.1, I42.6), alcoholic diseases of the digestive system (i.e. cirrhosis of the liver, hepatitis and pancreatitis) (K29.2, K70.0-70.4, 70.9, K85.2, K86.0), and acute alcohol poisoning (R78.0, X45, X65, Y15) **(**Table 5**)**. AID is a more narrowly defined outcome than other indicators of the burden of alcohol use, which also include unintentional injuries, homicides, and fetal alcohol syndrome. Were these deaths to be included, the estimated burden of alcohol-related deaths would be even greater [70].

Table 5. Underlying Cause of Alcohol-Induced Death, United States – 2008-2019

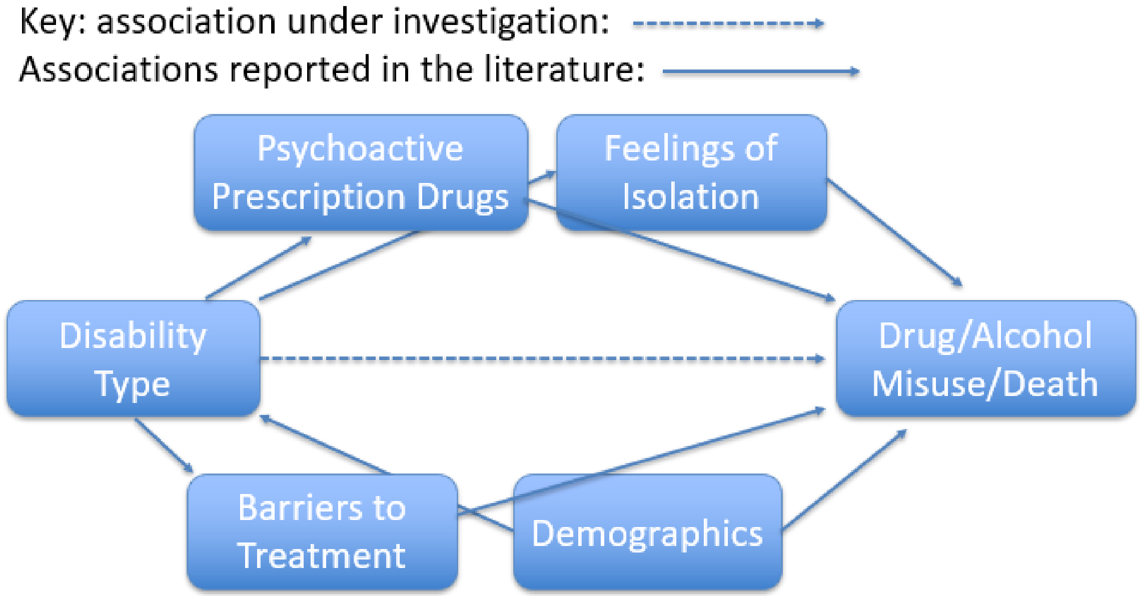
Cause of death	ICD-10 Code	Percent of Deaths
Mental and behavioral disorders due to use of alcohol, harmful use	F10.1-10.9	26%
Degeneration of nervous system due to alcohol	G31.2	<1%
Alcoholic polyneuropathy, myopathy	G62.1, 72.1,	<1%
Alcoholic cardiomyopathy	I42.6	2%
Alcoholic gastritis, fatty liver	K29.2	<1%
Alcoholic hepatitis, fibrosis and sclerosis, cirrhosis, hepatic failure	K70.0-70.4, 70.9	62%
Alcohol-induced pancreatitis	K85.2, 86.0	1%
Finding of alcohol in blood	R78.0	<1%
Accidental poisoning by and exposure to alcohol	X45	7%
Intentional self-poisoning by and exposure to alcohol	X65	<1%
Poisoning by and exposure to alcohol, undetermined intent	Y15	<1%

Source: CDC WONDER

Chapter 3: General Methods

Aim 1 utilizes the cross-sectional National Survey on Drug Use and Health (NSDUH), and Aims 2 and 3 utilize the longitudinal Mortality Disparities in American Communities (MDAC) study. Disability is the exposure in all three aims, and the outcomes are drug and alcohol use disorders (Aim 1), drug overdose (OD) death (Aim 2) and alcohol-induced health (AID) (Aim 3). Disability is conceived of as a social determinant of health,[39] which has a powerful influence on OD and AID mortality,[2–5] by putting people at increased risk for the conditions and circumstances which are the direct causes of drug OD and AID. Based on a review of the literature, these include exposure to prescription psychoactive drugs,[32] feelings of isolation,[31] and barriers to substance use disorder (SUD) treatment.[33,39] Furthermore, there are distinct patterns in the occurrence of both disability and OD and AID by demographic group.[6,12,71] Consequently, demographic categories such as age, sex, race, ethnicity, education and income have the potential to confound the association between disability and OD and AID. These relationships are depicted visually in Figure 1, where the dashed line represents the main association under investigation, and the solid lines represent associations with covariates that are reported in the literature. For all three aims, demographics are "parents" of both the exposure and outcome.[11,12,33,34] Therefore, demographics are assumed to affect the exposure and outcome unidirectionally. The graph also includes three mediators: prescription psychoactive drugs,[26,32] feelings of isolation,[31] and barriers to treatment.[33,34] These variables are assumed to be "children" of disability type and "parents" of drug or alcohol use or death. As a result, they are affected by disability type and they affect drug or alcohol use disorders or death (Figure 1).

Figure 1. Directed Acyclic Graph Summarizing Exposure, Outcome and Known Covariates



Unfortunately, none of the data sources used in this dissertation include all the necessary information to test this conceptualization of the disability and substance use association. This directed acyclic graph is presented as a conceptual outline which informs the three studies that make up the core of this dissertation.

The criteria and methods used to identify disability in the population are of primary importance in disability and health research. Despite efforts to standardize the definition of disability, estimates of disability prevalence vary across data sources. For example, the 2010 American Communities Survey (ACS) reports that approximately 33.9 million adults aged 16 or older have one or more disabilities, as defined by the 6 US Department of Health and Human Services (HHS) questions [19]; while the 2010 Current Population Survey (CPS), which is also implemented by the US Census Bureau and uses the 6 HHS questions, reports that 26.6 million adults aged 16 or older have one or more disabilities.[20] Similarly, in the results sections of Aim 1 of this dissertation, which used the 2018-2019 NSDUH, and Aims 2 and 3, which use the 2008

ACS, estimates of the prevalence of any disability, and specific disability types, differ. These differences are likely attributable to differences in survey mode, context and years of administration. The ACS is a mixed-mode survey in which most responses are provided using paper and pencil and returned by mail. The NSDUH is a computer-assisted self-interview. The context of the ACS survey is demographic and economic while the NSDUH focuses on health, and the ACS data come from 2008, while the NSDUH data come from 2018-2019.

A detailed description of the disability categories used in the dissertation manuscripts is included in chapters 4 - 6, respectively. Briefly, the distribution of disability types was used to inform classifications. It was necessary to create mutually-exclusive disability categories for analytic reasons, and this was accomplished by combining hearing and seeing into a single category, because both are sensory disabilities, and then using the survey weights to determine the most common individual disabilities and disability combinations. There are many possible combinations of reported disabilities, however combinations of disabilities representing less than one percent of the target population are especially prone to survey error. Therefore, several low-prevalence combinations of disabilities were combined into a category labelled “other.”

Analytically, the final disability categories were determined by coding each individual disability as 0 = “No”, 1 = “Yes,” and combining individual disability variables to form a single disability summary variable (Table 6).

Table 6. Creation of Disability Summary Variable Using Indicators of Three Distinct Types of Disabilities

Respondent ID	Ambulatory	Cognitive	Hearing/Seeing	Disability Summary
1	0	0	0	0,0,0
2	0	0	1	0,0,1
3	1	0	0	1,0,0
4	0	1	0	0,1,0
5	1	0	1	1,0,1
6	1	1	0	1,1,0
7	1	1	1	1,1,1
…	0	1	1	0,1,1

The weighted percentage of the target population within each category was then determined, and disability combinations representing approximately one percent or less of the target population were combined into a single "other" category. For Aim 1, the 2018-2019 NSDUH data from persons age 18 or older with no missing values for the analytic variables were used to determine the most common types of disabilities and disability combinations (**Table 7)**.

Table 7. Weighted Percentage of Disabilities and Disability Combinations: Data from 2018-2019 NSDUH Respondents Age 18 or Older

Disability Status	Weighted Percent
None	80.3%
Hearing/Seeing	5.4%
Ambulatory	4.9%
Cognitive	4.6%
Ambulatory, Hearing/Seeing	1.6%
Other[a]	3.2%

[a]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

For Aims 2 and 3, the 2008 ACS data from persons age 18 or older were used to determine the most common types of disabilities and disability combinations (**Table 8)**.

Table 8. Weighted Percentage of Disabilities and Disability Combinations: Data from 2008 ACS Respondents Age 18 or Older

Disability Summary	Weighted Percent
None	85.8%
Ambulatory	4.5%
Hearing/Seeing	3.3%
Cognitive	2.0%
Ambulatory, Hearing/Seeing	1.4%
Other[a]	3.0%

[a]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive, and hearing/seeing).

The Institutional Review Board of the University of Maryland classified the dissertation research as exempt.

Aim 1: Self-Reported, Non-Fatal Drug and Alcohol Use Disorder Among Adults with Different Types of Disabilities

Data Source

The NSDUH is a nationally representative cross-sectional study of the US civilian non-institutionalized population that collects information on drug and alcohol use, as well as detailed demographic and socioeconomic information.[72] The NSDUH is specifically designed to elicit accurate responses to questions about sensitive topics, like substance use. This is accomplished by using audio computer-assisted self-interviewing (ACASI) to minimize social desirability bias and interviewer effects. The NSDUH also reduces social desirability bias by not recording the full names of respondents.[73] The data collection protocol allows respondents to complete the survey on their own electronic device, or using a laptop provided by the interviewer. The survey takes approximately one hour to complete and respondents receive a $30 incentive for participating.[74]

The NSDUH Field Manual provides specific guidance for interviewing blind, deaf and physically impaired respondents. Blind individuals are to listen to recordings of the questions using headphones. If possible, blind individuals are to use the 1, 2, and Enter keys to answer the survey questions. If needed, a blind respondent can tell the field interviewer their answer and the interviewer can enter the information. Importantly, the interviewer is instructed to cover the computer screen with a piece of paper to ensure confidentiality.[75]

The Field Manual also provides special instructions for gathering information from deaf respondents. The instructions direct deaf respondents to read the survey questions themselves and enter their responses using the computer keypad. If the respondent has questions, or if the field representative needs to probe, the Field Manual instructs them to communicate in writing on paper.[75]

Disability Questionnaire

The NSDUH includes questions recommended by the HHS for the identification of disabilities in population-based surveys.[76] The public health literature includes several examples of peer-reviewed disability research papers that has been conducted using these questions.[22,77] Pilot testing by the US Census Bureau demonstrated that the questions produce consistent responses when administered to the same individual at different points in time, and produce few refusals and responses of “don’t know,” which are coded as missing values.[16] Furthermore, the validity of HHS disability measures has been corroborated through comparisons with the longer and more detailed National Health Interview Survey.[23]

HHS disability measures used in the classification of the exposure are:

Are you deaf or do you have serious difficulty hearing? [Y/N]

Are you blind or do you have serious difficulty seeing, even wearing glasses? [Y/N]

Because of a physical, mental or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions? [Y/N]

Do you have serious difficulty walking or climbing stairs? [Y/N]

Two additional questions which capture activities of daily living (ADLs) and instrumental activities of daily living (IADLs) were not included because they are not specific to a particular type of disability.

The ADL question is:

Do you have difficulty dressing or bathing? [Y/N]

The IADL question is:

Because of a physical, mental or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping? [Y/N]

Aims 1, 2 and 3 include sensitivity analyses demonstrating that the effect of this exclusion is negligible.

Identification of Drug and Alcohol Use Disorders

Aim 1 includes two outcomes: 1) illicit drug dependence or abuse in the past year; 2) alcohol dependence or abuse in the past year. The NSDUH drug and alcohol use disorder categories are based on the American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders 4th Revision (DSM-IV), and have been used in numerous peer-reviewed articles.[24–26,29,45,50,78,79] The derivation of drug and alcohol use disorder exposures is shown below **(Table 9).**

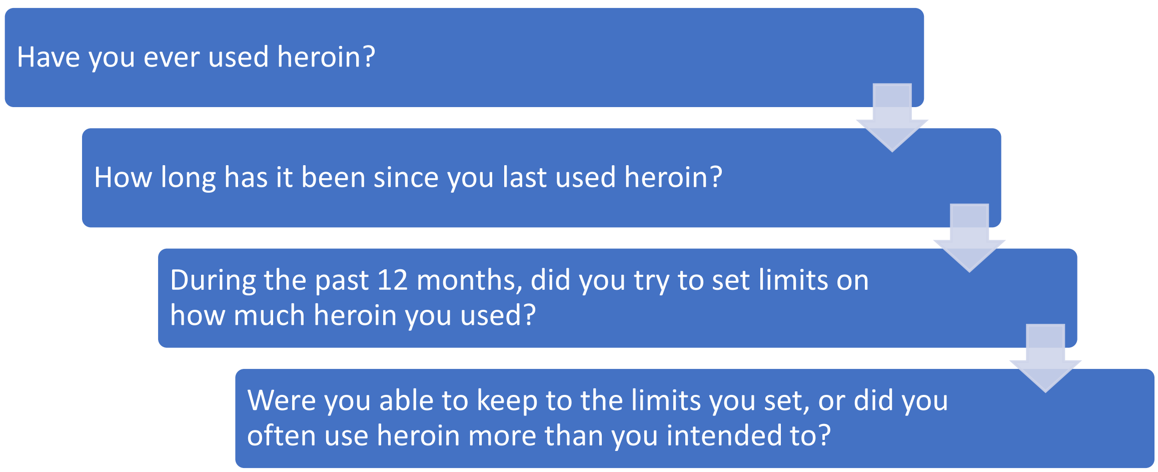
Table 9. Derivation of Drug and Alcohol Use Disorder Variables Using NSDUH Survey Questions

Dependence Criteria **(3 or more of the following + withdrawal)**	***Abuse Criteria*** **(1 or more of the following)**	***Final Analytic Variable***
1. Spent a great deal of time over a period of a month getting, using, or getting over the effects of the substance. 2. Unable to keep set limits on substance use or used more often than intended. 3. Needed to use substance more than before to get desired effects or noticed that using the same amount had less effect than before. 4. Unable to cut down or stop using the substance every time he or she tried or wanted to. 5. Continued to use substance even though it was causing problems with emotions, nerves, mental, or physical health problems.	1. Reported having serious problems due to substance use at home, work, or school. 2. Reported using substance regularly and then did something where substance use might have put them in physical danger. 3. Reported substance use causing actions that repeatedly got them in trouble with the law. 4. Reported having problems caused by substance use with family or friends and continued to use substance even though it was thought to be causing problems with family and friends.	Past year illicit drug dependence or abuse Past year alcohol dependence or abuse

6. Reduced or gave up participation in important activities due to substance use.

The criteria for substance use disorders can be met with unsafe use of illicit drugs, prescription drugs, or alcohol. Below, is an example of a four-question series used to identify substance use disorders among persons who use heroin **(Figure 2)**.

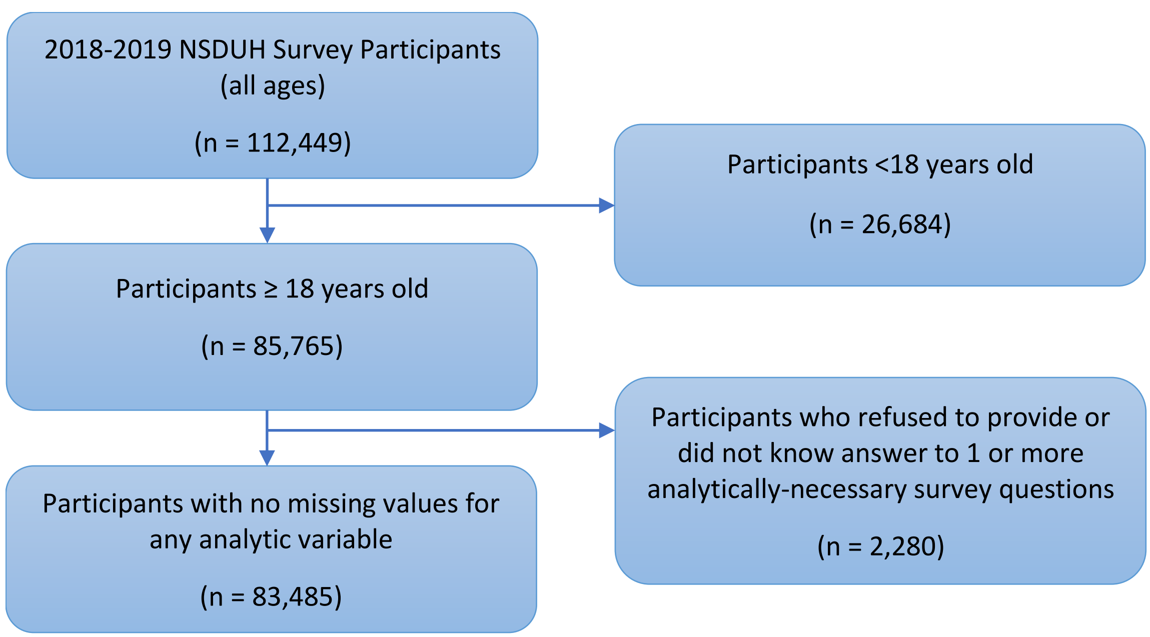
Figure 2. Sample of NSDUH Heroin Use Questions



The public-use microdata files available from samhsa.gov were used for data analysis. Although the 2020 public-use files were released during the writing of this dissertation, there were several compelling reasons to use the 2018-2019 data. First, in 2020 data collection methods were modified due to the COVID-19 pandemic. The use of different methods might have affected estimates by both disability and SUDs. For example, increased use of telephone interviewing may have reduced participation by deaf individuals. Second, the 2020 NSDUH used updated SUD case definitions from a more recent iteration of the DSM. As a result, the data cannot be pooled with earlier years to create the sample sizes necessary for this investigation, which focuses on both an exposure and an outcome with low prevalence.

The combined NSDUH 2018 and 2019 surveys included 112,449 participants and response rates were 66.6% and 64.9%, respectively.[80] The analytic sample was restricted to survey participants aged greater than or equal to 18, which resulted in the exclusion of 26,684 survey participants who were younger than 18 at the time of the survey. From the remaining 85,765 survey participants aged greater than or equal to 18, 2.7%, were excluded due to missing values for one or more of the analytic variables included in the study. After applying these criteria, the final analytic sample size was n=83,485 (Figure 3).

Figure 3. Creation of Study Population from NSDUH, Aim 1



Covariates

Disability status and substance use are both associated with a range of socioeconomic and demographic covariates, which could confound the association between the two phenomena. The literature indicates that both disability and substance use are associated with age, sex, race/ethnicity, poverty, education and marital status,[21,22,25,29,78] all of which are captured in the NSDUH and were included in the statistical analysis. Potential confounders were divided into two different groups: demographic and socioeconomic. The final results include unadjusted estimates, estimates adjusted for demographic confounders, and both demographic and socioeconomic confounders. Additional information about these covariates is included in chapter 4.

Potential Sources of Bias

The protocol for selecting NSDUH respondents is a potential source of bias in Aim 1. The protocol, which is summarized in the NSDUH Field Interviewer Manual says, “At some point, you might encounter a respondent who has limitations or is impaired in some way. The main concern is whether the respondent is physically, mentally, and emotionally capable of participating in the study. Always use sensitivity and good judgement to determine whether they are capable of participating in the study.”[75] This guidance could result in selection bias if field representatives deliberately avoid interviewing adults with more severe or more visible disabilities, thus jeopardizing the generalizability of the results for Aim 1. Rather than representing, the entire civilian, non-institutionalized population, Aim 1 results might only represent the subset of this population that does not have severe or visible disability.

The potential for exposure misclassification also exists within the NSDUH study population. As described above, the HHS disability questions ask whether survey participants experience “serious difficulty” seeing, hearing, thinking and walking. Because survey participants might perceive “serious difficulty” differently, the reporting of disability status is subject to both false positives and false negatives. In response to this concern, Altman et al.

analyzed data from the 2011 NHIS, which included the HHS disability questions used in this dissertation, and additional questions on Social Security Disability Income (SSDI).[23] Because SSDI requires medical verification, it is likely an objective indicator of disability. Altman et al.'s results show that the HHS question accurately identify most persons who receive SSDI, including persons with each of the 14 types of disability conditions included in the study. However, Altman et al.'s study does not include a determination of disability status by an independent observer, but rather compares two self-reported measures, thus the results of their study and this dissertation are still subject to differential and non-differential exposure misclassification, which would bias results away from or towards the null.

Social desirability bias is also a potential source of bias in Aim 1. Although the NSDUH is designed to minimize this bias by using ACASI and providing assurances of confidentiality,[80] the potential exists for both under- and over-reporting of substance use due to survey participant's perception of the socially-desirable response to the survey questions. A validity study conducted in conjunction with the 2000 and 2001 National Household Survey on Drug Abuse, a precursor to the NSDUH, evaluated the accuracy of self-reported information on drug use by corroborating participant's responses using urine test results. Survey questions were modified based on the limitations of urinalysis. Rather than asking about the past year, respondents were only asked about the past seven days, a timeframe in which urine tests can provide accurate results. Within a sample of 4,000, there were sufficient positive urine test and affirmative question responses to evaluate the accuracy of questions about cocaine use, but not opioids. The results showed 98.5% agreement between urine test results and responses to question about cocaine use in the previous seven days.[81] These results suggest that, within the study population, the effect of social desirability bias on estimates of some types of drug use might be negligible.

Despite evidence of a high level of accuracy in the overall NSDUH study population, the methods used to collect information from *disabled* NSDUH participants might be a source of social desirability bias within this subpopulation. The NSDUH Field Manual instructs blind survey participants who are unable to input their answers directly into a laptop computer to tell their response to the NSDUH interviewer. This could introduce social desirability bias if it results in the under-reporting of stigmatized behaviors, like substance use disorder. Because other survey participants input their answers directly into a computer, the bias would be differential, with blind participants underreporting substance use disorder to a greater extent than other survey participants. This would bias estimates of the association between blindness and substance use disorder towards the null, resulting in an underestimate of the true association.

As is the case for blind survey participants, data collection methods for deaf survey participants might also be a source of bias. The NSDUH Field Manual instructs deaf survey participants to read the survey questions themselves from the laptop computer used to collect the data. This procedure requires deaf participants to have sufficient reading comprehension to understand and answer correctly. Deaf participants who misunderstand questions might input answers less accurately, resulting in non-differential misclassification, and estimates of the association between deafness and substance use disorder that are biased towards the null, resulting in an underestimate of the true association. This source of bias is likely to be especially acute for survey participants with deafness *and* cognitive disability.

Power Calculations

The online logistic regression sample size calculator available from the Chinese University of Hong Kong (https://www2.ccrb.cuhk.edu.hk/stat/epistudies/reg3.htm) was used to perform a power analysis. Calculations are based on F. Hsieh, D. Bloch and M. Larsen's *A Simple Method of Sample Size Calculation for Linear and Logistic Regression.* Stanford, 1998. Print.

According to this method, a sample size of 28,885 would be required to detect a difference in the risk of drug or alcohol use disorder between disabled and non-disabled adults. The following parameters were used to estimate power:

Alpha (the probability of a type I error) = 0.05

Beta (the probability of a type II error) = 0.50

P_1 (the prevalence of substance use disorder among the exposed) = 0.00467. This was based on preliminary analysis of NSDUH data performed using public data.

P_2 (the prevalence of substance use disorder among the unexposed) = 0.00569. This was based on preliminary analysis of NSDUH data performed using public data.

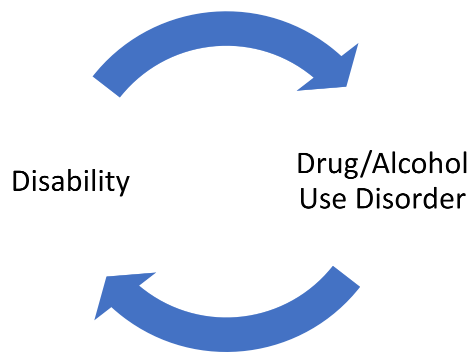
B (the proportion of the sample with the lowest prevalence disability – IADL difficulty) = 0.025.

Because the 2019 NDSUH has a sample size of 55,530, and a sample of 28,885 is required to detect differences, the proposed study is likely to have sufficient statistical power.

Limitations

Problems related to temporal ambiguity bias are an inherent limitation of cross-sectional data. In Aim 1, it is impossible to ascertain whether substance use disorder began before or after the onset of disability. In other words, it cannot be determined whether the exposure preceded the outcome. This is especially concerning in light of longitudinal studies that show that non-disabled adults who use alcohol might be at increased risk for developing disability.[64,65,82–84] The potential exists for a similar relationship between drug use and disability.[85] Among individuals with each of the disability types included in this analysis, there could be persons whose disability onset was related to substance use. Furthermore, there might be a reciprocal relationship between substance use and disability through which both conditions worsen in tandem (Figure 4).

Figure 4. Potential Bidirectional Relationship Between Disability and Drug/Alcohol Use Disorder



A related limitation is the one-time data collection process used by the NSDUH to determine disability status, and the survey's lack of information on duration of disability. Ideally, the duration of disability would be measured, and different exposure categories would be created for long-term and short-term disability. Because the NSDUH only captures disability status at the time of interview, and does not capture onset of disability,[86] it is impossible to distinguish between short-term and long-term disabilities. In future research, the robustness of the main findings reported in Aim 1 should examined by analyzing time trends. Specifically, whether adults with disabilities who gain new functional capacity experience a decrease in substance use disorders.

However, because the goal of Aim 1 is to describe the cross-sectional association between types of disabilities and substance use, the available data are likely adequate for achieving the research objective. It is also noteworthy that disability is just one of many characteristics that could be associated with increased risk of substance use disorder. Others include mental illness, genetics and environmental influences.[79,87]

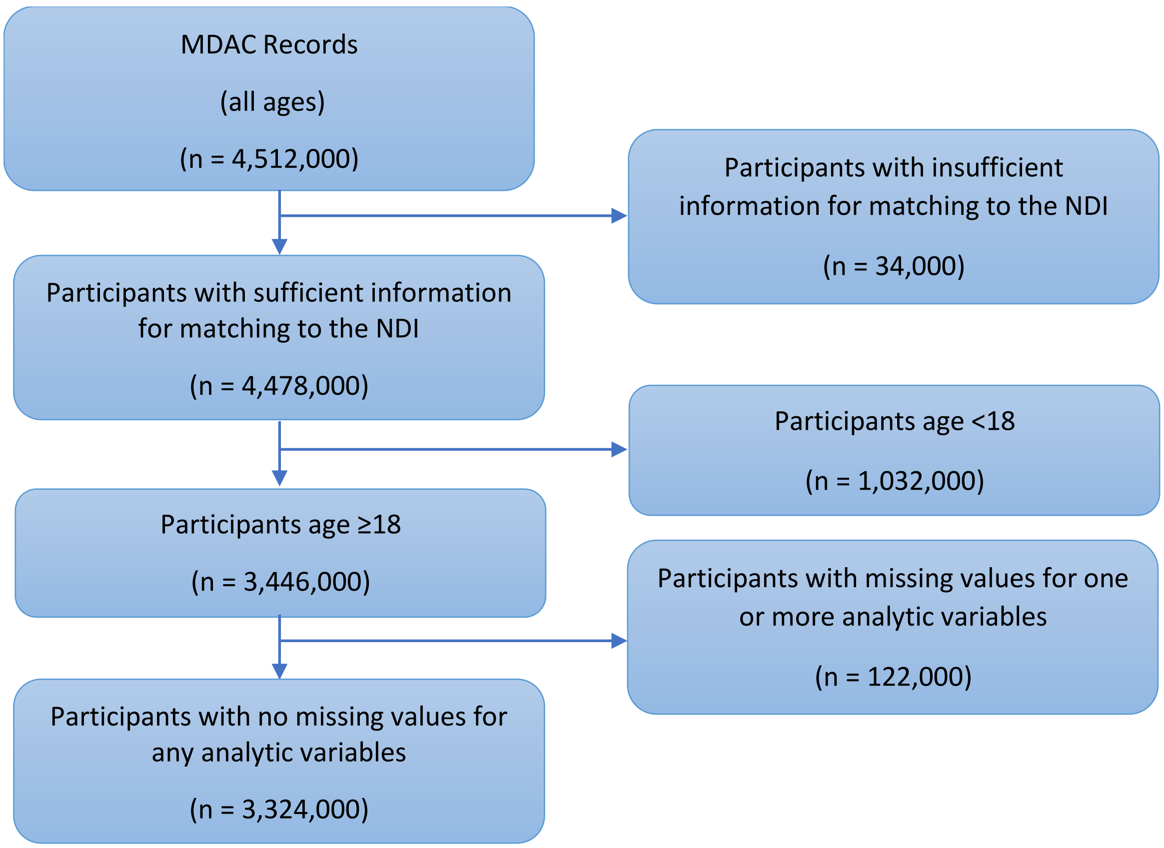
Aim 2: Drug Overdose Deaths Among Adults with Different Types of Disabilities

Data Source

The Mortality Disparities in American Communities (MDAC) study was formed by linking the 2008 ACS with 2019 National Death Index (NDI) data to create a prospective cohort. To be clear, the ACS is a cross-sectional survey, but it becomes a prospective cohort when it is linked to the National Death Index after 12 years has elapsed. More recent ACS data have not been linked to the NDI, which makes the study a close cohort. The 2008 ACS includes approximately 4,512,000 records and it contains questions on disability, demographics, and socioeconomic status. The NDI contains death certificate information reported by vital records offices throughout the US. The procedures used to ascertain cause of death depend on a decedent's place of death (i.e., inside or outside of a healthcare setting), and person completing the death certificate (i.e., a coroner or medical examiner).[88] Deaths that occur within healthcare settings, such as a hospital, are often certified by a physician and cause of death is ascertained using medical records, laboratory tests, and other diagnostic procedures.[89] Deaths that occur outside of a healthcare setting are often certified by a medical examiner or coroner. Medical examiners are often physicians trained to use laboratory testing and other medical techniques to ascertain cause of death.[90] Coroners are not necessarily physicians and might or might not receive specialized training to ascertain cause of death.[90] In the MDAC, the accuracy of cause of death information, including drug- and alcohol-related causes, likely varies by jurisdiction . Linkage to the NDI was used to determine which survey participants had died, their date of death, and their underlying cause of death, which was coded using *ICD*-10. Linkage was performed at the National Center for Health Statistics using Social Security Number (SSN), first name, last name and date of birth.[86] ACS records lacking sufficient information to match to the NDI and were excluded from the analytic sample used in Aims 2 and 3. The accuracy of record linkage is a product of the quality and completeness of both the ACS and NDI data, and both "false positive" and "false negative" matches are possible when data quality is poor.[91] The NDI minimizes false negatives by using different combinations of identifiers to match survey data to death certificates, including Social Security Number; date of birth; first name, last name and middle initial; and father's surname. In situations where survey records are missing one of these values, deaths can still be identified using the identifiers that are present. The NDI minimizes false positives by identifying the number of concordant and discordant fields in the ACS and death certificate data, and providing guidance for the adjudication of potential matches.[91] Nearly all (91%) of ACS records included a Social Security Number, which increased the potential for accurate matching to the NDI. Approximately half of the remaining records were eligible for matching to the NDI using name and date of birth (MDAC Manual). The PhD Candidate obtained all necessary approvals for accessing the MDAC data, including an FBI background check, fingerprinting, and numerous required trainings. To further protect confidentiality, all results are rounded to four significant digits.

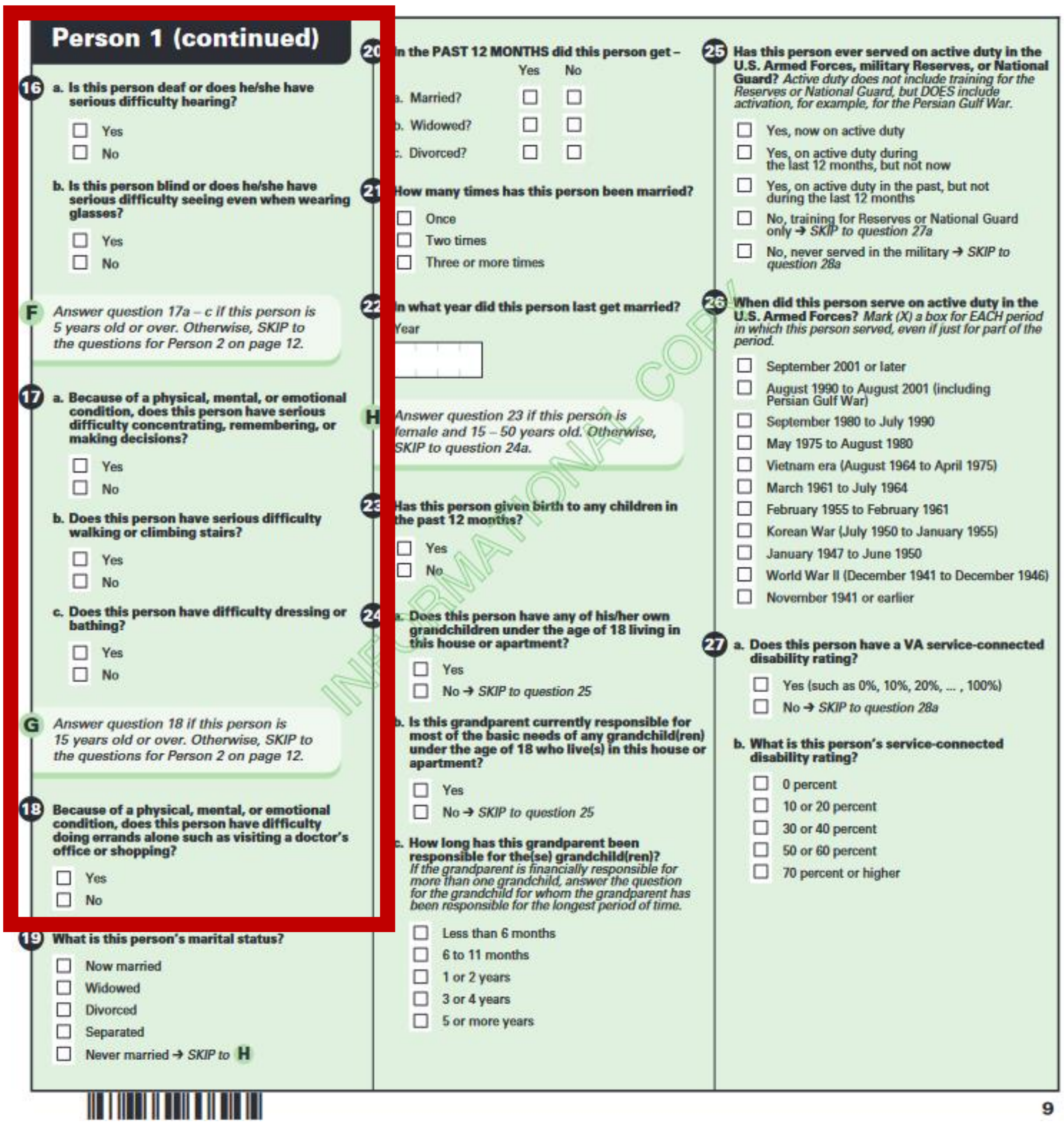
Of the 4,512,000 MDAC records, 34,000 (0.7%) had insufficient information for matching to the NDI and were excluded. Of the remainder, 1,032,000 (23.0%) corresponded to survey participants younger than 18 years and were excluded. Of the remainder, 122,000 (3.7%) had missing values for one or more of the analytic variables and were excluded. After applying these criteria, the final analytic sample size was n=3,324,000 (Figure 5).

Figure 5. Creation of Study Population from MDAC, Aim 2



The ACS includes the HHS disability questions, which are designed for use in population-based surveys.[92] Additional details are available under Aim 1. The full questionnaire, as it appeared in the 2008 ACS, is included below (Example 1).

Example 1. 2008 American Community Survey Questionnaire page 9



Person 1 (continued)

16 a. **Is this person deaf or does he/she have serious difficulty hearing?**
- ☐ Yes
- ☐ No

b. **Is this person blind or does he/she have serious difficulty seeing even when wearing glasses?**
- ☐ Yes
- ☐ No

F *Answer question 17a – c if this person is 5 years old or over. Otherwise, SKIP to the questions for Person 2 on page 12.*

17 a. **Because of a physical, mental, or emotional condition, does this person have serious difficulty concentrating, remembering, or making decisions?**
- ☐ Yes
- ☐ No

b. **Does this person have serious difficulty walking or climbing stairs?**
- ☐ Yes
- ☐ No

c. **Does this person have difficulty dressing or bathing?**
- ☐ Yes
- ☐ No

G *Answer question 18 if this person is 15 years old or over. Otherwise, SKIP to the questions for Person 2 on page 12.*

18 **Because of a physical, mental, or emotional condition, does this person have difficulty doing errands alone such as visiting a doctor's office or shopping?**
- ☐ Yes
- ☐ No

19 **What is this person's marital status?**
- ☐ Now married
- ☐ Widowed
- ☐ Divorced
- ☐ Separated
- ☐ Never married → *SKIP to* **H**

20 **In the PAST 12 MONTHS did this person get –**

	Yes	No
a. Married?	☐	☐
b. Widowed?	☐	☐
c. Divorced?	☐	☐

21 **How many times has this person been married?**
- ☐ Once
- ☐ Two times
- ☐ Three or more times

22 **In what year did this person last get married?**

Year

H *Answer question 23 if this person is female and 15 – 50 years old. Otherwise, SKIP to question 24a.*

23 **Has this person given birth to any children in the past 12 months?**
- ☐ Yes
- ☐ No

24 a. **Does this person have any of his/her own grandchildren under the age of 18 living in this house or apartment?**
- ☐ Yes
- ☐ No → *SKIP to question 25*

b. **Is this grandparent currently responsible for most of the basic needs of any grandchild(ren) under the age of 18 who live(s) in this house or apartment?**
- ☐ Yes
- ☐ No → *SKIP to question 25*

c. **How long has this grandparent been responsible for the(se) grandchild(ren)?** *If the grandparent is financially responsible for more than one grandchild, answer the question for the grandchild for whom the grandparent has been responsible for the longest period of time.*
- ☐ Less than 6 months
- ☐ 6 to 11 months
- ☐ 1 or 2 years
- ☐ 3 or 4 years
- ☐ 5 or more years

25 **Has this person ever served on active duty in the U.S. Armed Forces, military Reserves, or National Guard?** *Active duty does not include training for the Reserves or National Guard, but DOES include activation, for example, for the Persian Gulf War.*
- ☐ Yes, now on active duty
- ☐ Yes, on active duty during the last 12 months, but not now
- ☐ Yes, on active duty in the past, but not during the last 12 months
- ☐ No, training for Reserves or National Guard only → *SKIP to question 27a*
- ☐ No, never served in the military → *SKIP to question 28a*

26 **When did this person serve on active duty in the U.S. Armed Forces?** *Mark (X) a box for EACH period in which this person served, even if just for part of the period.*
- ☐ September 2001 or later
- ☐ August 1990 to August 2001 (including Persian Gulf War)
- ☐ September 1980 to July 1990
- ☐ May 1975 to August 1980
- ☐ Vietnam era (August 1964 to April 1975)
- ☐ March 1961 to July 1964
- ☐ February 1955 to February 1961
- ☐ Korean War (July 1950 to January 1955)
- ☐ January 1947 to June 1950
- ☐ World War II (December 1941 to December 1946)
- ☐ November 1941 or earlier

27 a. **Does this person have a VA service-connected disability rating?**
- ☐ Yes (such as 0%, 10%, 20%, ... , 100%)
- ☐ No → *SKIP to question 28a*

b. **What is this person's service-connected disability rating?**
- ☐ 0 percent
- ☐ 10 or 20 percent
- ☐ 30 or 40 percent
- ☐ 50 or 60 percent
- ☐ 70 percent or higher

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https://www2.census.gov/programs-surveys/acs/methodology/questionnaires/2008/quest08.pdf

Covariates

Disability status and drug OD are both associated with a range of socioeconomic and demographic covariates, which could confound the association between the two occurrences. In this study, only variables included in the 2008 ACS could be controlled statistically in the statistical models. A review of the literature determined that the following ACS variables are associated with both disability and drug OD: age, sex, marital status and poverty.[8,13,21,22,78,93] Other potential confounders are Hispanic origin, race, education and unemployment.[2–4] For modeling, these potential confounders were divided into two distinct groups: demographic and socioeconomic. Results of analyses adjusted of demographic risk factors indicate what the association between the exposure and outcome *would be* if the distribution of age, sex, and race/ethnicity were the same among the exposed and unexposed populations.[94] The results of estimates adjusted for demographic *and* socioeconomic risk factors indicate what the association between exposure and outcome *would be* if the distribution of the aforementioned variables, and poverty, education, unemployment, and marital status, were the same among exposed and unexposed populations.[94]

Potential Sources of Bias

The research conducted under Aim 2 is susceptible to information bias and social desirability bias. Information bias might occur if the survey questionnaire is not correctly understood or completed by survey participants or if cause of death is not accurately recorded on death certificates. Although the Census Bureau performed cognitive testing to improve the construct validity of the survey instrument,[16] some participants might still misunderstand the questions. This is likely to be more common among persons with cognitive difficulty, who are a major focus of Aims 2 and 3. The ascertainment of lower quality information from adults with cognitive disability would result in non-differential misclassification, which would bias results towards the null. Information bias might also result from inaccurately recorded causes of death, which would likely bias results towards the null. Underreporting of deaths from suicide has been reported worldwide,[95] and underreporting of drug overdose mortality is also likely. As described more fully in the limitations section below, the accuracy of cause of death information varies by jurisdiction in the U.S.. The comingling of more-accurate, and less-accurate information would result in the misclassification of the outcome of interest in Aims 2 and 3, categorizing some non-overdose decedents as overdose decedents, and vice versa. This non-differential misclassification would bias results towards the null.

Social desirability bias might also affect the accuracy of some variables included in the MDAC. The stigmatization of disability could result in underreporting of the conditions that comprise the main exposures in Aims 2 and 3. Reporting of cognitive disability caused by mental illness might be especially prone to this source of error. Social desirability bias might also result in underreporting of OD deaths due to the stigma associated with substance use, and this problem might be especially acute for intentional OD deaths (i.e., suicides involving drugs). In order to avoid this potential measurement issue, a broad definition of drug OD death was used that includes all intents (accidental, suicide, homicide, undetermined). Nevertheless, under-reporting of drug OD suicides might result in an underestimate of the association between cognitive disability, which includes severe anxiety and depression, and drug OD death.

Power Calculations

Power was estimated using the PS: Power and Sample Size Calculation Software from the Vanderbilt University Department of Biostatistics for Power Calculations.[96] Based on published summaries of the MDAC study population characteristics and hazard ratios from

Altekruse et al. 2020, power approaches 1.0 with a sample size of 1,000 (Figure 6).[3,86] The MDAC has a sample size of 4,512,376 which provides sufficient power to determine the effect of disability status on OD risk.[86] Additional details are provided below.

Definitions and inputs:

Power – is the probability of correctly rejecting the null hypothesis of equal survival times for exposed and unexposed given *n* exposed survey respondents, *m* unexposed survey respondents per exposed respondent, Type I error probability *alpha*, and the true median survival time m_1 and the hazard ratio *R* (or true median survival times m_1 and m_2).

Alpha – the Type I error probability for a two-sided test. This is the probability that we falsely rejected the null hypothesis (0.05).

A – the accrual time during which patients are recruited (1 year).

R – the hazard ratio (1.25).[3]

m – the ratio of exposed to unexposed survey respondents (40 because the lowest prevalence disability is difficulty seeing (2.5%)[86] and 1.000 / 0.025 = 40)

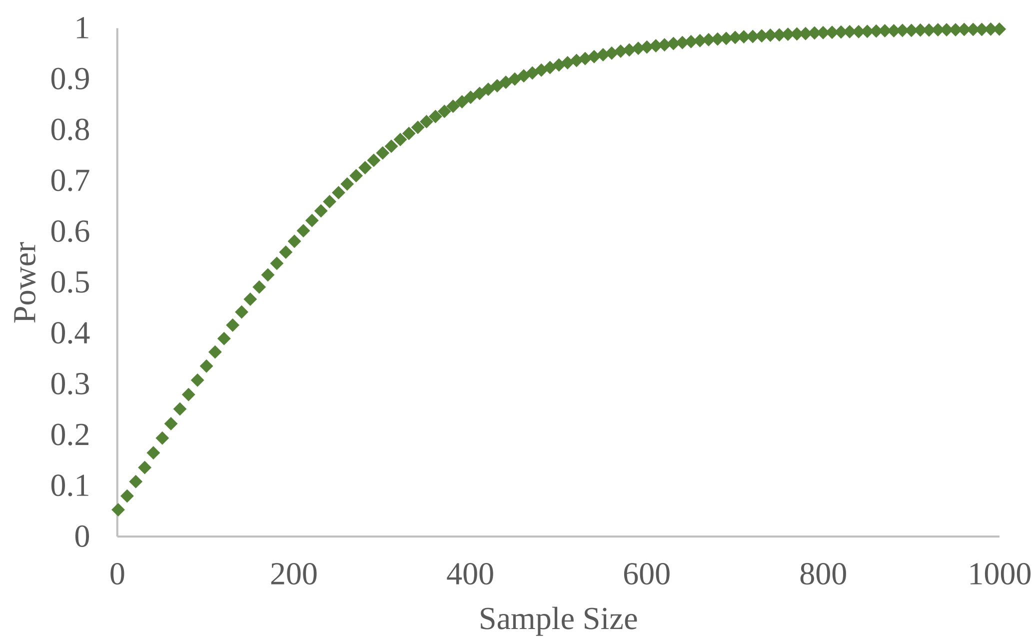
F – additional follow-up time after the end of recruitment (12 years because 2019 – 2008 = 12, when time is counted from January 1st until December 31st)

n – number of patients who receive the experimental treatment (the number with difficulty seeing, the lowest prevalence disability = 111,298[3])

m_1 – the median survival time of control patient (12 years because 92% of subjects were alive at the end of the 12-year study)[3]

The MDAC includes at least 111,298 disabled adults (equal to the number of ACS respondents with visual impairment, the lowest prevalence disability), 4,451,920 unexposed survey respondents (equal to the number of ACS respondents without visual impairment), an accrual interval of 1 year (the amount of time the 2008 ACS was in the field), and additional follow-up after the accrual interval of 12 years (the amount of time between baseline and the end of follow-up). In a previous study by Altekruse et al., 93% of ACS participants were alive after 8 years. If the true hazard ratio (relative risk) of control subjects relative to experimental subjects is 1.25 (a conservative estimate considering Altekruse's 2020 report of an HR of 2.80), this study will be able to reject the null hypothesis that the exposed and unexposed curves are equal with probability (power) 1.000. The Type I error probability associated with this test of this null hypothesis is 0.05.

Figure 6. Power Calculation Based on Published Estimates of Overdose Risk by Disability Status and MDAC Study Population Characteristics



Limitations

ACS disability data might be subject to several limitations. Because disability information is self-reported or reported by a proxy, it might be affected by the respondent's comprehension of the survey question, awareness of disabling conditions and willingness to disclose such information. This could lead to misclassification of the exposure. Furthermore, the questions are yes/no, which fails to capture the extent of an individual's limitations.

The validity of the ACS disability questions has been assessed using data from the National Health Interview Survey (NHIS). As reported by Altman et al (2017), the 2011 NHIS included the ACS disability questions in addition to questions about Social Security Disability and Supplemental Security Income benefits. Because qualification for these benefits requires a medical examination, they are thought to be accurate measures of disability. The NHIS also includes questions about mental and physical health, which were used to construct additional measures of disability. Altman's study found that the ACS questions, "produce an unbiased picture of the population with disabilities by including persons with all conditions, more severe disabilities or selected types of functional limitations."[23]

In future studies, concordance analyses could be used to determine the accuracy of disability status using Medicare data. Medicare provides insurance coverage to adults ages 65 or older and younger people with certain disabilities.[97] The Master Beneficiary Summary File (MBSF) provides Medicare information on all Medicare beneficiaries and is available to researchers who meet certain confidentiality requirements and have a valid research-related need to know Medicare beneficiary status.[98] The MBSF details when Medicare coverage began, and reason for qualification, including age or disability status. The accuracy of the disability identification procedure used in the present studies could be determined by evaluating the concordance of disability status identified using the HHS questions and the MBSF.

The design of the ACS and the survey's high response rate might also improve the accuracy of the disability information it collects. The ACS allows one respondent to provide information for every member of a sampled household. If the household includes a person with a disability that interferes with his or her ability to respond, the option of proxy response might avoid the omission of the person with the disability. Additionally, the use of Census Field Staff to obtain information from households that do not complete the survey might also prevent the omission of adults with disabilities from the survey. Furthermore, the inclusion of group quarters in the ACS might provide better coverage of the disabled population than surveys that exclude group quarters.

The use of one-time data collection techniques in the MDAC is also a limitation.[86] Ideally, multiple observations of the study population used in Aims 2 and 3 would be utilized to determine onset and duration of disability, and distinct exposure categories would be used for adults with long-term and short-term disabilities. A less resource intensive alternative to repeat measures of disability status would be the use of survey questions on the onset of disability, which could also be used to distinguish between long-term and short-term disabilities. If a higher "dose" (i.e., longer duration) of disability was associated with greater risk of overdose death, this would support a causal relationship between exposure and outcome. Unfortunately, no such information is available in the MDAC and therefore adults with long-term and short-term disabilities are combined into a single category. Additional research is also needed to determine whether adults who regain functional capacity display a decreased risk of drug OD or AID. Longitudinal studies that track functional capacity over time could inform public health efforts to decrease drug and alcohol deaths. Existing evidence indicating that abstinence from alcohol is associated with recovery of cognitive function,[57] suggests that a scaling up of recovery support services might reduce disparities in drug and alcohol deaths by disability status. In public health research, ecologic studies could also be used to identify time trends in disability status and determine whether there are concomitant changes in drug and alcohol deaths.

The use of the NDI to identify drug overdose death is also a limitation of the MDAC data. The NDI is comprised of death certificate information reported by state and local vital records offices throughout the US. Inconsistent procedures for investigating death scenes, and limited availability of toxicology testing, could lead to under-reporting of drug OD deaths. To minimize the potential effect of limited toxicology testing, multiple drug classes (depressants (i.e., opioids), stimulants (i.e., methamphetamine and cocaine), tranquilizers (i.e., benzodiazepines like Xanax©)) and deaths due to “other and unknown” drugs, were included in the drug OD case definitions, rather than restricting to opioids only.

In future studies, the impact of inaccurate cause of death information could be minimized by restricting the study population to persons living in jurisdictions with high-quality vital statistics. Previous studies have identified *ICD*-10 codes that represent implausible or overly general causes of death.[99] Using these “rubbish codes,” jurisdictions with poor quality vital statistics information could be excluded. Sensitivity analyses could then be used to determine the extent to which quality of cause of death information affects analyses of disability and drug overdose mortality.

A final limitation is the use of a single, point-in-time measure of disability to determine the exposure status of MDAC study participants in Aims 2 and 3. This method fails to account for the possibility that disability status could have changed during the study period. For example, some individuals identified as disabled at the time of the survey could have completed rehabilitation and not experienced disability during the rest of follow-up. Conversely, some individuals identified as non-disabled at baseline could have developed a disability during the study.

Aim 3: Alcohol-Induced Deaths Among Adults with Different Types of Disabilities

Data Source

The study design and data source in this study are identical to those listed under Aim 2. Please refer to the section above for more information.

Covariates

Similar to the approach taken in Aim 2, covariates were selected based on the information captured in the ACS, and the existing literature. Using this method, it was determined that both disability status and alcohol use disorder are associated with age, sex, income and education.[12,21,50,67] As described under Aims 1 and 2, these covariates were then divided into demographic and socioeconomic to specify the final analytic models.

Potential Sources of Bias

Because the data source and main exposures are the same in Aims 2 and 3, many of the potential sources of bias are also the same. Please refer to Aim 2 for more information. Identification of AID might be a source of bias in Aim 3. As discussed in chapter 2, AID is identified using the underlying cause of death recorded on decedent's death certificates. For non-infectious causes of death, like AID, the insights provided by diagnostic tools such as blood tests and imaging might be limited, and physicians recording underlying causes of death might instead rely heavily on notes from previous medical encounters to identify underlying cause of death. If adults with disabilities have more extensive contact with the healthcare system, the causes of death recorded on their death certificates could be more accurate than non-disabled persons. Inaccurate assignment of cause of death among non-disabled persons would result in non-differential misclassification, and bias the results in Aim 3 towards the null.

Power Calculations

PS: Power and Sample Size Calculation Software from the Vanderbilt University Department of Biostatistics was used for all power calculations.[96] The MDAC reference manual was used to gather information about the size of the study population and the prevalence of different disabilities.[86] A review of the literature did not identify studies that reported the risk of alcohol-attributable death among disabled adults. Therefore, drug OD death was used as a proxy. OD deaths were obtained from Altekruse *et al* 2020.[3] Based on this information, power approaches 1.0 with a sample size of 1,000 (Figure 7). The MDAC has a sample size of 4,512,376, which will likely provide sufficient power to determine the effect of disability status on AID risk.[86] Additional details are provided below.

Power – is the probability of correctly rejecting the null hypothesis of equal survival times for exposed and unexposed given n exposed survey respondents, m unexposed survey respondents per exposed respondent, Type I error probability *alpha*, and the true median survival time m_1 and the hazard ratio R (or true median survival times m_1 and m_2).

Alpha – the Type I error probability for a two-sided test. This is the probability that the null hypothesis will be falsely rejected (0.05).

A – the accrual time during which patients are recruited (1 year).

R – the hazard ratio (1.25).[3]

m – the ratio of exposed to unexposed survey respondents (40 because the lowest prevalence disability is difficulty seeing (2.5%)[86] and 1.000 / 0.025 = 40)

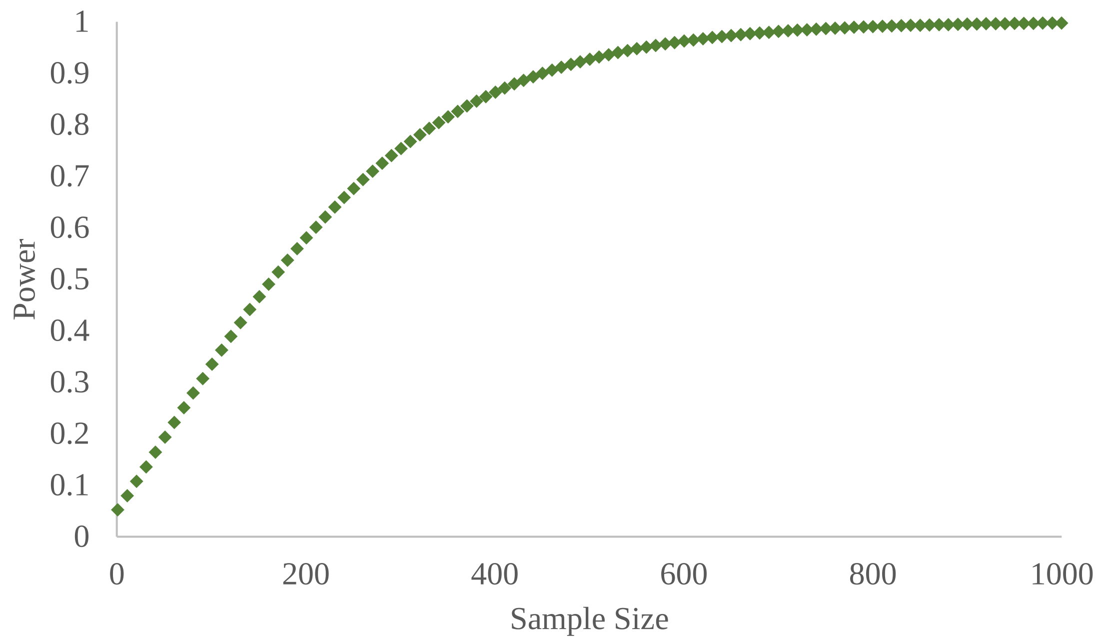
F – additional follow-up time after the end of recruitment (12 years because 2019 – 2008 = 12 when time is measured from January 1st to December 31st)

n – number of patients who receive the experimental treatment (the number with difficulty seeing, the lowest prevalence disability = 111,298)[3]

m_1 – the median survival time of control patient (12 years because 92% of subjects were alive at the end of the 8-year study)[3]

The MDAC included at least 111,298 disabled adults (equal to the number of ACS respondents with visual impairment, the lowest prevalence disability), 4,451,920 unexposed survey respondents (equal to the number of ACS respondents without visual impairment), an accrual interval of 1 year (the amount of time the 2008 ACS was in the field), and additional follow-up after the accrual interval of 12 years (the amount of time between baseline and the end of follow-up). In a previous study the median survival time of unexposed survey respondents was 8 years. This study was Altekruse 2020 in which 93% of ACS participants were alive after 8 years. If the true hazard ratio (relative risk) of control subjects relative to experimental subjects is 1.25 (a conservative estimate since Altekruse 2020 reported an HR of 2.80), the null hypothesis that the exposed and unexposed curves are equal will be rejected with a probability (power) 1.000. The Type I error probability associated with this test of this null hypothesis is 0.05.

Figure 7. Power Calculation Based on Published Estimates of Overdose Risk by Disability Status and MDAC Study Population Characteristics



Limitations

Because the same data source and main exposure are used for Aims 2 and 3, limitations related to the ascertainment of disability using the ACS, and the use of a single, point-in-time measure of disability, apply to both aims. Please refer to Aim 2 for more information.

The identification of deaths caused by alcohol using death certificates could be subject to several measurement problems. First is the inconsistent assignment of underlying cause of death. According to the CDC, the death certificate should include both the chain of events that directly caused the death, and conditions that contributed to the death. When this information is not recorded correctly, an incorrect cause of death could be assigned. Second is the potential for multiple exposures to contribute to alcohol-involved deaths. For example, cardiomyopathy could be caused by heavy alcohol use and ischemia. Similarly, hepatitis could be cause by heavy alcohol use and the hepatitis C virus. In both cases, it might be difficult to determine whether a death should be attributed to alcohol or some other cause.

Chapter 4: Drug and Alcohol Use Disorders Among Adults with Select Disabilities: the National Survey on Drug Use and Health

Keywords: Alcohol use disorder; Disability; Drug use disorder; Epidemiology; National Survey on Drug Use and Health

Abstract

Background: Deaths caused by drugs and alcohol have reached high levels in the U.S., and prior research shows a consistent association between disability status and substance use. Using national data, this study quantifies the association between disability status and drug and alcohol use disorders among U.S. adults.

Methods: The most recent pre-pandemic years (2018-2019) of the cross-sectional National Survey on Drug Use and Health (n = 83,485) were used to examine how the presence of any disability, and specific disabilities, were associated with past year drug and alcohol use disorders. Logistic regression was used to estimate adjusted odds ratios (aORs) controlling for potential sociodemographic confounders.

Results: Adults with any disability had increased odds of drug (aOR = 2.7; CI = 2.5 – 3.0), and alcohol use disorder (aOR = 1.8; CI = 1.6 – 2.0), compared to adults without disability. Examining specific types and combinations of disabilities, adults with cognitive disability had increased odds of drug (aOR = 3.3; CI = 2.9 – 3.8), and alcohol use disorders (aOR = 2.3; CI = 2.0 – 2.6), compared to adults without disability. Smaller associations were observed between hearing/seeing and ambulatory disabilities and drug use disorder. Ambulatory and hearing/seeing disabilities were not significantly associated with alcohol use disorder; but the heterogeneous "other" disability category was associated with both drug and alcohol use disorders.

Conclusions: The presence of disability, especially cognitive impairment, is associated with elevated odds of drug and alcohol use disorder among U.S. adults. Additional research should examine the temporal relationship between and mechanisms linking disability and substance use.

Introduction

Deaths caused by drugs and alcohol have reached unprecedented levels in the US, [1,71] and in response, researchers have examined a range of characteristics to describe populations at greatest risk for these occurrences.[2–4,10,78,100] A growing body of evidence indicates that there is a strong and positive association between substance use disorder and disability status.[2–4,24–26,29,50,51,53,55,59,63,68,101] Disability is the result of an interaction between an individual's abilities and their environment, which limits participation in a range of activities, rather than an inherent or immutable characteristic of an individual.[14] Disability can be categorized by the level and type of difficulty that individuals experience, including auditory, visual, ambulatory, and cognitive difficulty, which prior research shows to vary with age, sex and other demographic characteristics.[6] Disability is also associated with lower socioeconomic position, including educational attainment[22] and poverty.[21] Furthermore, approximately 40% of disabled adults have more than one type of disability,[6] which has received limited attention in prior studies.

The majority of prior studies on disability and substance use have assessed substance use among adults using a binary indicator of any disability,[24–26,50] or by specific singular types of disability.[51,53,55,59,68,101] Prior studies which used a dichotomous measure to indicate the presence or absence of any disability, defined as inability to work, the presence of specific conditions, or limitations in performing certain activities,[25,26,50,55,59] reported increased substance use among persons with any disability. Other research which assessed specific disabilities, like deafness or blindness, in relation to substance use[25,51,59,68] also shows positive associations between the presence of each of these conditions and different types of substance use. Specifically, adults with hearing loss have reported increased prevalence of heavy alcohol use,[51,59] and lifetime use of illicit drugs,[59] compared to adults that did not report hearing loss. Likewise, adults with vision loss have reported increased lifetime use of illicit drugs, compared to adults without vision loss.[59] Evidence related to substance use among adults with cognitive impairments or intellectual disabilities is limited. A number of non-probability surveys report higher rates of drug use among adults with intellectual disabilities, as measured by intelligence quotient (IQ),[53,55] but less is known about substance use among adults with cognitive disabilities more broadly.

There is also limited evidence that people with multiple disabilities are at greater risk for substance use than individuals with one disability.[59,63] One study found that adults with both vision and hearing loss have a higher prevalence of lifetime drug use, compared to adults with either condition alone.[59] Similarly, college students with two or more disabilities reported increased use of drugs and alcohol, compared to college students with one type of disability.[63] Thus, the limited research that has examined the presence of multiple disabilities in relation to substance use indicates increased use among persons with more than one disability.

Because many of the correlates of disability are also associated with substance use, a careful consideration of confounding is required in this area of research. Like disability, substance use is associated with age, sex, education and poverty,[21,22,25,29,78] and these covariates are often included as adjustment factors in statistical modeling.[25,50,51] The consistent finding of higher rates of disability, but lower rates of substance use, among women compared to men,[6,24,78,79] also raises the possibility that sex could be an effect modifier of the association between disability and substance use.

Although research during the last 20 years has demonstrated a clear link between disability status and substance use, prior studies[24–26,50,63] have utilized binary disability measures or focused exclusively on one type of disability.[51,53,55,59,68] The objective of the current study was to examine which disability types and combinations are associated with the greatest risk for drug and alcohol use disorders, and to evaluate the strength of these associations after controlling for known sociodemographic covariates and considering potential effect modification by sex, which is an especially salient characteristic in disability and substance use research.

Methods

Data Source

This cross-sectional analysis utilizes data from the most recent pre-pandemic (i.e., 2018-2019) National Survey on Drug Use and Health (NSDUH) public-use microdata files. The NSDUH is a nationally-representative survey of the US civilian non-institutionalized population ages 12 years and older which gathers health and demographic information, as well as detailed information on substance use.[102] Pre-pandemic data were used because COVID-19 necessitated increased reliance on telephone, rather than in-person interviewing, which might have under sampled adults with hearing and other disabilities. Two years of data were pooled to increase the sample of adults with specific disabilities. NSDUH response rates were 66.6% and 64.9% in 2018 and 2019, respectively.[80]

The NSDUH data were collected using audio computer-assisted self-interviewing, which allows survey participants to enter their responses directly into a computer. The NSDUH Field Manual provides specific guidance for interviewing blind and deaf respondents. Blind respondents listened to recordings of the questions using headphones and input their answers using the computer keypad.[103] Deaf respondents read the survey questions themselves and entered their responses using the computer keypad.[103] Interviews took place in a private space within the respondent's home and lasted approximately one hour.[104]

The combined NSDUH 2018 and 2019 surveys included 112,449 participants. To describe the association between disability and substance use disorder among adults, survey participants younger than age 18 (n = 26,684) were excluded. This exclusion resulted in 85,765 adult respondents who were age 18 or older at the time of the interview. The analytic sample was then restricted to participants with no missing values for the analytic variables, who comprised 97.3% of respondents who met age criteria for inclusion. After applying these criteria, the final analytic sample size was n=83,485.

Disability Measures

The NSDUH includes questions recommended by the U.S. Department of Health and Human Services (HHS) for the identification of disabilities in population-based surveys, which have been used widely in disability research.[22,76,77] Furthermore, the validity of HHS disability measures has been corroborated through comparisons with the longer and more detailed National Health Interview Survey.[23] Four of the six HHS-recommended questions determine disability status: *Are you deaf or do you have serious difficulty hearing? [Y/N]; Are you blind or do you have serious difficulty seeing, even when wearing glasses? [Y/N]; Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions? [Y/N]; Do you have serious difficulty walking or climbing stairs? [Y/N]*. The two questions that capture activities of daily living and instrumental activities of daily living were excluded from this analysis because they overlap with the other four questions and are not specific to particular disabilities. The excluded questions are: *Do you have difficulty dressing or bathing? [Y/N] Because of a physical, mental or emotional condition, do you have difficulty doing errands alone such as visiting a doctors' office or shopping? [Y/N].* Sensitivity analyses were used to determine how this exclusion affected the results.

For this analysis, disability was assessed as:1) any disability versus no disability (dichotomous); 2) mutually-exclusive categories that reflect the prevalence of individual disabilities and common disability combinations within the NSDUH target population, informed by both conceptual and practical considerations. First, because seeing and hearing are both sensory disabilities, they were combined into a single category. Then, survey weights were used to determine the most common individual disability types and disability combinations among adult NSDUH participants. This left a small number of adults with less common combinations of two or three disabilities (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing), for whom a fifth, “other” category was created. Last, a sixth category was created for no disability. This approach minimized the number of categories that represent <1% of the NSDUH target population, which might be especially prone to survey error, while still providing greater detail than most of the existing literature. The final disability categories, as determined using the weighed frequencies, were 1) hearing/seeing only; 2) ambulatory only; 3) cognitive only; 4) ambulatory and hearing/seeing; 5) other combinations of disabilities, and 6) no disability.

Drug and Alcohol Use Disorders

The NSDUH drug and alcohol use disorder categories were based on the American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders 4th Revision (DSM-IV). Hereafter, “drug use disorder” refers to illicit drug dependence or abuse in the past year, and “alcohol use disorder” refers to alcohol dependence or abuse in the past year. Importantly, “illicit” drug dependence and abuse includes use of heroin, cocaine and methamphetamine, and prescription opioids and benzodiazepines when these are used without a prescription or in a way that is inconsistent with a prescriber’s instructions.

Covariates

Sociodemographic covariates were selected based on the existing literature.[24,50] These are age (24-25, 26-34, 35-49, 50-64, ≥65); sex (female, male); race/ethnicity (Hispanic, non-Hispanic American Indian/Alaska Native, non-Hispanic Native Hawaiian/Pacific Islander, non-Hispanic Asian, non-Hispanic Black, non-Hispanic more than one race, non-Hispanic White); marital status (married, never married, divorced/separated, widowed); education (less than high school, high school graduate, associate's degree/some college (no degree), bachelor's degree or higher); employment (employed full time, employed part time, unemployed, not in the labor force); and poverty (at or below the poverty level, up to two times the poverty level, more than two times the poverty level). Race/ethnicity is conceptualized by the authors as a proxy for survey respondent's potential experiences of privilege, discrimination, or segregation, rather than a biological trait. Poverty level was based on family size and income according to the federal guidelines [105].

Statistical Analyses

Descriptive statistics were generated to summarize the disability categories and demographic and socioeconomic characteristics of the study population. Unweighted counts and weighted percentages were calculated, and logistic regression models were developed to evaluate the strength of the association between drug and alcohol use disorders separately with disability status. Crude and adjusted odds ratios (ORs and aORs) and 95% confidence intervals (CIs) were computed. Odds ratios were considered statistically significant if the confidence intervals did not include the null value of one. Disability status was dichotomous in the analysis comparing any disability to no disability (reference), and a six-level categorical variable in the analysis comparing specific disability types and combinations to no disability (reference).

Two multivariable logistic models were developed. The first included adjustment for the demographic covariates age, sex, and race/ethnicity. The second was adjusted for the aforementioned covariates, and socioeconomic covariates education, employment, marital status, and poverty. An interaction term was also used to determine whether sex was a statistically-significant effect modifier. Where significant interactions were present, analyses were stratified by sex and repeated to determine the sex-specific association between disability and substance use disorders. As a sensitivity analysis, the prevalence of any disability was recalculated using all six HHS questions, rather than the four questions used in the primary analysis. Then, crude ORs were estimated to measure the association between disability and substance use disorders using six, rather than four disability questions. Statistical analyses were performed using weight, cluster and stratum to account for the complex design of the NSDUH. The Institutional Review Board of the University of Maryland classified this research project as exempt.

Results

Distributions of Sociodemographic Characteristics and Substance Use Disorder

Distributions of sociodemographic characteristics of the study population are presented in Table 10, along with unweighted counts and weighted percentages of drug and alcohol use disorders. Within the study population of 2018-2019 NSDUH respondents, total unweighted cases of past year substance use disorder were 3,536 for drugs and 6,063 for alcohol. Comparing the weighted distributions of the sociodemographic characteristics of the target population with the subpopulations with drug and alcohol use disorders reveals several disproportionately affected groups. Men, persons ages 26-34 years old, and never married and divorced persons, were overrepresented among those with both drug and alcohol use disorders. Non-Hispanic persons of more than one race, persons with high school education or some college but no degree, persons with family income at or below the federal poverty level, and persons who were unemployed were overrepresented among those with drug use disorder. Alcohol use disorder varied little by major racial/ethnic category, education or poverty status. Persons who were employed full time or unemployed were overrepresented among those with alcohol use disorder, while persons who were employed part time or not in the labor force were underrepresented.

Distributions of Disability Status and Substance Use Disorder

Sample sizes and the prevalence of disabilities by disability type and combination within the study population are presented in Table 11, along with weighted percentages of drug and alcohol use disorders. Adults with no disability comprised 80.3% of the target population. The most common disabilities and disability combinations reported in the NSDUH were hearing/seeing only (5.4%), ambulatory only (4.9%), cognitive only (4.6%), other combinations of disabilities (3.2%), and ambulatory and hearing/seeing (1.6%). Drug and alcohol use disorders were elevated among adults with any disability, who comprised 19.7% of the target population but accounted for 34.9% of adults with drug use disorder and 24.1% of adults with alcohol use disorder. Despite making up 4.6% of the target population, adults reporting only a cognitive disability accounted for 17.1% of adults with drug use disorder and 10.7% of adults with alcohol use disorder. Adults with hearing/seeing and ambulatory disabilities were underrepresented among those with drug and alcohol use disorders, compared to their share of the total population, while adults in the heterogeneous “other” disability category were overrepresented.

In sensitivity analyses, the use of six, rather than four, questions to identify disability increased the prevalence of disability within the target population by less than one percentage point, the prevalence of drug use disorder among adults identified as having disability by approximately two percentage points, and the prevalence of alcohol use disorder among adults identified as having any disability by approximately one and a half percentage points (Table 14).

Odds of Drug Use Disorder by Disability

Results from logistic regression models assessing relationships between disability and drug use disorder are summarized in Table 12, including unadjusted and adjusted estimates. In the fully-adjusted model, drug use disorder was positively associated with the presence of any disability (aOR = 2.7; 95% CI = 2.5 – 3.0). Examinations of specific disability types as compared to adults with no disability revealed that the magnitude of the association was higher among adults with cognitive disabilities only (aOR = 3.3; 95% CI = 2.9 – 3.8), and ambulatory and hearing/seeing disabilities (aOR = 2.8; 95% CI = 1.6 – 5.1). The "other" disability category had even higher adjusted odds of drug use disorder (aOR = 4.3; 95% CI = 3.5 – 5.2). Weaker associations were observed for adults in the hearing/seeing only category (aOR = 1.5; 95% CI = 1.1 – 1.9) and the ambulatory only category (aOR = 1.6; 95% CI = 1.0 – 2.6) as compared to those with no disability. Comparing results across the three models suggests both positive and negative confounding effects. For cognitive disability, adjustment for both demographic (model 2) and socioeconomic (model 3) covariates weakened the association with drug use disorder. For hearing/seeing only and ambulatory only, adjustment for demographic (model 2) and socioeconomic (model 3) covariates strengthened the association with drug use disorder. The use of six, rather than four, questions to identify disability resulted in similar estimates of the odds of drug use disorder among adults with any disability (Table 15).

Odds of Alcohol Use Disorder by Disability

Results from logistic regression models assessing the relationships between disability and alcohol use disorder are summarized in Table 13. Elevated alcohol use disorder was observed among adults with one or more disabilities. The fully-adjusted estimate indicated approximately two times the odds of alcohol use disorder among adults with any disability, compared to adults without disability (aOR = 1.8; 95% CI: 1.6 – 2.0). Alcohol use disorder was also associated with two of the five specific disability categories examined. The fully-adjusted models showed significantly higher odds of alcohol use disorder among adults with cognitive disabilities only (aOR = 2.3; 95% CI = 2.0 – 2.6), and "other" disabilities (aOR = 2.8; 95% CI = 2.2 – 3.4). Hearing/seeing disability (aOR = 1.1; 95% CI = 0.9 – 1.4), ambulatory disability (aOR = 1.1; 95% CI: 0.8 – 1.4), and ambulatory and hearing/seeing disability (aOR = 1.6; 95% CI = 0.9 – 2.6) were not significantly associated with alcohol use disorder. Comparing results from across the three models indicates positive and negative confounding effects due to demographic (model 2) or socioeconomic (model 3) covariates. The use of six, rather than four, questions to identify disability had minimal effect on the estimated odds of alcohol use disorder among adults with any disability (Table 16).

Evaluation of Effect Modification by Sex

Statistically-significant interactions between disability category and sex were observed in the analysis of alcohol use disorder (Table 17), but not drug use disorder (data not shown). In the fully-adjusted model, the odds of alcohol use disorder among adults with cognitive disability were stronger for females (aOR = 2.8; 95% CI = 2.4 – 3.2), compared to males (aOR = 1.9; 95% CI = 1.6 – 2.2). For other disability categories, the interaction between disability and sex was either not statistically significant, or the estimated odds ratio was not significantly different from the null in the fully-adjusted model (Table 17).

Discussion

This analysis of nationally representative cross-sectional data supports a positive association between disability status and past year drug and alcohol use disorders. Results show that while approximately 20% of adults report having a disability, adults with disabilities make up approximately 35% of adults with past year drug use disorder and 24% of adults with past year alcohol use disorder. Disaggregating by disability type revealed heterogeneity among adults with hearing/seeing, ambulatory, cognitive, and other types of disabilities. Adults with cognitive disabilities had slightly more than three times the odds of drug use disorder, while those with hearing/seeing and ambulatory disabilities had approximately three times the odd of drug use disorder, compared to non-disabled adults. In the examination of alcohol, adults with cognitive disabilities had approximately two times the odds of alcohol use disorder, compared to non-disabled adults. Adults with hearing/seeing and ambulatory disability did not have significantly elevated odds of alcohol use disorder, compared to non-disabled adults. Adults with "other" disabilities, a category comprised of combinations of two or more disabilities that occur among approximately one percent of the weighted study population, also had elevated odds of drug and alcohol use disorders. Controlling for sociodemographic covariates lessened the association between cognitive disability and drug use disorder, but did not eliminate it altogether. The sociodemographic covariates examined had minimal effect on the estimated odds of alcohol use disorder.

The findings reported herein align with much of the existing literature which shows elevated burden of drug and alcohol use disorder among persons with disabilities.[24–26,29,50,55,59,63,68] Similar to previous studies that focused on the association between substance use and any disability using the NSDUH, the findings reported herein indicate increased prevalence of drug use[24–26,50] and alcohol use[29] among adults with any disability, compared to those without disability. Our analysis uses more recent NSDUH data than prior studies and examines broad drug and alcohol use measures, including dependence and abuse of several classes of illicit and prescription drugs.

Findings from the present analysis also align with previous studies conducted utilizing other data sources. Using data from the cross-sectional National Health and Nutrition Examination Survey (NHANES), Hinson-Enslin et al. report that adults with hearing/seeing disabilities have higher lifetime prevalence of cocaine, heroin and methamphetamine use, compared to adults without hearing/seeing difficulty.[59] In reviews of the literature, McGillicuddy et al. and Burgard et al. report a greater likelihood of negative costs from alcohol use, such as legal and job-related problems, among adults with intellectual disabilities, compared to those without.[55,68] The majority of the studies included in the reviews had small sample sizes and used non-probability sampling methods. The study presented here builds on this previous work by using nationally-representative data to show that adults with cognitive disability have higher prevalence of past year DSM-IV drug and alcohol use disorders, independent of other sociodemographic characteristics.

The findings presented here make a unique contribution to the literature by specifically examining ambulatory disabilities. Although approximately 40% of disabled adults have an ambulatory disability,[6] to our knowledge there are no studies that focused on substance use within this population. The finding that ambulatory disability is associated with drug, but not alcohol use disorder, is a distinctive contribution of this study.

Limitations

Owing to its cross-sectional design and lack of questions about initial onset of either disability and substance use disorder, this analysis cannot determine whether substance use disorder preceded and contributed to disability, or vice versa. Bidirectional relationships between the focal constructs are likely: while the stress of a disability could lead to substance use disorder, the reverse direction is also plausible. There is a large body of literature linking chronic alcohol consumption with cognitive impairment.[84] Alcohol use could also increase the risk of traumatic brain injuries involving motor vehicles and falls,[82,83] and drug use could increase the risk of non-fatal overdose and hypoxic brain injury.[85] Unfortunately, these questions cannot be resolved with the NSDUH data, but they highlight the need for further longitudinal research which distinguishes between cognitive disabilities of different etiologies. Existing qualitative research has identified motivating factors the contribute to alcohol use among adults with intellectual disabilities.[31] The use of similar methods could also be used to elucidate the association between other types of disability and substance use disorders. Semi-structured interviews and focus groups involving adults with brain injuries and mental health conditions could examine factors related to substance use initiation, escalation, recovery, and relapse. Other limitations include the potential for misclassification of alcohol and/or drug use disorders among adults with certain disabilities. Although the NSDUH provides accommodations for adults with seeing/hearing difficulty, the field manual does not include instructions for gathering information from adults with cognitive disabilities. This could result in the ascertainment of lower quality data from this population. Furthermore, the exclusion of individuals residing in institutional group quarters from the NSDUH sample might omit a portion of the disabled population and differentially exclude adults with more severe disabilities. This limits the generalizability of the present study to non-institutionalized persons with disabilities. Last, the “other” disability category, which included individuals with combinations of two or more disabilities found among approximately one percent of the NSDUH target population, provides limited information for identifying populations in need of substance use disorder prevention and treatment services. Future studies with larger samples of adults with disabilities and utilizing different kinds of methods (e.g., qualitative in-depth interviews) could be useful in understanding the relationships observed herein. Strengths of the analysis include the use of specific disability categories representing the most common disability types and disability combinations observed in the large, nationally representative NSDUH data. The analyses also controlled for known confounders and tested for sex differences in the associations.

Conclusions

Disability is associated with past year drug and alcohol use disorders among U.S. adults, and the strength of the association varied among adults with different types of disabilities. Of the disability categories examined, cognitive difficulty showed an especially strong association with drug and alcohol use disorders in adjusted models. Future research is needed to establish the temporal relationship between disability and substance use disorders, and to better understand substance use disorders among adults with low-prevalence combinations of two or more disabilities. Further study is also needed to investigate the more pronounced relationship between alcohol use disorder and cognitive disability among females, compared to males, which was observed in both the unadjusted and adjusted analyses. Longitudinal studies that include stressful life events, timing of initiation of substance use disorder, and onset of cognitive disabilities could provide insights into the drivers of the sex differences reported herein. Longitudinal studies could also investigate whether improved access to educational and occupational opportunities reduces the risk of substance use disorder among adults with cognitive disabilities. Efforts to prevent and treat substance use disorders should account for the unique needs of adults with different types of disabilities.

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Table 10. Distribution of Sociodemographic Characteristics in the Overall Population and by Drug and Alcohol Use Disorder: Data from 2018-2019 NSDUH Survey Respondents Age 18 Years or Older

	Total Population n = 83,485	Drug Use Disorder[a] n = 3,536		Alcohol Use Disorder[b] n = 6,063	
	Weighted %	Un-weighted n	Weighted %	Un-weighted n	Weighted %
Sex					
Female	51.8	1,492	38.4	2,471	36.5
Male	48.2	2,044	61.6	3,592	63.5
Age Group (years)					
18-25	13.2	1,950	33.9	2,575	22.5
26-34	16.1	785	27.9	1,405	24.1
35-49	24.5	603	21.9	1,479	26.5
50-64	25.2	169	13.1	453	20.5
≥65	21.0	29	3.2	151	6.4
Race/Ethnicity					
Hispanic	16.3	596	16.4	996	15.5
Non-Hispanic American Indian/Alaska Native	<1.0	85	<1.0	137	<1.0
Non-Hispanic Native Hawaiian/Pacific Islander	<1.0	21	<1.0	38	<1.0
Non-Hispanic Asian	5.7	91	2.9	205	3.9
Non-Hispanic Black	11.8	436	13.2	579	10.3
Non-Hispanic more than one race	1.8	222	3.3	243	2.1
Non-Hispanic White	63.6	2,085	62.7	3,865	66.9
Educational Attainment					
Less than High School	12.0	532	13.9	670	10.8
High School Graduate	24.4	1,142	29.7	1,530	23.7
Associate's Degree/ Some College, No Degree	30.8	1,331	36.9	2,192	33.9

Bachelor's Degree or Higher	32.8	531	19.5	1,671	31.6
Marital Status					
Married	51.5	508	20.2	1,505	33.5
Never Married	28.6	2,637	63.9	3,810	48.8
Divorced/ Separated	13.9	359	14.1	669	15.5
Widowed	6.0	32	1.8	79	2.2
Family Poverty Status					
Federal Poverty Level or Below	13.3	923	23.8	1,100	14.9
Up to 2x Federal Poverty Level	19.3	819	22.1	1,174	17.7
More than 2x Federal Poverty Level	67.4	1,794	54.1	3,789	67.4
Employment Status					
Employed full time	49.9	1,619	45.5	3,660	60.5
Employed part time	12.9	652	15.8	931	13.1
Unemployed	4.0	469	12.8	470	6.6
Not in labor force	33.2	796	25.9	1,002	19.8

[a]Past year DSM-IV drug dependence or abuse.

[b]Past year DSM-IV alcohol dependence or abuse.

Table 11. Drug and Alcohol Use Disorder by Disability: Data from 2018-2019 NSDUH Respondents Age 18 Years or Older

	Total Population	Drug Use Disorder[a]		Alcohol Use Disorder[b]	
	Weighted %	Un-weighted n = 3,536	Weighted %	Un-weighted n = 6,063	Weighted %
Any Disability					
Yes	19.7	3,536	34.9	6,063	24.1
Disability Type					
None	80.3	2,310	65.1	4,563	75.9
Hearing/Seeing	5.4	176	4.6	262	4.2
Ambulatory only	4.9	67	3.1	94	2.6
Cognitive only	4.6	697	17.1	837	10.7
Other[c]	3.2	260	8.7	279	5.6
Ambulatory and Hearing/Seeing	1.6	26	1.4	28	1.0

[a]Past year DSM-IV drug dependence or abuse.

[b]Past year DSM-IV alcohol dependence or abuse.

[c]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

Table 12. Results of Logistic Regression Models Evaluating the Strength of the Association Between Disability and Drug Use Disorder[a]: Data from 2018-2019 NSDUH Respondents Age 18 Years or Older (n=83,485)

	Unweighted n	Model 1: Unadjusted	Model 2: Adjusted for Demographics[b]	Model 3: Adjusted for Demographic and Socioeconomic Characteristics[c]
Any Disability		OR (95% CI)	OR (95% CI)	OR (95% CI)
No	68,787	Ref	Ref	Ref
Yes	14,698	2.3 (2.0 - 2.5)	3.2 (3.0 - 3.6)	2.7 (2.5 - 3.0)
Disability Type				
None	68,787	Ref	Ref	Ref
Hearing/Seeing only	3,633	1.0 (0.8 - 1.4)	1.6 (1.2 - 2.1)	1.5 (1.1 - 1.9)
Ambulatory only	2,453	0.8 (0.5 - 1.2)	2.0 (1.2 - 3.3	1.6 (1.0 - 2.6)
Cognitive only	5,461	5.0 (4.4 - 5.8)	3.9 (3.3 - 4.5)	3.3 (2.9 - 3.8)
Other[d]	2,393	3.6 (3.0 - 4.4)	5.5 (4.5 - 6.7)	4.3 (3.5 - 5.2)
Ambulatory and Hearing/Seeing	758	1.1 (0.6 - 1.9)	3.6 (2.0 - 6.4)	2.8 (1.6 - 5.1)

[a]Past year DSM-IV drug dependence or abuse.

[b]Age, sex, race/ethnicity.

[c]Age, sex, race/ethnicity, marital status, education, employment, poverty.

[d]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

OR = Odds ratio

Table 13. Results of Logistic Regression Models Evaluating the Strength of the Association Between Disability and Alcohol Use Disorder[a]: Data from 2018-2019 NSDUH Respondents Age 18 Years or Older (n=83,485)

	Unweighted n	Model 1: Unadjusted	Model 2: Adjusted for Demographics[b]	Model 3: Adjusted for Demographic and Socioeconomic Characteristics[c]
		OR (95% CI)	OR (95% CI)	OR (95% CI)
Any Disability				
No	68,787	Ref	Ref	Ref
Yes	14,698	1.3 (1.2 - 1.4)	1.7 (1.6 - 1.9)	1.8 (1.6 - 2.0)
Disability Type				
None	68,787	Ref	Ref	Ref
Hearing/Seeing only	3,633	0.8 (0.6 - 1.0)	1.1 (0.8 - 1.4)	1.1 (0.9 - 1.4)
Ambulatory only	2,453	0.5 (0.4 - 0.7)	1.0 (0.8 - 1.3)	1.1 (0.8 - 1.4)
Cognitive only	5,461	2.7 (2.4 - 3.0)	2.3 (2.1 - 2.6)	2.3 (2.0 - 2.6)
Other[d]	2,393	2.0 (1.6 - 2.4)	2.6 (2.1 - 3.2)	2.8 (2.2 - 3.4)
Ambulatory and Hearing/Seeing	758	0.7 (0.4 - 1.1)	1.5 (0.9 - 2.4)	1.6 (0.9 - 2.6)

[a]Past year DSM-IV alcohol dependence or abuse.

[b]Age, sex, race/ethnicity.

[c]Age, sex, race/ethnicity, marital status, education, employment, poverty.

[d]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

OR = Odds ratio

Table 14. Distribution of Disability and Drug and Alcohol use Disorders Using Either Six or Four of the HHS Questions to Identify Disability: Data from 2018-2019 NSDUH Respondents Age 18 Years or Older

Questions Used to Identify Disability	Any Disability	Drug Use Disorder[a] n = 3,536	Alcohol Use Disorder[b] n = 6,061
	Weighted %	Weighted %	Weighted %
Six	20.6	37.0	25.4
Four	19.7	34.9	24.1

[a]Past year DSM-IV drug dependence or abuse.

[b]Past year DSM-IV alcohol dependence or abuse.

Table 15. Results of Logistic Regression Models Evaluating the Strength of the Association Between Disability and Drug Use Disorder[a] Using Either Six or Four of the HHS Questions to Identify Disability: Data from 2018-2019 NSDUH Respondents Age 18 Years or Older

Questions Used to Identify Disability	Any Disability	Model 1: Unadjusted OR (95% CI)
Six	No	Ref
	Yes	2.3 (2.1 - 2.6)
Four	No	Ref
	Yes	2.3 (2.0 - 2.5)

[a]Past year DSM-IV drug dependence or abuse.

OR = Odds ratio

Table 16. Results of Logistic Regression Models Evaluating the Strength of the Association Between Disability and Alcohol Use Disorder[a] Using Either Six or Four of the HHS Questions to Identify Disability: Data From 2018-2019 NSDUH Respondents Age 18 Years or Older

Questions Used to Identify Disability	Any Disability	Model 1: Unadjusted OR (95% CI)
Six	No	Ref
	Yes	1.3 (1.2 - 1.5)
Four	No	Ref
	Yes	1.3 (1.2 - 1.4)

[a]Past year DSM-IV alcohol dependence or abuse.

OR = Odds ratio

Table 17. Results of Logistic Regression Models Evaluating the Strength of the Association Between Disability and Alcohol Use Disorder[a]: Sex-Specific Data from 2018-2019 NSDUH Respondents Age 18 Years or Older

	Unweighted n	Model 1: Unadjusted	Model 2: Adjusted for Demographics[b]	Model 3: Adjusted for Demographics and Socioeconomic Characteristics[c]
		OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**
Disability Type				
None				
Male	32,879	Ref	Ref	Ref
Female	35,908	Ref	Ref	Ref
Hearing/Seeing only				
Male	1,805	0.9 (0.6 – 1.2)	1.2 (0.9 – 1.7)	1.3 (0.9 – 1.7)
Female	1,828	0.6 (0.4 – 0.9)	0.8 (0.6 – 1.2)	0.8 (0.6 – 1.2)
Ambulatory only				
Male	957	**0.8 (0.6 – 1.0)**	1.3 (0.9 – 1.7)	1.4 (1.0 – 1.9)
Female	1,496	**0.4 (0.2 – 0.6)**	0.7 (0.4 – 1.1)	0.7 (0.4 – 1.1)
Cognitive only				
Male	2,140	**2.3 (2.0 – 2.8)**	**1.9 (1.6 – 2.3)**	**1.9 (1.6 – 2.2)**
Female	3,321	**3.5 (3.0 – 4.1)**	**2.8 (2.4 – 3.3)**	**2.8 (2.4 – 3.2)**
Other[d]				
Male	875	2.3 (1.7 – 3.1)	2.9 (2.2 – 3.9)	3.2 (2.5 – 4.3)
Female	1,518	1.9 (1.4 – 2.5)	2.2 (1.6 – 3.0)	2.3 (1.7 – 3.1)
Ambulatory and Hearing/Seeing				
Male	328	0.8 (0.5 – 1.4)	1.7 (0.9 – 3.0)	1.8 (1.0 – 3.2)
Female	430	0.6 (0.2 – 1.4)	1.2 (0.5 – 2.9)	1.2 (0.5 – 3.1)

[a]Past year DSM-IV alcohol dependence or abuse.

[b]Age, race/ethnicity.

[c]Age, race/ethnicity, marital status, education, employment, poverty.

[d]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

OR = Odds ratio

Bold text indicates statistically-significant interaction between disability and sex and estimated odds ratios are significantly different than the null.

Chapter 5: The Risk of Drug Overdose Death Among Adults with Select Types of Disabilities – a Longitudinal Study Using Nationally Representative Data

Keywords: Drug Overdose; Disabled Persons; Mortality

Abstract

Purpose: To estimate the risk of drug overdose death among US adults with different types of disabilities and to explore potential confounders.

Methods: The most common individual disabilities and co-occurring disabilities were identified in the Mortality Disparities in American Communities Study (MDAC) using participants ages 18 or older with baseline information collected in 2008 and mortality follow-up through 2019 (n = 3,324,000). Drug overdose deaths were examined using bivariate statistics, rates per 100,000 person years, hazard ratios (HRs) and adjusted hazard ratios (aHRs), controlling for potential demographic and socioeconomic confounders.

Results: 4,800 drug overdose deaths occurred during a maximum of 12 years of follow-up. Compared to non-disabled adults, risk was elevated among adults with cognitive (HR = 5.8; 5.3 – 6.4; aHR = 2.6; 2.4 – 2.9), ambulatory (HR = 3.0; 2.8 – 3.3; aHR = 2.8; 2.6 – 3.1), ambulatory and hearing/seeing (HR = 2.0; 1.7 – 2.5; aHR = 2.5; 2.0 – 3.1), and hearing/seeing disability only (HR = 1.4; 1.2 – 1.6; aHR = 1.6; 1.4 – 1.9). Risk was also elevated among adults in the heterogeneous “other types of disabilities” category (HR = 5.0; 4.5 – 5.5; aHR = 3.1; 2.8 – 3.4).

Conclusions: Across all of the subtypes of disabilities examined, disabled adults had elevated risk of drug overdose death, compared to non-disabled adults. Risk estimates varied by disability type, with cognitive disability at greatest risk in the unadjusted analysis, and “other types of disabilities” at greatest risk in the adjusted analysis. Adults with disabilities should be prioritized in recovery support services, and controlled substance prescribing reforms.

1. Background

Between 1999 and 2020, the age-adjusted drug overdose (OD) death rate in the United States (US) more than quadrupled, from 6.1 to 28.3 per 100,000,[71] and a growing body of evidence details OD disparities by employment characteristics,[4,106] state of residence,[11] and educational attainment.[8] Disability is an underappreciated dimension of health disparities research,[39] and has received limited attention in drug OD studies. Disability is the result of interactions between health conditions and environmental factors that prevent full participation in society.[14] In US research, disability is often classified as sensory (i.e. auditory and visual), ambulatory, cognitive, and self-care.[6] Importantly, under the Americans with Disabilities Act (ADA), which informs many of the disability measures used in US disability research, drug use is not considered a disability.[15] Disability is associated with older age and female sex,[6] and despite legislation mandating equal access to opportunities for people with disabilities,[15] disability is also associated with poverty[21] and lower educational attainment.[22]

Longitudinal research has reported three to seven times the risk of drug OD death among adults identified as disabled, compared to those identified as non-disabled.[2–4,28] These studies have defined disability as the presence of one or more of the conditions captured by the US Department of Health and Human Services (HHS) disability survey questions,[3] inability to work,[4] receipt of a disability pension,[28] or receipt of Medicare disability benefits.[2] Findings from fatal drug OD research are reinforced by studies of *non-fatal* drug OD hospitalizations, which are also associated with Medicare disability beneficiary status.[61,62] This prior research informs OD prevention efforts by highlighting the burden of disease among individuals broadly categorized as disabled, but it fails to account for the unique experiences of persons with different types of disabilities.

Different types of disabilities have been examined in the non-fatal drug use literature.[51,53,55,59,68] Adults with hearing difficulty have reported elevated prevalence of lifetime illicit drug use[59] and current cannabis use;[51] and lifetime illicit drug use is also higher among adults with visual difficulty.[59] There is evidence of increased illicit stimulant use among adults with intellectual disability, compared to the general population,[53] and potentially more serious legal and work-related consequences for intellectually disabled persons who use drugs.[55] The limited research on adults with more than one type of disability, who make up forty percent (40%) of adults identified as disabled in the US,[6] has found that college students with two or more disabilities have reported higher rates of drug use compared to students reporting just one type of disability.[63] To date, research focusing on substance use among persons with ambulatory disability, or cognitive disability related to conditions other than intellectual disability is limited.

Examining the risk of OD death by disability type, and exploring the effect of potential confounders, is complicated by a number of methodological challenges. Traditional US public health surveillance systems, like the National Vital Statistics System, often lack detailed disability information. Detailed disability information is captured in large cross-sectional surveys, such as the National Survey on Drug Use and Health, but many cross-sectional surveys lack information about OD deaths. Recently, the linkage of the American Communities Survey (ACS) to the National Death Index (NDI) has provided a means to overcome these challenges. In 2020, Altekruse and colleagues used the ACS-NDI linked files, which are referred to as the Mortality Disparities in American Communities (MDAC) study,[107] to examine the association between a binary measure of disability and opioid OD death through 2015.[3] In the current analysis, we extend their investigation to disaggregate disability status into specific disability types, and to include a longer follow-up period that is inclusive of the sharp increase in drug OD deaths that occurred in the US after 2015.[71]

Methods

Data Source

This longitudinal analysis utilized the most recent MDAC data available at the time of analysis. Baseline information is derived from the 2008 ACS, which is a nationally-representative survey of the US resident population that includes all persons who usually reside in the US, but excludes military service members overseas.[108] Follow-up information was based on NDI linkage with records for deaths that occurred through December 31st, 2019. The ACS is a mixed-mode survey that contacts approximately 1 in 38 US households per year.[109] From each household, one knowledgeable person provides information for all persons residing at the sampled address. Respondents in need of assistance completing the survey can contact the Census Bureau by telephone or telephone device for the deaf (TDD) using numbers included in the ACS packet. The ACS packet does not include special instructions for respondents with visual or cognitive difficulties. Households that do not respond by mail are contacted by telephone, and those that do not respond by telephone are eligible to receive an in-person visit from a Census Field Representative.[110] In addition to housing units, the ACS collects information from a sample of group quarters. Respondents in group quarters provide information through face-to-face interviewing, self-report on paper questionnaires, telephone interview, or proxy interview.[110] Participation in the ACS is required by law, and in 2008 the response rate was 97.9%.[111] The NDI, which is operated by the US Centers for Disease Control and Prevention (CDC), is a database of all deaths in the US, which provides date and cause of death information.[91] To reduce confidentiality concerns, counts obtained from MDAC data are rounded before being released to the public.

The MDAC study contains 4,512,000 records. The application of exclusion criteria resulted in the removal of records with insufficient information for matching to the NDI (n = 34,000), records for persons age less than 18 years (n = 1,032,000), or missing values for any of the exposure, outcome or covariate variables included in this analysis (n = 122,000). After applying these criteria, the final analytic sample size was n = 3,324,000 US adults.

Disability Measures

The MDAC includes disability questions endorsed by HHS, which have been used widely in population-based research,[22,77] and validated through a comparison with the longer and more detailed National Health Interview Survey.[23] Four of the six HHS questions were used in this study: *Are you deaf or do you have serious difficulty hearing? [Y/N]; Are you blind or do you have serious difficulty seeing, even when wearing glasses? [Y/N]; Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions? [Y/N]; Do you have serious difficulty walking or climbing stairs? [Y/N]*. The remaining two questions, which capture activities of daily living (ADLs), and instrumental activities of daily living (IADLs), were excluded because they overlap with the other four questions and are not specific to particular disabilities. The excluded questions are: *Do you have difficulty dressing or bathing? [Y/N]; Because of a physical, mental or emotional condition, do you have difficulty doing errands alone such as visiting a doctors' office or shopping? [Y/N]*. A sensitivity analysis was used to determine how this exclusion affected the results of this study (discussed below).

For analytic purposes, a categorical variable with mutually-exclusive disability categories was created including: 1) ambulatory only; 2) hearing/seeing only; 3) cognitive only; 4) ambulatory and hearing/seeing; 5) some other combination of disabilities; and 6) no disability. Seeing and hearing were combined into a single category because both are sensory disabilities. Other categories were determined by using survey weights to identify individual disabilities and disability combinations present among ≥1% of adult ACS participants. Less common combinations were grouped into a fifth "other" category, and a sixth category was created for no disability. This method provided greater detail than much of the existing literature, while minimizing the use of narrow disability categories, which are prone to survey error.

Drug Overdose Deaths

Drug OD deaths were identified with the CDC case definition, which includes the International Classification of Disease, Tenth Revision (ICD-10) underlying cause of death codes X40-X44, X60-X64, X85, Y10-Y14.[112] This definition captures deaths caused by drugs, regardless of intent (i.e. accidental or suicide). It also includes different classes (i.e., stimulant, depressant, tranquilizer) and both illicit (e.g., heroin, cocaine, methamphetamine) and prescription (e.g., oxycodone, alprazolam) drugs.

Covariates

Sociodemographic covariates were selected *a priori* based on the existing literature[3] and include age (18-29, 30-39, 40-49, 50-59, 60-69, 70-79, ≥80 years); sex (female, male); race/ethnicity (Hispanic, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian, non-Hispanic Black, non-Hispanic White, other non-Hispanic); poverty (at or below the poverty level, up to two and a half times the poverty level, two and a half to four times the poverty level, greater than or equal to four times the poverty level); educational attainment (less than high school, high school graduate, associate's degree/some college (no degree), bachelor's degree or higher); marital status (married, widowed, divorced/separated, never married) and employment (employed, unemployed, not in the labor force, in the armed forces). Race/ethnicity is included as a proxy for potential experiences of discrimination or privilege, rather than a biological characteristic. Poverty was calculated according to US federal guidelines, which account for family size and income.[105]

Statistical Analyses

The demographic and socioeconomic characteristics of the study population were summarized using descriptive statistics, including unweighted counts and weighted percentages and rates per 100,000 person years. Cox proportional hazards regression models were used to determine the strength of the association between reported disability and OD death. Follow-up time was calculated as the difference between interview date and date of drug OD death. Participants who died of another cause were right-censored on their date of death, and participants who did not die were right-censored on December 31, 2019. Crude and multivariable adjusted hazard ratios (HRs and aHRs) and 95% confidence intervals (Cis) were computed. Disability status was analyzed as a six-level categorical variable with no disability used as the reference.

Two multivariable adjusted models were developed. The first was adjusted for the demographic covariates age, sex, and race/ethnicity. The second was adjusted for the aforementioned covariates, and the socioeconomic covariates education, employment, marital status, and poverty. The exploration of potential confounding factors depicts the associations that might exist, if the distribution of factors were balanced within the disabled and non-disabled populations.[94] The proportionality assumption was assessed using a plot of the negative log of the survivor function. Statistical analyses were performed using survey weights, to account for the design of the ACS. Lastly, a competing risk model was used to assess the effect of censoring on the estimated HRs.

Sensitivity Analyses

Sensitivity analyses were performed to determine whether the exclusion of the ADL and IADL HHS disability questions affected the results of this study. The prevalence of any disability was calculated using the four questions that were employed in this study, and then recalculated also including the two excluded questions (i.e., the standard six-question series). Similarly, the percentage of drug overdose decedents with any disability was calculated using first four, then all six of the disability questions. Finally, the unadjusted risk of drug overdose death was calculated using first four, then all six of the disability questions.

Results

Distributions of the sociodemographic characteristics of the study population and drug OD decedents are presented in Table 18, along with unweighted counts and weighted percentages and rates per 100,000 person years. Within the study population, there were 4,800 drug OD deaths, and the weighted drug OD death rate was 15.7 per 100,000 person years. Males, persons age 18 – 49 years, non-Hispanic American Indians/Alaska Natives and Whites, persons with education less than a bachelor's degree, persons who were never married or were divorced/separated, persons with family income less than or equal to two and a half times the poverty level, and persons who were unemployed or not in the labor force, were overrepresented among drug OD decedents, relative to their share of the study population. Large differences in

OD rates were observed between age groups, as the rate among adults age 18 – 29 was 20.6, and among age 70 – 79 was 3.2. Large differences were also observed by race/ethnicity, as the rate among non-Hispanic American Indian/Alaska Native adults was 30.1, and among non-Hispanic Asian adults the rate was 3.4.

Distributions of Disability Status and Drug Overdose Deaths

Distributions of disability types within the total study population and among drug OD decedents are presented in Table 19 using unweighted counts and weighted percentages and counts per 100,000 person years. Within the study population, 85.8% of participants had no disability, and the most common individual disabilities and co-occurring disabilities reported in the MDAC were ambulatory only (4.5%), hearing/seeing only (3.3%), cognitive only (2.0%), ambulatory and hearing/seeing (1.4%), and other combinations of disabilities (3.0%). With the exception of persons with hearing/seeing disabilities only, persons with all types of disabilities were overrepresented among drug OD decedents, relative to their share of the study population. Persons with cognitive disability only had the highest drug OD rate, which was 71.3; and persons with all other disabilities had the second-highest rate, which was 59.4. The drug OD rate among adults without reported disability was 12.3.

Risk of Drug Overdose Death by Disability

Results from Cox proportional hazards models assessing the relationship between disability and drug OD death are summarized in Table 20, including unadjusted and adjusted analyses. Across all models, adults with any disability had significantly elevated risk of drug OD death, compared to adults without reported disability. Adults with cognitive disabilities had the greatest risk in the unadjusted model (HR = 5.8; 5.3 – 6.4), but the risk was considerably lower in the fully-adjusted model (aHR = 2.6; 2.4 – 2.9). Likewise, adults with other combinations of disabilities had substantially elevated unadjusted risk (HR = 5.0; 4.5 – 5.5), and lower adjusted risk (aHR = 3.1; 2.8 – 3.4). Unadjusted risk was lower for adults with ambulatory only (HR = 3.0; 2.8 – 3.3), with little difference observed in the fully-adjusted model (aHR = 2.8; 2.6 – 3.1). Ambulatory and hearing/seeing displayed lower unadjusted risk (HR = 2.0; 1.7 – 2.5), and an increase in the estimated risk in the fully-adjusted model (aHR = 2.5; 2.0 – 3.1). Similarly, hearing/seeing only displayed lower unadjusted risk (HR = 1.4, 1.2 – 1.6), and an increase in the risk in the fully-adjusted model (aHR = 1.6; 1.4 – 1.9). The use of a competing risk model had no effect on the drug and OD death HR. Plots of the negative log of the survivor functions indicated no crossing of the survivor functions.

Sensitivity Analyses

Sensitivity analyses indicated negligible differences when six, rather than four, of the HHS questions were used to estimate the prevalence of disability in the target population, and the share of adults with disabilities among drug OD decedents (Table 21). The use of six questions had no effect on the direction or magnitudes of the HRs (Table 22).

Discussion

Using recent, nationally representative longitudinal data, this analysis shows a consistent and strong association between five reported disability types and drug OD death. Over the 12-year follow-up period, adults with any of the reported disability types had approximately one and a half to six times the risk of OD death, compared to adults without disability. The highest OD risk was observed among adults with cognitive disabilities only, and “other” disabilities as compared to adults without disability. Drug OD risk was also considerably higher among adults with ambulatory disabilities only, and ambulatory and hearing/seeing disabilities. Adults with hearing/seeing disabilities only had the lowest unadjusted risk of drug OD of all adults with disabilities but were still at higher risk than adults without disabilities.

Statistical adjustment for demographic and socioeconomic covariates was undertaken to explore the potential confounding effect of factors that are more common among adults with disabilities, compared to non-disabled adults, including older age, female sex,[6] lower educational attainment[22] and poverty.[21] Results indicate that controlling for these potential confounders changed the magnitude of the HRs, but not their statistical significance, in comparison to the reference group of adults without disability.

The results of this study corroborate the literature on fatal drug overdose,[2–4,28] and non-fatal drug use.[51,53,55,59,68] In an MDAC analysis by Altekruse et al. with mortality outcomes ascertained through 2015 (i.e., 7 years of follow-up), adults with any reported disability had approximately four times the risk of opioid overdose death compared to non-disabled adults in unadjusted models. Similar to most of the results reported here, adjustment for demographic factors increased the HRs, and adjustment for both demographic and socioeconomic factors decreased the HRs for the association between disability and opioid OD death.[3] The robust associations between disability and OD observed in the present analysis extend Altekruse et al.'s analysis with inclusion of a longer follow-up period, capturing the rapid increase in overdose deaths that occurred after 2015, and it illustrates the importance of disaggregating drug OD death by disability type.

Our results also complement a study by Kuo et al. that reported approximately five times the risk of opioid OD death among disabled adults overall, compared to the general population, and considerable differences across subgroups of disability created in combination with information on psychiatric and pain conditions. Using a study population comprised entirely of working-age Medicare disability beneficiaries whose initial Medicare eligibility was due to disability, Kuo et al. demonstrated that within the disabled population, age-adjusted opioid OD death rates were highest among adults with substance abuse, followed by psychiatric disease, and chronic pain. For adults with all three conditions, age-adjusted opioid OD rates were substantially higher than the sum of the rates for adults with just one of the three conditions, which suggests a synergistic relationship between these comorbidities. Importantly, disabled adults without substance abuse, psychiatric disease or chronic pain had lower age-adjusted opioid OD rates than the non-disabled population.[2] Kuo's findings raise the possibility that the association between cognitive disability and drug OD risk reported in this study might be driven by mental and emotional conditions, which Kuo's study includes in the psychiatric disease category. In the future, longitudinal studies that include disability type, medical history and drug OD death should explore this possibility further.

A nationally representative sample collected in the early 2000s was used by Aram et al. to study the association between disability and drug OD death in the general population.[4] The results show that adults who were disabled had approximately seven times the risk of drug OD death, compared to adults who were employed, and patterns of negative and positive confounding that are similar to the findings reported here and previously published studies.[4] Taken together, this body of research suggests that the association between disability and substance use is consistent over time and across study populations.

The present study has several public health implications. Overdose prevention activities should be tailored to minimize the barriers faced by adults with cognitive disabilities. This could mean screening for cognitive disability upon intake at substance use treatment facilities, and providing counseling that is tailored for adults with cognitive disabilities.[113] The findings also reiterate the importance of judicious prescribing of controlled substances, which have historically been overprescribed to adults with some disabilities.[26] The reduction in the estimated risk of drug OD death when demographic and socioeconomic factors (i.e. education, employment and poverty) were balanced among disabled and non-disabled adults using statistical adjustment suggests that opportunities for adults with disabilities to study, work, earn and participate in their communities might also reduce the risk of drug OD death.

Limitations

The use of a single, point-in-time measure of disability is a limitation of this study. The method fails to account for the possibility that disability status could change during the study period, which could result in exposure misclassification. The use of disability data that is self-reported or reported by proxy is also a limitation. Survey respondent's comprehension of the disability question and willingness to disclose this information might also result in misclassification of disability status for some respondents. Finally, the use of the NDI to identify drug overdose deaths is a limitation. Inconsistent use of toxicology testing across US jurisdictions might result in under reporting of drug overdose deaths. Strengths of this analysis include the use of nationally representative longitudinal data, and disability categories that provide more detail than much of the existing literature.

Conclusions

Disability is associated with drug OD death among US adults, and the strength of the association varies by disability type. Future longitudinal research that includes repeat measures of disability and substance use is needed to understand the temporal relationship between these exposures. The collection of additional information on mental health conditions could also improve understanding of overdose risk among disabled adults. The use of sex stratification might enhance future studies, given that both disability[6] and overdose[13] vary by sex. The disparities reported in this study underscore the importance of including disability status in evaluations of health equity, with the overarching goal of reducing avoidable differences in the burden of substance use. Framing drug OD deaths among adults with disabilities as a health inequity might also increase awareness of the role of historical and contemporary disadvantages in the current drug OD epidemic. Drug OD death prevention activities should address the unique needs of adults with disabilities and minimize barriers to recovery support services.

Tables for Chapter 5

Table 18. Distribution of Sociodemographic Characteristics in the Overall Population and Among Drug Overdose Decedents: Data from Mortality Disparities in American Communities Study, Participants Age 18 Years or Older (n = 3,324,000; 2008-2019)

	Drug Overdose Death[a]		Total Study Population		Death Rate
	Unweighted n[b]	Weighted %	Unweighted n[b]	Weighted %	100,000 person-years (weighted)
Overall					
	4,800	100	3,324,000	100	15.7
Sex					
Female	2,000	39.7	1,749,000	51.7	12.0
Male	2,800	60.3	1,574,000	48.3	19.7
Age Group (years)					
18 – 29	1,300	29.4	576,000	21.3	20.6
30 – 39	1000	22.2	522,000	17.8	18.7
40 – 49	1200	25.5	641,000	19.7	19.5
50 – 59	850	17.2	650,000	17.8	15
60 – 69	200	3.7	468,000	11.8	5.1
70 – 79	80	1.2	290,000	7.1	3.2
80+	40	0.7	176,000	4.5	4.1
Race/Ethnicity					
Hispanic	300	7.2	333,000	13.5	8.1
Non-Hispanic American Indian/Alaska Native	90	1.7	33,600	0.9	30.1
Non-Hispanic Asian	50	1.0	140,000	4.7	3.4
Non-Hispanic Black	350	9.3	285,000	11.4	12.8
Non-Hispanic White	4,000	80.6	2,521,000	69.1	18.5
Non-Hispanic Other	<15	0.2	11,000	0.4	7.1
Educational Attainment					
Less than High School	900	19.6	451,000	15.0	21.5
High School/ GED	1800	36.6	971,000	28.6	20.4
Associate's Degree/ Some College, No Degree	1600	33.3	1,005,000	30.5	16.9
Bachelor's Degree or Higher	500	10.5	897,000	25.9	6.2
Marital Status					

Married	1,500	28.9	1,967,000	53.9	8.4
Never Married	1,900	43.0	709,000	26.3	24.8
Divorced/Separated	1200	24.9	415,000	13.5	29.2
Widowed	200	3.2	232,000	6.3	10.4
Family Poverty Status					
≤100%	1200	26.1	335,000	11.7	35.6
101%-250%	1,400	28.1	792,000	24.9	18.2
251%-400%	900	19.7	757,000	22.3	13.8
≥400%	1,300	26.1	1,440,000	41.0	9.8
Employment Status					
Employed	2,300	48.3	2,082,000	64.3	11.4
Unemployed	500	11.5	119,000	4.1	42.6
Not in labor force	2,000	39.9	1,110,000	31.2	22
In the armed forces	<15	0.3	12,000	0.4	10.7

[a]Includes accidental drug OD deaths and drug OD suicides as defined by ICD-10 codes X40-X44, X60-X64, X85, Y10-Y14

[b]Counts have been rounded to protect confidentiality. Totals may vary due to rounding.

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Table 19. Distribution of Disability Status Among Drug Overdose Decedents and Total Population: Data from Mortality Disparities in American Communities Study, Participants Age 18 or Older (n = 3,323,000; 2008-2019)

	Drug Overdose Death[a]		Total Study Population		Death Rate
	Unweighted n[b]	Weighted %	Unweighted n[b]	Weighted %	100,000 person-years (weighted)
Disability Type					
Ambulatory only	400	8.7	160,000	4.5	36.5
Hearing/seeing only	150	3.2	124,000	3.3	16.9
Cognitive only	400	8.8	63,000	2.0	71.3
Ambulatory and hearing/seeing	90	1.5	52,000	1.4	24.1
All others[c]	450	8.9	101,000	3.0	59.4
None	3,000	68.9	2,824,000	85.8	12.3

[a]Includes accidental drug OD deaths and drug OD suicides as defined by ICD-10 codes X40-X44, X60-X64, X85, Y10-Y14

[b]Counts have been rounded to protect confidentiality. Totals may vary due to rounding.

[c]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing)

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Table 20. Results of Proportional Hazards Regression Models Evaluating the Strength of the Association Between Disability and Drug Overdose Death[a]: Data from Mortality Disparities in American Communities Study, Participants Age 18 or Older (n = 3,324,000)

	Model 1: Unadjusted	Model 2: Adjusted for Demographics[b]	Model 3: Adjusted for Demographic and Socioeconomic Characteristics[c]
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Disability Type			
Ambulatory only	3.0 (2.8 – 3.3)	5.2 (4.7 – 5.7)	2.8 (2.6 – 3.1)
Hearing/seeing only	1.4 (1.2 – 1.6)	2.1 (1.8 – 2.4)	1.6 (1.4 – 1.9)
Cognitive only	5.8 (5.3 – 6.4)	5.3 (4.8 – 5.8)	2.6 (2.4 – 2.9)
Ambulatory and hearing/seeing	2.0 (1.7 – 2.5)	5.0 (4.0 – 6.2)	2.5 (2.0 – 3.1)
All others[d]	5.0 (4.5 – 5.5)	7.1 (6.4 – 7.8)	3.1 (2.8 – 3.4)
None	(ref)	(ref)	(ref)

[a]Drug overdose deaths are identified using ICD-10 underlying cause of death codes X40-44, X60-64, X85, and Y10-Y14.

[b]Age, sex, race/ethnicity.

[c]Age, sex, race/ethnicity, marital status, education, employment, poverty.

[d]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing)

[e]Age at the time of the survey.
HR = Hazard ratio

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Table 21. Distribution of Disability and Drug Overdose Death Using Either Six or Four of the HHS Questions to Identify Disability: MDAC Study Participants Age 18 or Older (n = 3,324,000)

Questions Used to Identify Disability	Any Disability	Drug Overdose[a]
	Weighted %	Weighted %
Six	14.8	32.2
Four	14.2	31.1

[a]Includes accidental drug OD deaths and drug OD suicides as defined by ICD-10 codes X40-X44, X60-X64, X85, Y10-Y14

Table 22. Results of Proportional Hazards Regression Models Evaluating the Strength of the Association Between Disability and Drug Overdose[a] Using Either Six or Four of the HHS Questions to Identify Disability: MDAC Study Participants Age 18 or Older (n = 3,324,000)

Questions Used to Identify Disability	Any Disability	Model 1: Unadjusted HR (95% CI)
Six	No	Ref
	Yes	3.4 (3.2 – 3.6)
Four	No	Ref
	Yes	3.4 (3.2 – 3.6)

[a]Includes accidental drug OD deaths and drug OD suicides as defined by ICD-10 codes X40-X44, X60-X64, X85, Y10-Y14

HR = Hazard ratio

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Chapter 6: The Risk of Alcohol-Induced Death Among Adults with Different Types of Disabilities – a Longitudinal Study Using Nationally Representative Data

Keywords: Alcohol poisoning; Disabled Persons; Mortality

Abstract

Background: Alcohol-induced deaths (AIDs) have doubled in the last two decades, but disability, which is associated with alcohol use and drug overdose death, has received little attention in alcohol mortality research.

Objective: To quantify the risk of AID among adults with different disabilities in a nationally representative longitudinal sample of US adults.

Methods: The most common individual disabilities and co-occurring disabilities were identified among participants ages 18 or older in the Mortality Disparities in American Communities (MDAC) study (n = 3,324,000). Baseline data were collected in 2008 and mortality outcomes were ascertained through 2019 using the National Death Index. Adjusted hazard ratios (aHRs) and 95% confidence intervals (CIs) were estimated for the association between disability type and AID, controlling for demographic and socioeconomic covariates.

Results: During a maximum of 12 years of follow-up, 4,000 AIDs occurred in the study population. Using non-disabled adults as the reference, the risk of AID was elevated for adults with co-occurring ambulatory and hearing/seeing disability (aHR=1.8; 95% CI=1.5–2.2), ambulatory disability only (aHR=1.5; 95% CI=1.3–1.7), and hearing/seeing disability only (aHR=1.2; 95% CI=1.0–1.4). Risk of AID was also elevated among the heterogeneous “other” category (aHR=1.4; 95% CI=1.2–1.6), which included less common combinations of disabilities.

Conclusions: The risk of AID is elevated among adults with ambulatory, hearing/seeing and other types of limitations. AID prevention efforts should include early diagnosis and treatment of alcohol use disorder within these populations. Improved access to occupational and educational

opportunities for adults with disabilities should be considered as AID primary prevention strategies, given that unemployment and lower educational attainment are associated with AID.

Disclaimer: The views expressed in this manuscript are those of the authors and do not represent the views of the National Heart, Lung, and Blood Institute; the National Institute on Drug Abuse; or the U.S. Census Bureau. Results were reviewed by the Census Bureau's Disclosure Review Board (DRB) to prevent disclosure of confidential information. DRB release: CBDRB-FY23-CES004-003, CBDRB-FY23-CES004-008.

Introduction

Between 2000 and 2020, the rate of alcohol-induced deaths (AIDs) in the United States (US) increased from 7.0 to 14.9 per 100,000,[1] making alcohol use a leading cause of preventable death. AID disparities research has examined sex, age, race/ethnicity and urban/rural residence,[12,66,70] but disability status, which is associated with an increased risk of drug overdose mortality,[2–4,28] and non-fatal alcohol use,[29,51,54,55,63,67] has received scarce consideration. Disability is not an inherent characteristic of an individual. Rather, it is the result of an interaction between an individual's abilities and their environment which limits participation in society.[14] The Americans with Disabilities Act (ADA) of 1990 mandated equal access to opportunities for persons with disabilities,[15] and also catalyzed the development of survey questions that could be used to monitor the implementation of the ADA.[16] As a result, US disability research has often classified disability as hearing, seeing, cognitive, ambulatory, self-care, or independent living capacity,[6] although this is far from a comprehensive list of activity-limiting conditions. Importantly for the present research question, the ADA does not define substance abuse as a disability.[15] Population-level research reports that disability is more common among women, compared to men, older adults, compared to younger adults, and that many adults have more than one type of disability.[6] Despite the requirements of the ADA, disability is also associated with economic[21] and educational disadvantage.[22]

To date, limited research has been conducted on disability in relation to AID[114] or alcohol use[29,51,67] in nationally representative samples. During the time period of 1990 to 2011, adults with disability, defined as inability to work, had approximately four times the risk of alcoholic liver disease mortality, when compared to a group of employed adults.[5] Likewise, alcohol morbidity studies have found that persons with work disability also exhibit increased prevalence of past-year alcohol dependence, compared to non-disabled reference groups.[29,67] Alcohol morbidity research has also found that adults who are deaf or hard of hearing report higher lifetime prevalence of heavy alcohol use, compared to adults who are not deaf or hard of hearing.[51] Adults with intellectual disabilities appear to use alcohol at rates that are the same or somewhat lower than the general population, but might drink in riskier ways when alcohol is used.[53,55,68] Finally, research conducted in student populations indicates higher prevalence of heavy alcohol use among those with multiple disabilities, compared to students with no disability,[63] and higher alcohol use among those with "emotional disturbances," compared students with other types of disabilities.[54]

The existing evidence linking disability status and alcohol use is subject to several limitations. Research conducted using older data sources combines individuals with different types of limitations into one[5,67] or two categories.[29] A subset of the existing literature also uses convenience sampling and other data collection techniques that limit the generalizability of the findings[55,63] or fail to account for confounding.[54,55] Finally, no recent research has directly examined the association between disability status and the most severe of alcohol-related health outcomes, death.

Estimating the risk of AID by disability status is complicated by methodological challenges. Many health surveys include disability status, but most do not follow participants longitudinally to ascertain fact or cause of death. Furthermore, the National Vital Statistics System, the primary data source for most AID statistics, does not capture disability status. The Mortality Disparities in American Communities (MDAC) study overcomes these challenges by linking historical American Communities Survey (ACS) data to recent data from the National Death Index (NDI) to produce a nationally representative sample that includes disability status, and fact and cause of death, with a maximum of 12 years of follow-up. The objective of the present study was to use the MDAC data to examine the risk of AID by disability type while controlling for potential confounders identified in the literature and captured by the ACS.

Methods

Data Source

The most recent MDAC data available include baseline information collected in the 2008 ACS with mortality ascertainment through December 31, 2019. The ACS is a mixed-mode household survey that contacts approximately 1 in 38 US households per year, including group quarters. The questionnaire instructs one respondent to provide information for every person living at the sampled address. The ACS packet includes numbers for telephone and telephone device for the deaf (TDD), which respondents in need of assistance can use to contact the Census Bureau. The ACS does not include special instructions for respondents with cognitive or visual disabilities. Most questionnaires are returned by mail, but a subset is completed through telephone or in-person interviewing. Participation in the ACS is required by law, and in 2008, the ACS response rate was 98%.[111] Over 99% of respondents provided sufficient identifying information for matching to the NDI. The ACS gathers self-reported demographic and socioeconomic information, and also includes survey questions developed based on the ADA definitions of disability.[16] Counts obtained from the MDAC data are rounded before release to the public and values less than 15 are suppressed in order to protect confidentiality.

There are approximately 4,512,000 records in the MDAC study. In the present analysis, records were excluded due to ineligibility for linkage to the NDI (n=34,000), age less than 18 years (n=1,032,000), or missing values for the variables required for the analysis (n=122,000). The application of these criteria resulted in an analytic sample of n=3,324,000.

Disability Measures

The disability questions included in the MDAC[92] have been used widely in survey research,[22,77,93] and validated through a comparison with the National Health Interview Survey.[23] For this analysis, the four questions that pertain to specific disabilities were included. The specific disability questions are: *Are you deaf or do you have serious difficulty hearing? [Y/N]; Are you blind or do you have serious difficulty seeing, even when wearing glasses? [Y/N]; Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions? [Y/N]; Do you have serious difficulty walking or climbing stairs? [Y/N].* The remaining two questions, which capture activities of daily living (ADLs), and instrumental activities of daily living (IADLs), were excluded because they overlap with the other four questions and are not specific to particular disabilities. The excluded questions are: *Do you have difficulty dressing or bathing? [Y/N]; Because of a physical, mental or emotional condition, do you have difficulty doing errands alone such as visiting a doctors' office or shopping? [Y/N].* The effect of this exclusion was evaluated using a sensitivity analysis, which is described below.

Disability was defined as 1) ambulatory only; 2) hearing/seeing only; 3) cognitive only; 4) ambulatory and hearing/seeing; 5) other combinations of disabilities, and 6) no disability. Categories were created to represent the most common disability types and combinations present among ≥1% of MDAC study subjects, as determined using survey weights. Hearing and seeing were combined because both are sensory disabilities. The "other" category was used for less common combinations of two or three disabilities (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing). This approach resulted in mutually-exclusive disability categories that represent common individual disabilities and co-occurring disabilities reported by ACS participants.

Alcohol-Induced Deaths

AIDs were identified using the US Centers for Disease Control and Prevention (CDC) case definition,[70] which includes both decedents with alcohol dependence (i.e. alcoholism) and decedents without alcohol dependence. The definition captures deaths directly caused by alcohol, like alcoholic cirrhosis of the liver, accidental poisoning due to alcohol, and alcoholic cardiomyopathy. It does not include deaths indirectly related to alcohol such as unintentional injuries, homicides and fetal alcohol syndrome. Were these deaths to be included, the estimated burden of alcohol-related deaths would be even greater.[70] The International Classification of Diseases, Tenth Revision codes for AIDs are E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15.

Covariates

The existing literature[12,21,50,67] was used to select sociodemographic covariates from the information collected in the MDAC. These are age (18-29, 30-39, 40-49, 50-59, 60-69, 70-79, ≥80 years); sex (female, male); race/ethnicity (Hispanic, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian, non-Hispanic Black, non-Hispanic White, other non-Hispanic); poverty (at or below the poverty level, up to two and a half times the poverty level, two and a half to four times the poverty level, greater than or equal to four times the poverty level); educational attainment (less than high school, high school graduate, associate’s degree/some college (no degree), bachelor’s degree or higher); marital status (married, widowed, divorced/separated, never married) and employment (employed, unemployed, not in the labor force, in the armed forces). Race/ethnicity was included as a proxy for potential experiences of discrimination or privilege, rather than a biological characteristic. Poverty was calculated according to US federal guidelines, which account for family size and income.[105]

Statistical Analyses

Characteristics of the study population were summarized using unweighted counts and weighted percentages. These variables were cross-tabulated with AIDs, and used to calculate weighted rates per 100,000 population. In order to account for variations in follow-up time within the study population, survival analysis techniques were used to measure the association between disability type and AID. Person time was calculated as the difference between the date of the ACS interview and AID. Members of the study population who did not die during the study were right censored on December 31, 2019. Those who died of a cause other than AID were censored on their date of death. Weighted Cox proportional hazards regression was used to estimate crude hazard ratios (HRs), adjusted hazard ratios (aHRs) and 95% confidence intervals (CIs) while controlling for covariates. No disability was used as the reference in the analyses of the six-level categorical disability variable.

Three Cox models were specified: 1) unadjusted; 2) adjusted for demographic factors only; 3) adjusted for demographic and socioeconomic factors. The included demographic factors were age, sex and race/ethnicity; and the socioeconomic factors were education, employment, marital status, and poverty. Unadjusted results are included to depict the *actual distribution* of disability within the different demographic and socioeconomic groups included in the study.[94] Adjusted results, which reflect what the association *would have been* if disability were distributed equally within demographic and socioeconomic groups,[94] are also included to promote discussion of possible primary prevention strategies to reduce AIDs. Log of the negative log of the survivor function plots were used to assess the proportionality assumption.

Sensitivity Analyses

Sensitivity analyses were performed to compare the use of four, rather than all six, of the MDAC disability questions to identify disabled adults. The four questions utilized in this study were employed to create an indicator of any disability, which was then used to estimate the prevalence of any disability in the target population, and the subpopulation of AID decedents. For comparison, these same statistics were then estimated using the standard six question series. Finally, the HR summarizing the association between disability and AID was estimated using first four, then all six disability questions, and the results were compared.

The robustness of the main results was evaluated using a Fine and Gray competing risk model. The model retains individuals who died of other causes in the risk set, rather than removing them on their date of death,[115] to simulate what the association between disability and AID would be if the deaths from competing causes had not occurred.

Results

The distribution of sociodemographic characteristics in the overall study population and among AID decedents is presented in Table 1 using unweighted counts and weighted percentages and rates per 100,000 person-years. The application of exclusion criteria and rounding to protect confidentiality resulted in 4,000 unweighted AIDs and a weighted AID rate of 11.3 (95% CI=11.0–11.7) per 100,000 person-years. Comparing the AID decedents to the total study population reveals that the following groups are disproportionately affected by AID: males; adults ages 40 – 69; non-Hispanic American Indian/Alaska Native and White adults;

adults with less than a bachelor's degree; adults who are divorced/separated; adults with family income less than or equal to 250% of the poverty level; and adults who are unemployed or not in the labor force. The largest absolute differences in AID rates per 100,000 person years were among adults in different race/ethnicity, marital status, and age groups. Among non-Hispanic American Indian/Alaska Native adults, the rate was 42.0 (95% CI=35.2–49.7), compared to 4.3 (95% CI=3.4–5.4) among non-Hispanic Asians; among divorced/separated adults, the rate was 26.8 (95% CI=25.3–28.3), compared to 8.1 (95% CI=7.7–8.5) among married adults; among 50–59 year old's, the rate was 20.4 (95% CI 19.4–21.6), compared to 2.4 (95% CI=2.1–2.8) among 18–29 year old's.

The distributions of disability status among AID decedents and the overall study population are presented in Table 2 using unweighted counts, and weighted percentages and rates per 100,000 person years. The prevalence of disability in the study population was 85.8% with no disability, 4.5% ambulatory only, 3.3% hearing/seeing only, 3.0% all others, 2.0% cognitive only, 1.4% ambulatory and hearing/seeing. Adults with all types of disabilities were overrepresented among AID decedents, relative to their share of the total study population. From highest to lowest, AID rates per 100,000 person years were: 31.4 (95% CI=27.7–35.4) among adults in the heterogeneous "all others" category, 30.8 (95% CI=25.3–37.2) among adults with ambulatory and hearing/seeing disabilities, 26.3 (95% CI=23.6–29.1) among adults with ambulatory disability only, 20.3 (95% CI=17.1–24.0) among adults with cognitive disability only, and 16.9 (14.5-19.5) among adults with hearing/seeing disability only. Among non-disabled adults, the AID rate per 100,000 person years was 9.5 (95% CI=9.2-9.9).

The results of proportional hazards regression models evaluating the strength of the association between disability and AID are presented in Table 3. Non-disabled adults were used as the reference in all models. In the unadjusted analysis (model 1), adults with ambulatory and seeing/hearing (HR=3.4; 95% CI=2.8–4.1), and all other disabilities (HR=3.4; 95% CI=3.0–3.8) had the greatest risk of AID, followed by ambulatory only (HR=2.8; 95% CI=2.5–3.1), cognitive only (HR=2.1; 95% CI=1.8–2.5), and hearing/seeing only (HR=1.8; 95% CI=1.5–2.1). Adjustment for demographic covariates (model 2) attenuated the association between most disabilities and AID, but did not change the pattern seen in the crude results. Additional adjustment for socioeconomic covariates (model 3) further attenuated the associations, and only ambulatory and seeing/hearing (HR=1.8; 95% CI=1.5–2.2), ambulatory only (HR=1.5; 95% CI=1.3–1.7), all others (HR=1.4; 95% CI=1.2–1.6), and hearing/seeing only (HR= 1.2; 95% CI=1.0–1.4) remained statistically significant. Plots of the negative log of the survivor functions displayed no crossing of the survivor functions, indicating consistent relationships between disability type and AID risk throughout the study period.

Sensitivity analyses showed only small differences when the standard six-question disability series was used to identify adults with disabilities, compared to the four questions used in this analysis. The use of six questions increased the estimated prevalence of disability within the target population by less than one percentage point, and the estimated share of alcohol-induced decedents with disability by slightly more than one percentage point (Supplemental Table 1). The use of six questions had no effect on the estimated risk of AID comparing disabled and non-disabled adults (Supplemental Table 2). The use of a competing risk model attenuated the estimated HRs, but all remained significantly different from the null.

Discussion

Each of the disability categories examined in this study are positively associated with AID, with observed differences in the magnitude of AID risk by disability type. In unadjusted analyses, adults with multiple disabilities, which were categorized as ambulatory and hearing/seeing, and other (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing) had approximately three and a half times the risk of AID, compared to non-disabled adults, while adults with other types of disabilities had approximately two to three times the risk of AID. Adjustment for demographic factors weakened these associations but did not change the pattern seen in the crude results. After further adjustment for socioeconomic characteristics, adults with ambulatory and seeing/hearing disabilities still displayed the greatest risk for AID.

Our findings agree with and extend the existing literature on disability and alcohol-related harms. We build on work by Kposowa et al. by demonstrating that the association between disability and AID varies by disability type and remains after adjustment for sociodemographic covariates and the addition of eight years of more recent data.[5] We also show that hearing difficulty is significantly associated with AID mortality risk, expanding on research by Anderson et al. which reported an association between hearing difficulty and lifetime history of heavy alcohol use. Some previous studies of alcohol use among adults with cognitive disabilities had limited generalizability or lacked analyses of confounding.[53,55,68] We develop this research by using nationally-representative data and controlling for potential confounders. However, given evidence that both disability,[6] and AID[12] vary by sex, future research should explore the potential for sex to modify the association between disability type and AID. Finally, we demonstrate more severe alcohol-related outcomes among persons with co-occurring disabilities, in comparison to adults reporting one type of disability, and we add that this finding is present in the general adult population, in addition to undergraduate students.[63]

Limitations

The absence of substance use from the study variables is a limitation of this analysis. Because the ACS is primarily an economic study, it does not capture history of substance use. Consequently, it is impossible to know whether some study subjects became disabled as a result of alcohol use. This is an important consideration given the potential for alcohol use disorder to cause cognitive impairment,[57,58] and evidence of higher incidence of disability pension among persons with heavy alcohol use, relative to moderate alcohol use.[65] There is a possibility that for some adults, disability is an intermediate step between substance use and AID, rather than a distinct risk factor for AID. This pathway could involve cognitive impairment due to chronic alcohol consumption,[57,58,84] or alcohol-involved traumatic brain injuries involving motor vehicles and falls.[82,83] While our study was not etiologic in scope, it does establish the temporal relationship between disability status, as captured in the 2008 ACS, and AID, as identified in the 2019 NDI data. Strengths of our study include the use of specific disability categories, a robust, nationally representative, and longitudinal dataset, and more recent results than previous analyses.

Conclusions

To our knowledge, this is the first study to examine AID disparities by disability status using recent, nationally representative data. The finding that approximately one quarter of AID decedents had a disability at the time of their ACS interview indicates considerable need for AID prevention interventions focusing on adults with ambulatory, auditory, visual and cognitive disabilities. Primary prevention of AID among adults with disability could include improved access to occupational and educational opportunities, given that unemployment and lower educational attainment are associated with AID. Primary prevention could also incorporate opportunities for adults with disabilities to participate in recreational, social and religious activities, as isolation can be a motivator of alcohol use.[31] Secondary prevention can also be effectively tailored for adults with different types of disabilities. Results from a feasibility study of a brief intervention designed for adults with intellectual disabilities show that low-intensity interventions could reduce harmful drinking in this population.[116] Opportunities also exist to improve tertiary prevention. Participation in Alcoholics Anonymous has been shown to increase abstinence from alcohol among adults with a history of alcohol use disorder,[117] thus this and other recovery-oriented peer support groups should be available to adults with different types of disabilities. Barriers faced by persons with disabilities in need of in-patient treatment for substance use disorders should also be minimized,[33] especially in light of evidence that persons with disabilities may be no less successful than non-disabled adults at achieving treatment goals.[34,52] Taken together, this research indicates that investments in primary, secondary and tertiary prevention of AIDs among adults with disability could bring about improvements in public health.

Table 23. Distribution of Sociodemographic Characteristics in the Overall Population and Among Alcohol-Induced Decedents[a]: Data from Mortality Disparities in American Communities Study, Participants Age 18 Years or Older (n = 3,324,000; 2008-2019)

	Alcohol-Induced Death[a]		Total Study Population		Death Rate
	Unweighted n[b]	Weighted %	Unweighted n[b]	Weighted %	100,000 person-years (weighted)
Overall	4,000	100	3,324,000	100	11.3
Sex					
Female	1,200	29.3	1,749,000	51.7	6.4
Male	2,800	70.7	1,574,000	48.3	16.6
Age Group (years)					
18 – 29	150	4.8	576,000	21.3	2.4
30 – 39	400	12.3	522,000	17.8	7.5
40 – 49	1,100	28.8	641,000	19.7	15.9
50 – 59	1,300	32.6	650,000	17.8	20.4
60 – 69	700	15.4	468,000	11.8	15.2
70 – 79	250	5.1	290,000	7.1	9.6
80+	40	1.0	176,000	4.5	4.0
Race/Ethnicity					
Hispanic	350	11.9	333,000	13.5	9.7
Non-Hispanic American Indian/Alaska Native	150	3.3	33,600	0.9	42.0
Non-Hispanic Asian	60	1.8	140,000	4.7	4.3
Non-Hispanic Black	250	7.1	285,000	11.4	7.0
Non-Hispanic White	3,200	75.4	2,521,000	69.1	12.5
Non-Hispanic Other	<15	D	11,000	0.4	12.2
Educational Attainment					
Less than High School	700	18.8	451,000	15.0	14.9
High School/ GED	1300	33.1	971,000	28.6	13.3
Associate’s Degree/ Some College, No Degree	1300	32.4	1,005,000	30.5	11.9
Bachelor’s Degree or Higher	600	15.6	897,000	25.9	6.7

Marital Status					
Married	1,700	39.0	1,967,000	53.9	8.1
Never Married	850	23.7	709,000	26.3	9.9
Divorced/Separated	1,200	31.7	415,000	13.5	26.8
Widowed	250	5.6	232,000	6.3	12.8
Family Poverty Status					
≤100%	750	21.2	335,000	11.7	20.8
101%-250%	1,100	28.2	792,000	24.9	13.1
251%-400%	850	20.7	757,000	22.3	10.5
≥400%	1,300	30.0	1,440,000	41.0	8.1
Employment Status					
Employed	2,000	50.7	2,082,000	64.3	8.6
Unemployed	300	8.0	119,000	4.1	21.4
Not in labor force	1,700	41.3	1,110,000	31.2	16.4
In the armed forces	<15	D	12,000	0.4	1.6

[a]Alcohol-induced deaths defined by ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15

[b]Counts have been rounded to protect confidentiality. Totals may vary due to rounding.

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Table 24. Distribution of Disability Status Among Alcohol-Induced Decedents[a] and Total Population: Data from Mortality Disparities in American Communities Study, Participants Age 18 or Older (n = 3,323,000; 2008-2019)

	Alcohol-Induced Death[a]		Total Study Population		Death Rate
	Unweighted n[b]	Weighted %	Unweighted n[b]	Weighted %	100,000 person-years (weighted)
Disability Type					
Ambulatory only	350	8.7	160,000	4.5	26.3
Hearing/seeing only	200	4.5	124,000	3.3	16.9
Cognitive only	150	3.5	63,000	2.0	20.3
Ambulatory and hearing/seeing	100	2.7	52,000	1.4	30.8
All others[c]	250	6.5	101,000	3.0	31.4
None	3,000	74.1	2,824,000	85.8	9.5

[a]Alcohol-induced deaths defined by ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15

[b]Counts have been rounded to protect confidentiality. Totals may vary due to rounding.

[c]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing)

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Table 25. Hazard Ratios (HRs) and 95% Confidence Intervals (CIs) for the Strength of the Association Between Disability and Alcohol-Induced Death[a]: Data from Mortality Disparities in American Communities Study, Participants age 18 or Older (n = 3,324,000; 2008)

	Model 1: Unadjusted	Model 2: Adjusted for Demographics[b]	Model 3: Adjusted for Demographic and Socioeconomic Characteristics[c]
	HR (95% CI)	HR (95% CI)	HR (95% CI)
Disability Type			
Ambulatory only	2.8 (2.5 – 3.1)	2.6 (2.3 – 2.9)	1.5 (1.3 – 1.7)
Hearing/seeing only	1.8 (1.5 – 2.1)	1.5 (1.3 – 1.7)	1.2 (1.0 – 1.4)
Cognitive only	2.1 (1.8 – 2.5)	2.2 (1.9 – 2.6)	1.0 (0.8 – 1.2)
Ambulatory and hearing/seeing	3.4 (2.8 – 4.1)	3.3 (2.7 – 4.0)	1.8 (1.5 – 2.2)
All others[d]	3.4 (3.0 – 3.8)	3.1 (2.7 – 3.5)	1.4 (1.2 – 1.6)
None	(ref)	(ref)	(ref)

[a]Alcohol-induced deaths defined by ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15

[b]Age, sex, race/ethnicity.

[c]Age, sex, race/ethnicity, marital status, education, employment, poverty.

[d]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing)

[e]Age at the time of the survey.
HR = Hazard ratio

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Table 26. Distribution of Disability and Alcohol-Induced Death Using Either Six or Four of the HHS Questions to Identify Disability: MDAC Study Participants Age 18 or Older (n = 3,324,000)

HHS Questions Used to Identify Disability	Any Disability	Alcohol-Induced Death[a] N = 2,010
	Weighted %	Weighted %
Six	14.8	27.0
Four	14.2	25.9

[a]Alcohol-induced deaths defined using ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15

Table 27. Results of Proportional Hazards Regression Models Evaluating the Strength of the Association Between Disability and Alcohol-Induced Death[a] Using Either Six or Four of the HHS Questions to Identify Disability: MDAC Study Participants Age 18 or Older (n = 3,324,000)

HHS Questions Used to Identify Disability	Any Disability	Model 1: Unadjusted HR (95% CI)
Six	No	Ref
	Yes	2.6 (2.4 – 2.8)
Four	No	Ref
	Yes	2.6 (2.4 – 2.8)

[a]Alcohol-induced deaths defined using ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15

DRB Approval Number CBDRB-FY23-CES004-003

Chapter 7: Conclusions

Summary of findings

The findings from Aim 1, as reported in Table 28, indicate that cognitive disability only, and "other" types of disabilities, a heterogeneous category made up of adults with two or three co-occurring disabilities, are significantly associated with drug and alcohol use disorders in crude analyses, which reflect the actual distribution of disability within demographic and socioeconomic groups in the US. In most cases, adjustment for demographic and socioeconomic covariates strengthens the cross-sectional association between disability and substance use disorders (SUDs), and in the fully-adjusted analyses, hearing/seeing only, ambulatory only, and ambulatory and hearing/seeing are also associated with drug and alcohol use disorders.

The findings from Aim 2, as reported in Table 28, reveal that all examined disability types are significantly associated with increased risk of drug overdose (OD) death in crude and adjusted analyses. In unadjusted analyses, the risk is greatest among adults with cognitive disability only, and "other" types of disabilities. The findings from Aim 3 demonstrate that all examined disability types are also significantly associated with increased risk of alcohol-induced death (AID) in the unadjusted analyses. In the adjusted analyses, the estimated risk of AID for all groups is attenuated, and cognitive disability only is not associated with AID.

Table 28. Crude and Adjusted Estimates of Drug Use Disorder[a], Alcohol Use Disorder[b], Drug Overdose Death[c], and Alcohol-Induced Death[d]: Data from 2018 – 2019 NSDUH (n = 83,485) and 2008 – 2019 MDAC (n = 3,324,000) Participants Age 18 or Older.

		Unadjusted		**Adjusted for Demographic and Socioeconomic Characteristics[e]**	
		Use Disorder[a,b]	**Death[c,d]**	**Use Disorder[a,b]**	**Death[c,d]**
	Disability Type	**OR (95% CI)**	**HR (95% CI)**	**OR (95% CI)**	**HR (95% CI)**
Drug Use Disorder / Death	None	Ref	Ref	Ref	Ref
	Hearing/Seeing only	1.0 (0.8 - 1.4)	1.4 (1.2 – 1.6)	1.5 (1.1 - 1.9)	1.6 (1.4 – 1.9)
	Ambulatory only	0.8 (0.5 - 1.2)	3.0 (2.8 – 3.3)	1.6 (1.0 - 2.6)	2.8 (2.6 – 3.1)
	Cognitive only	5.0 (4.4 - 5.8)	5.8 (5.3 – 6.4)	3.3 (2.9 - 3.8)	2.6 (2.4 – 2.9)
	Other[f]	3.6 (3.0 - 4.4)	5.0 (4.5 – 5.5)	4.3 (3.5 - 5.2)	3.1 (2.8 – 3.4)
	Ambulatory and Hearing/Seeing	1.1 (0.6 - 1.9)	2.0 (1.7 – 2.5)	2.8 (1.6 - 5.1)	2.5 (2.0 – 3.1)
Alcohol Use Disorder / Death	None	Ref	Ref	Ref	Ref
	Hearing/Seeing only	0.8 (0.6 - 1.0)	1.8 (1.5 – 2.1)	1.1 (0.9 - 1.4)	1.2 (1.0 – 1.4)
	Ambulatory only	0.5 (0.4 - 0.7)	2.8 (2.5 – 3.1)	1.1 (0.8 - 1.4)	1.5 (1.3 – 1.7)
	Cognitive only	2.7 (2.4 - 3.0)	2.1 (1.8 – 2.5)	2.3 (2.0 - 2.6)	1.0 (0.8 – 1.2)
	Other[f]	2.0 (1.6 - 2.4)	3.4 (3.0 – 3.8)	2.8 (2.2 - 3.4)	1.4 (1.2 – 1.6)
	Ambulatory and Hearing/Seeing	0.7 (0.4 - 1.1)	3.4 (2.8 – 4.1)	1.6 (0.9 - 2.6)	1.8 (1.5 – 2.2)

[a]Past year DSM-IV drug dependence or abuse.

[b]Past year DSM-IV alcohol dependence or abuse.

[c]Includes accidental drug OD deaths and drug OD suicides as defined by ICD-10 codes X40-X44, X60-X64, X85, Y10-Y14.

[d]Alcohol-induced deaths defined by ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15.

[e]Age, sex, race/ethnicity, marital status, education, employment, poverty.

[f]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

OR = Odds ratio

HR = Hazard ratio

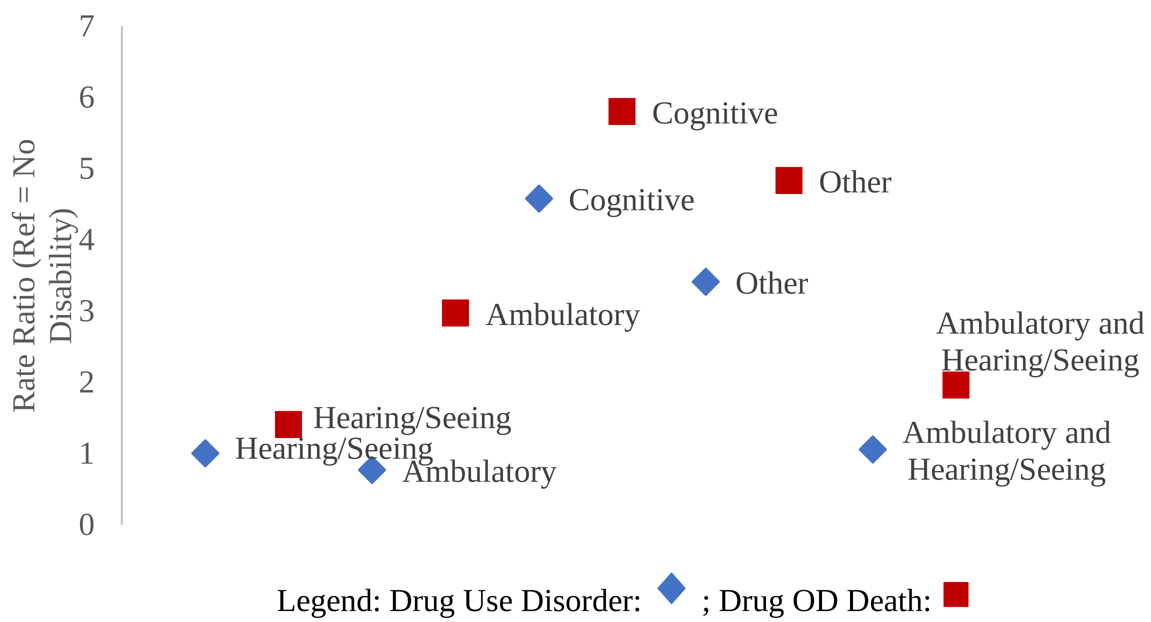
These findings make two contributions to drug OD and AID research:

1. The positive association between binary measures of any disability and SUDs demonstrated previously is probably not due to a single high-risk group that inflates measures of association when all disabilities are pooled together. Instead, ambulatory, cognitive, hearing/seeing and other combinations of disabilities are all associated with SUDs, but the strength of the association varies, and some associations are not independent of sociodemographic covariates.

2. Adults with disabilities should be considered a health disparities population within the field of drug OD and AID research because the risk of drug OD and AID is in excess of disabled adults' level of substance use disorder, and in some cases, it appears to be compounded by socioeconomic challenges.

Health disparities are differences in health which, according to some definitions, are avoidable.[118] The findings presented in this dissertation indicate that the risk of drug OD and AID is in excess of that which would be expected based only on the prevalence of SUDs among adults with several types of disabilities. For comparison, the main results have been converted to rate ratios (RRs) and plotted in two separate figures. Figure 8 depicts drug use disorder and drug overdose death RRs by disability type. Non-disabled adults are used as the reference for all RRs. Figure 9 depicts the same information for alcohol use disorder and alcohol induced death. In the analysis of drugs (Aims 1 and 2), adults in the five disability groups examined had drug overdose death RRs which were 27% to 287% greater than the corresponding non-fatal drug use disorder RRs. The excess risk of drug OD death was most apparent among adults with ambulatory disabilities who had 0.8 times the rate of drug use disorder, compared to non-disabled adults, but 3.0 times the rate of drug OD death, compared to non-disabled adults. Excess OD mortality rates were also evident in the disability groups with significantly elevated rates of drug use disorder. Adults with cognitive disability had 4.6 times the rate of drug use disorder, compared to non-disabled adults, but 5.8 times the rate of drug OD death, compared to non-disabled adults. These results suggest that the elevated risk of drug OD death among adults with disabilities might not be solely attributable to increased substance use disorder prevalence, and instead barriers to substance use treatment[34] might also contribute to the disparity. This perspective is supported by evidence that adults with disability and substance use disorder are less likely to receive the treatment they need,[34,59] but no less likely to successfully complete treatment, when it is accessible.[34,52]

Figure 8. Crude Drug Use Disorder[a] and Drug Overdose Death[b] Rate Ratios: Data from 2018 – 2019 NSDUH (n = 83,485) and 2008 – 2019 MDAC (n = 3,324,000) Participants Age 18 or Older.

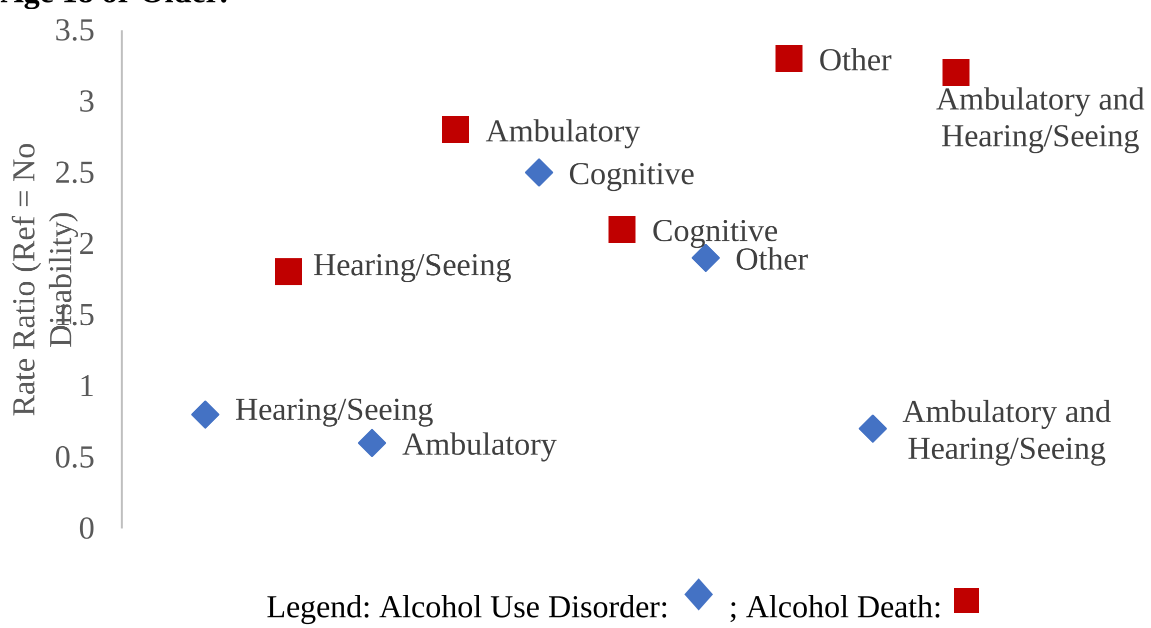


[a]Past year DSM-IV drug dependence or abuse.

[b]Includes accidental drug OD deaths and drug OD suicides as defined by ICD-10 codes X40-X44, X60-X64, X85, Y10-Y14.

The analysis of alcohol (Aims 1 and 3) also indicates that adults with disabilities experience AID risk that is in excess of their level of alcohol use disorder. Excess AID risk is evident in the low-risk population of adults with ambulatory disabilities, who have 0.6 times the crude rate of alcohol use disorder, compared to non-disabled adults, but 2.8 times the crude rate of AID, compared to non-disabled adults. Excess risk is also evident in the high-risk population of adults with all other types of disabilities, who have 1.9 times the rate of drug use disorder, compared to non-disabled adults, but 3.3 times the rate of AID, compared to non-disabled adults. As is the case with drug OD deaths, the excess risk of AID is likely related to access to substance use treatment.[34]

Figure 9. Crude Alcohol Use Disorder[a] and Alcohol-Induced Death[b] Rate Ratios: Data from 2018 – 2019 NSDUH (n = 83,485) and 2008 – 2019 MDAC (n = 3,324,000) Participants Age 18 or Older.



[a]Past year DSM-IV alcohol dependence or abuse.

[b]Alcohol-induced deaths defined by ICD-10 codes E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X45, X65, and Y15.

Comparisons of the crude and adjusted estimates of the risk of drug OD and AID also suggest that adults with disabilities experience excess risk of drug and alcohol mortality. Conceptually, the crude estimates reflect the risk of death in the actual target population of US adults, while the adjusted estimates reflect what the risk of death would be if disability and substance use disorder were equally distributed within variables included in the statistical models. In the analysis of drug OD deaths, adjusted estimates were lower for adults with ambulatory only, cognitive only, and all other disabilities, compared to non-disabled adults. The adjustment variables were demographic and socioeconomic characteristics, which suggests that if the aforementioned groups of disabled adults had the same demographic and socioeconomic characteristics as their non-disabled peers, their risk of drug OD might be lower. Similarly, adjustment of AID estimates for demographic and socioeconomic characteristics attenuated the estimated risk of AID, which suggests that if the examined groups of adults with disabilities had the same overall demographic and socioeconomic characteristics as their non-disabled peers, their risk of AID might be lower. The link between disability and economic[21] and educational[22] disadvantage is well established. This dissertation suggests that improved access to substance use disorder treatment, and improved economic, educational and occupational opportunities for adults with disabilities might reduce drug OD and AID.

Public Health Implications

These findings have several public health implications. Efforts to reduce drug- and alcohol-related health problems should be tailored to meet the needs of the large share of adults with both SUD and disability. For example, medication-assisted therapy for opioid use disorder should minimize the access burdens (e.g. complex handouts and forms) faced by adults with cognitive disabilities, screen for cognitive disability at intake, and adapt SUD counseling services for people with cognitive disabilities.[113] Communities should use public health strategies like Complete Streets (i.e. streets that enable safe mobility for all users, including drivers, pedestrians and public transportation riders)[119] to increase opportunities for adults with disabilities to be active and engaged in the areas where they live, regardless of walking, seeing, hearing or cognitive difficulty. To the extent that drug and alcohol use are used to cope with isolation and depression, opportunities for adults with disabilities to participate in their communities may reduce the allure of substance use. Maintaining limits on days and hours of alcohol sales and increasing alcohol taxes could reduce alcohol use population-wide,[120] including among adults with disabilities.

Limitations

Data limitations did not allow for an exploration of the extent to which substance use might have caused disability. Biologically, non-fatal drug overdose[85] and excess alcohol use[84] might cause cognitive impairment, and the use of both substances can contribute to physical trauma.[82,83] However, the finding that hearing/seeing disabilities, which are less likely to be cause by substance use, are also associated with increased risk of drug OD and AID, could indicate that the positive association between substance use and disability is not entirely due to a bidirectional relationship between the two occurrences.

Future Directions

Key to understanding the underlying causal mechanisms that produced the results reported in this dissertation is whether disability preceded the onset of substance use. Due to the limitations of both the NSDUH and MDAC, these questions cannot be definitively answered using data analyzed herein. However, results of prior studies cast doubt on the theory that most disabilities are caused by substance use. In 2019, approximately 8% of US adults age 18 or older had substance use disorder,[121] but approximately 27% had disability.[122] There is some evidence that mental and substance abuse disorders cause a significant share of years lived with disability among persons younger than age 60,[123] but because the overall prevalence of disability among younger adults is low,[6] the absolute number of adults with disability caused by substance use disorder is likely much smaller than the absolute number with disability caused by musculoskeletal disorders, diabetes and chronic respiratory diseases. For most adults, some loss of functioning appears to be part of the aging process. A nationally-representative longitudinal study of substance use conducted in the early 2000's indicates functioning declined with age among persons without alcohol use disorder (AUD) at baseline.[124] Among adults with AUD at baseline, those who developed alcohol dependence experienced a significant decrease in functioning, but so did those who achieved non-abstinent remission, findings which produce a decidedly mixed picture of the effect of alcohol misuse on the loss of functioning. A follow-up studying using the same data source reported that AUDs were significant predictors of disabilities related to social functioning and emotional conditions, but not physical functioning or mental health.[125] Furthermore, unemployment and physical health conditions were significant predictors of limitations related to all disabilities examined, and the estimated predictive power was typically greater than AUD. The timeliness of these results, and possible lack of statistical power to detect significant differences, are limitations of the existing literature.

Future research focused on disability and substance use should use novel data collection methods to construct a large research database that captures key experiences throughout the lifecourse, including initiation of substance use, timing of educational and occupational experiences, onset of disability, and substance use disorder recovery and relapse episodes.

Unlike heart disease and other leading causes of death, the rates of drug OD and AID in the US general population are comparatively low (in 2020, 14.9 per 100,000 for AID and 211.5 per 100,000 for heart disease[1]) which means that a very large study population would be required to study drug OD and AID using classical epidemiological methods, like the prospective cohort design used in the Framingham Heart Study. The CDC's State Unintentional Drug Overdose Surveillance System utilizes an alternative approach by using death certificates to identify drug OD decedents, then retrospectively investigating treatment for SUDs, prior non-fatal overdoses, and other exposures related to drug OD death.[126] This design results in large amounts of information on drug OD decedents, but it does not produce the denominators needed for the calculation of many epidemiological measures of association. An alternative would be to use data linkage to combine information from existing administrative data sources. The addition of Medicare and Social Security Disability information to the 4.5 million record MDAC study could allow for the identification of non-fatal drug OD hospital visits paid for by Medicaid and Medicare disability benefits, the receipt and timing of Social Security Disability benefits, diagnosis of SUD by a clinician, and the prescription of buprenorphine, naltrexone, and other medicines used to treat SUDs. The continual rise in drug OD and AID rates suggests that this area of research will remain a high public health priority for many years to come.

Appendix

The existing literature was used to identify potential confounders in Aims 1-3, which were the demographic variables sex, age group, and race/ethnicity; and the socioeconomic variables educational attainment, marital status, family poverty status, and employment status. Post-hoc analyses were performed to confirm whether the identified covariates were significantly associated with disability and substance use disorders, as defined in Aim 1 of this dissertation. Bivariate logistic regression models were used to estimate the odds of disability, drug use disorder, and alcohol use disorders using the 2018 – 2019 NSDUH data for adults ages 18 or older. Point estimates were generated using weights, and variance was estimated using cluster and stratum to account for the complex design of the NSDUH. The results show that sex, age group, race/ethnicity, educational attainment, marital status, family poverty status and employment status are associated with both disability and drug use disorder. With the exception of educational attainment and family poverty status, these variables are also associated with alcohol disorder (Table 29).

Table 29. Bivariate Associations Between Covariates, Disability, and Drug and Alcohol Use Disorders – Adults Aged 18+, National Survey On Drug Use and Health (2018-2019)

	Disability (Y/N)		Drug Use Disorder (Y/N)		Alcohol Use Disorder (Y/N)	
	OR	p-value	OR	p-value	OR	p-value
Sex						
Female	0.83	<0.001	0.59	<0.001	0.53	<0.001
Male	ref		ref		ref	
Age Group (years)						
18-25	0.39	<0.001	18.46	<0.001	6.08	<0.001
26-34	0.27		12.14		5.28	
35-49	0.25		6.11		3.73	
≥65	ref		ref		ref	
Race/Ethnicity						
Hispanic	ref	<0.001	ref	<0.001	ref	0.004
Non-Hispanic American Indian/Alaska Native	1.58		0.6		0.71	
Non-Hispanic Native Hawaiian/Pacific Islander	0.49		0.97		0.83	
Non-Hispanic Asian	0.39		1.89		1.44	
Non-Hispanic Black	0.96		0.88		0.97	
Non-Hispanic more than one race	1.72		0.5		0.63	
Non-Hispanic White	1.08		1		0.82	
Educational Attainment						
Less than High School	1.5	<0.001	1.2	<0.001	1.01	0.11
High School Grad	ref		ref		ref	
Associate's Degree/ Some College, No Degree	0.85		0.93		0.86	
Bachelor's Degree or Higher	0.43		1.83		1.03	
Marital Status						
Married	ref	<0.001	ref	<0.001	ref	<0.001
Never Married	1.16		0.2		0.34	
Divorced/Separated	1.99		0.13		0.55	
Widowed	3.66		1.84		1.63	
Family Poverty Status						
Poverty	2.58	<0.001	0.5	<0.001	0.92	0.16
Up to 2x Fed Pov Thresh	1.99		0.75		1.07	
More than 2x Fed Pov Thresh	ref		ref		ref	
Employment Status						

Employed full-time	ref	<0.001	ref	<0.001	ref	<0.001
Employed part-time	2.17		1.05		1.41	
Unemployed	2.51		0.22		0.65	
Not in labor force	4.59		1.09		2.08	

This post-hoc analysis of the statistical association between the covariates included in Aims 1-3, the exposure, and the outcome, demonstrates that the included covariates met the criteria for the data-driven approach to identification of confounders in the analysis of drug use disorder, and most of the covariates also met the criteria in the analysis of alcohol use disorder. These findings confirm the appropriateness of the covariates which were initially selected based on existing evidence (i.e., the literature). The findings also elucidate the unique associations that exist between each of the examined covariates, the exposure, and the outcomes. For example, disability is strongly associated with higher odds of unemployment, part-time work, and labor force non-participation. However, drug and alcohol use disorders are associated with lower odds of unemployment, but higher odds of labor force non-participation. The complexity of these relationships is underscored by ethnographic research which indicates that drug use can both enable, or impede employment.[127]

Post-hoc multivariable logistic regression analyses were performed to identify the most influential covariates in the analysis of disability status. A series of simple models was specified, each of which included drug use disorder as the dependent variable, disability type as the independent variable, and one covariate. All covariates were defined as categorical variables. No disability was used as the reference in all models, and a different model was specified for each of the seven covariates. An eighth model with just the dependent and independent variables (no covariate) was also specified for use as a reference. Finally, the same eight models were specified again using alcohol use disorder as the dependent variable. The levels of the demographic covariates were age (24-25, 26-34, 35-49, 50-64, ≥65); sex (female, male);

race/ethnicity (Hispanic, non-Hispanic American Indian/Alaska Native, non-Hispanic Native Hawaiian/Pacific Islander, non-Hispanic Asian, non-Hispanic Black, non-Hispanic more than one race, non-Hispanic White) and marital status (married, never married, divorced/separated, widowed). The levels of the socioeconomic covariates were education (less than high school, high school graduate, associate's degree/some college (no degree), bachelor's degree or higher); employment (employed full time, employed part time, unemployed, not in the labor force); and poverty (at or below the poverty level, up to two times the poverty level, more than two times the poverty level). Analyses used survey weight, cluster and stratum to account for the complex design of the NSDUH. Once all ORs had been computed, percent differences were used to determine which covariates resulted in the largest change in the estimated ORs. Percent differences were only calculated for statistically significant ($p < 0.05$) ORs.

In the examination of drug use disorder, the results of the analysis of covariates determined that adjustment for age group resulted in the largest change in OR estimate for seeing/hearing (64%), all others (49%) and cognitive only (-20%). Adjustment for marital status resulted in the largest change in OR estimate for ambulatory only (16%). In the examination of alcohol used disorder, adjustment for employment status resulted in the largest change in the OR estimate for hearing/seeing only (19%), all others (47%). Adjustment for age group resulted in the largest change in the OR estimate for ambulatory only (66%). Adjustment for marital status resulted in the largest change in the OR estimate for cognitive only (-15%), and adjustment for sex and race ethnicity both resulted in the same magnitude of change in the estimate for ambulatory and hearing/seeing (3% and -3%) (Table 30).

Table 30. Percent Change in Odds Ratios Summarizing the Association Between Disability Type and Substance Use Disorder Among Adults with Different Types of Disabilities in Univariate and Multivariable Models: Data from 2018-2019 NSDUH Respondents Age 24 or Older

		Drug Use Disorder[a]			Alcohol Use Disorder[b]		
		OR	p-value	% Diff	OR	p-value	% Diff
Disability	**Covariate**						
Hearing/Seeing Only vs None	None (Unadjusted)	1.10	<0.01	Ref	0.81	0.02	Ref
	Sex	1.06	<0.01	-4%	0.77	<0.01	-5%
	Age Group	1.80	<0.01	64%	1.14	0.06	--
	Race/Ethnicity	1.09	<0.01	-1%	0.79	0.02	-2%
	Educational Attainment	1.05	<0.01	-5%	0.81	0.02	0%
	Marital Status	1.27	<0.01	15%	0.89	0.05	10%
	Family Poverty Status	1.07	<0.01	-3%	0.81	0.02	0%
	Employment Status	1.19	<0.01	8%	0.96	<0.01	19%
All Others[c] vs None	None (Unadjusted)	4.07	<0.01	Ref	2.07	<0.01	Ref
	Sex	4.35	<0.01	7%	2.23	<0.01	8%
	Age Group	6.06	<0.01	49%	2.64	<0.01	28%
	Race/Ethnicity	3.93	<0.01	-3%	2.03	<0.01	-2%
	Educational Attainment	3.69	<0.01	-9%	2.10	<0.01	1%
	Marital Status	4.05	<0.01	0%	2.06	<0.01	0%
	Family Poverty Status	3.38	<0.01	-17%	2.10	<0.01	1%
	Employment Status	4.70	<0.01	15%	3.05	<0.01	47%
Cognitive Only vs None	None (Unadjusted)	5.52	<0.01	Ref	2.81	<0.01	Ref
	Sex	5.97	<0.01	8%	3.07	<0.01	9%
	Age Group	4.44	<0.01	-20%	2.42	<0.01	-14%
	Race/Ethnicity	5.45	<0.01	-1%	2.78	<0.01	-1%
	Educational Attainment	5.31	<0.01	-4%	2.81	<0.01	0%
	Marital Status	4.39	<0.01	-20%	2.40	<0.01	-15%
	Family Poverty Status	5.09	<0.01	-8%	2.83	<0.01	1%

	Employment Status	5.44	<0.01	-1%	3.00	<0.01	7%
Ambulatory and Hearing/Seeing vs None	None (Unadjusted)	1.23	0.18	Ref	0.74	0.06	Ref
	Sex	1.28	0.18	--	0.76	0.05	3%
	Age Group	3.73	0.20	--	1.49	0.97	--
	Race/Ethnicity	1.19	0.16	--	0.72	0.05	-3%
	Educational Attainment	1.13	0.14	--	0.75	0.06	--
	Marital Status	1.61	0.60	--	0.91	0.27	--
	Family Poverty Status	1.09	0.14	--	0.74	0.06	--
	Employment Status	1.50	0.33	--	1.15	0.31	--
Ambulatory Only vs None	None (Unadjusted)	0.92	<0.01	Ref	0.58	<0.01	Ref
	Sex	0.98	<0.01	7%	0.62	<0.01	7%
	Age Group	2.09	0.25	--	0.96	<0.01	66%
	Race/Ethnicity	0.89	<0.01	-3%	0.56	<0.01	-3%
	Educational Attainment	0.84	<0.01	-9%	0.58	<0.01	0%
	Marital Status	1.07	0.01	16%	0.64	<0.01	10%
	Family Poverty Status	0.82	<0.01	-11%	0.58	<0.01	0%
	Employment Status	1.09	0.01	18%	0.84	<0.01	45%

[a]Past year DSM-IV drug dependence or abuse.

[b]Past year DSM-IV alcohol dependence or abuse.

[c]Includes other combinations of two or three disabilities not included in the categories shown (i.e., ambulatory and cognitive; cognitive and hearing/seeing; ambulatory, cognitive and hearing/seeing).

-- Not statistically significant

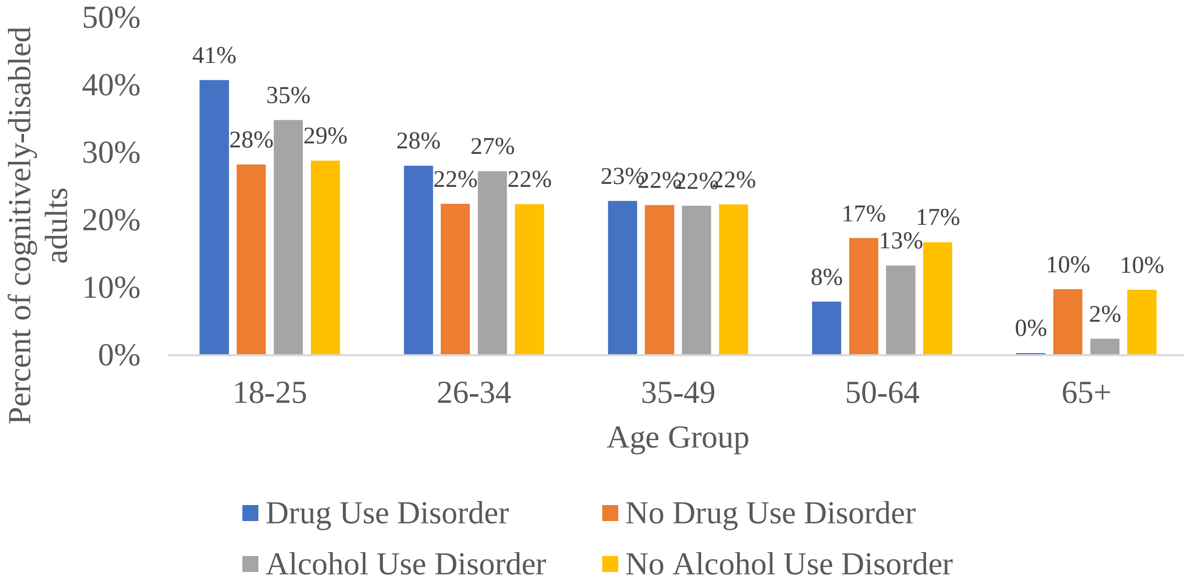
This post-hoc analysis of the most influential covariates in the analysis of disability type and drug and alcohol use disorders revealed considerable heterogeneity across disability types and substance use disorder categories. Age was salient in the analysis of drug use disorder, but marital status was also influential. Employment status was salient in the analysis of alcohol use disorder, as were marital status, sex, and race/ethnicity. These results provide additional support for the inclusion of each of the covariates used in Aims 1 – 3, as each appears to be influential in the estimated association between disability type and substance use disorder.

During the drafting of manuscript one, which focuses on self-reported substance use disorders by disability type, a dissertation committee member pointed out that the features of cognitive disability could be caused by acute drug or alcohol intoxication, or long-term brain damage due to the use of either substance. This raised the possibility that within the population of adults with cognitive disability, there could be two distinct groups: 1) those with impairments not directly due to substance use, including dementia, developmental disabilities and psychiatric conditions; and 2) those with impairment due to substance use. If these two distinct groups exist, there is the potential for the overall association between cognitive disability and substance use disorders to be driven by the subset of adults whose disability was due to drug use (group 2), in which case the question of whether disability is associated with substance use disorders would be obvious. Unfortunately, the NSDUH does not distinguish between cognitive disabilities with different etiologies, nor does it include the age at which disability became discernable.

In light of the absence of information on the etiology of cognitive disability, the committee member suggested a comparison of the age characteristics of cognitively-disabled adults with and without drug or alcohol use disorder. If the age distributions were different, this could suggest that those without drug or alcohol use disorder were primarily affected by age-related dementias, and those with drug and alcohol use disorder were primarily affected by cognitive disabilities related to substance use.

Results indicated that cognitively-disabled adults with drug and alcohol use disorder had a younger age distribution than cognitively-disabled adults without drug or alcohol use disorder (Figure 10). Forty-one percent (41%) of cognitively-disabled adults with drug use disorder were ages 18 – 25, compared to 28% of those without drug use disorder. Thirty-five percent (35%) of cognitively-disabled adults with alcohol use disorder were ages 18 – 25, compared to 29% of those without alcohol-use disorder (Figure 10).

Figure 10. Age Distribution of Cognitively-Disabled Adults with Drug Use Disorder, Alcohol Use Disorder, and in the Total Population: Data From 2018-2019 NSDUH Survey Respondents Age 18 Years or Older



To summarize, there is some indirect evidence to support the hypothesis that the population of adults with cognitive disabilities contains two distinct groups: 1) those with impairments not directly due to substance use, including age-related dementia; and 2) those with impairment due to substance use. Future research should use data sources that include the etiology of cognitive disability, and distinguish between age-related dementia, emotional conditions, developmental disabilities, sequalae of substance use, and other causes, in relation to current drug and alcohol use disorders.

References

1. CDC WONDER. *Underlying Cause of Death 1999-2020 on CDC WONDER Online Database*. Centers for Disease Control and Prevention, National Center for Health Statistics; 2021. Accessed June 11, 2022. http://wonder.cdc.gov/ucd-icd10.html

2. Kuo YF, Raji MA, Goodwin JS. Association of Disability With Mortality From Opioid Overdose Among US Medicare Adults. *JAMA Netw Open*. 2019;2(11):e1915638-e1915638. doi:10.1001/jamanetworkopen.2019.15638

3. Altekruse SF, Cosgrove CM, Altekruse WC, Jenkins RA, Blanco C. Socioeconomic risk factors for fatal opioid overdoses in the United States: Findings from the Mortality Disparities in American Communities Study (MDAC). *PLOS ONE*. 2020;15(1):e0227966. doi:10.1371/journal.pone.0227966

4. Aram J, Johnson NJ, Lee MLT, Slopen N. Drug overdose mortality is associated with employment status and occupation in the National Longitudinal Mortality Study. *The American Journal of Drug and Alcohol Abuse*. 2020;46(6):769-776. doi:10.1080/00952990.2020.1820018

5. Kposowa A. Disability Status, Unemployment, and Alcohol-Related Liver Disease (ALD) Mortality: A Large Sample Individual Level Longitudinal Study. *Subst Abuse Rehabil*. 2021;12:81-88. doi:10.2147/SAR.S334851

6. Brault MW. Household Economic Studies. Published online 2012:24.

7. *Causes of Injury-Related Death*. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2021. Accessed May 26, 2021. https://www.cdc.gov/injury/wisqars/index.html

8. Case A, Deaton A. Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proc Natl Acad Sci USA*. 2015;112(49):15078-15083. doi:10.1073/pnas.1518393112

9. Applebaum KM, Asfaw A, O’Leary PK, Busey A, Tripodis Y, Boden LI. Suicide and drug-related mortality following occupational injury. *American Journal of Industrial Medicine*. 2019;62(9):733-741. doi:10.1002/ajim.23021

10. Harduar Morano L, Steege AL, Luckhaupt SE. Occupational Patterns in Unintentional and Undetermined Drug-Involved and Opioid-Involved Overdose Deaths - United States, 2007-2012. *MMWR Morb Mortal Wkly Rep*. 2018;67(33):925-930. doi:10.15585/mmwr.mm6733a3

11. Hedegaard H. Drug Overdose Deaths in the United States, 1999–2017. *NCHS data brief*. 2018;(329):8.

12. Spencer MR, Curtin SC, Hedegaard H. Rates of Alcohol-induced Deaths Among Adults Aged 25 and Over in Urban and Rural Areas: United States, 2000-2018. *NCHS Data Brief*. 2020;(383):1-8.

13. Hedegaard H, Miniño AM, Warner M. Drug Overdose Deaths in the United States, 1999-2018. *NCHS Data Brief*. 2020;(356):1-8.

14. United Nations. Convention on the Rights of Persons with Disabilities and Optional Protocol. Published online 2007. Accessed August 3, 2022. https://www.un.org/disabilities/documents/convention/convoptprot-e.pdf

15. US Congress. Americans with Disabilities Act of 1990,AS AMENDED with ADA Amendments Act of 2008. Published 1990. Accessed September 19, 2020. https://www.ada.gov/pubs/adastatute08.htm#12102

16. Brault M. Evaluation Report Covering Disability. Published online January 3, 2007. Accessed April 9, 2022. https://www.census.gov/library/working-papers/2007/acs/2007_Brault_01.html

17. U.S. Department of Health and Human Services. U.S. Department of Health and Human Services Implementation Guidance on Data Collection Standards for Race, Ethnicity, Sex, Primary Language, and Disability Status. Published online October 2011. Accessed April 9, 2022. https://aspe.hhs.gov/reports/hhs-implementation-guidance-data-collection-standards-race-ethnicity-sex-primary-language-disability-0

18. SAMHSA. NATIONAL SURVEY ON DRUG USE AND HEALTH 2014 AND 2015 REDESIGN CHANGES. Published online 2015. Accessed June 11, 2022. https://www.samhsa.gov/data/sites/default/files/NSDUH-RedesignChanges-2015.pdf

19. Erickson W. Disability Statistics from the American Community Survey (ACS). Published online 2022. http://www.disabilitystatistics.org/

20. US Bureau of Labor Statistics. Databases, Tables & Calculators by Subject. Published online 2022. Accessed June 12, 2022. https://www.bls.gov/webapps/legacy/cpsatab6.htm

21. Brucker D, Mitra S, Chaitoo N, Mauro J. More Likely to Be Poor Whatever the Measure: Working-Age Persons with Disabilities in the United States*. *Social Science Quarterly*. 2015;96(1):273-296. doi:10.1111/ssqu.12098

22. Singh GK, Lin SC. Marked ethnic, nativity, and socioeconomic disparities in disability and health insurance among US children and adults: the 2008-2010 American community survey. *Biomed Res Int*. 2013;2013:627412-627412. doi:10.1155/2013/627412

23. Altman BM, Madans J, Weeks JD. An evaluation of the American Community Survey indicators of disability. *Disability and Health Journal*. 2017;10(4):485-491. doi:10.1016/j.dhjo.2017.03.002

24. Casseus M, West B, Graber JM, Wackowski O, Cooney JM, Lee HS. Disparities in illicit drug use and disability status among a nationally representative sample of U.S. college students. *Disability and Health Journal*. 2021;14(1):100949. doi:https://doi.org/10.1016/j.dhjo.2020.100949

25. Ford JA, Hinojosa MS, Nicholson HL. Disability status and prescription drug misuse among U.S. adults. *Addictive Behaviors*. 2018;85:64-69. doi:10.1016/j.addbeh.2018.05.019

26. Lauer EAM PhD, Henly MP, Brucker DLM PhD. Prescription opioid behaviors among adults with and without disabilities - United States, 2015-2016. *Disability and Health Journal*. 2019;12(3):519-522. doi:10.1016/j.dhjo.2018.12.001

27. World Health Organization. Global Burden of DIsease 2004 Update: Disability Weights for Diseases and Conditions. Published online 2004.

28. Amundsen EJ. Drug-related causes of death: Socioeconomic and demographic characteristics of the deceased. *Scand J Public Health*. 2015;43(6):571-579. doi:10.1177/1403494815585909

29. Brucker D. Estimating the Prevalence of Substance Use, Abuse, and Dependence Among Social Security Disability Benefit Recipients. *Journal of Disability Policy Studies*. 2007;18(3):148-159. doi:10.1177/10442073070180030301

30. Krieger N. Epidemiology and the web of causation: has anyone seen the spider? *Soc Sci Med*. 1994;39(7):887-903. doi:10.1016/0277-9536(94)90202-x

31. Taggart L, McLaughlin D, Quinn B, McFarlane C. Listening to people with intellectual disabilities who misuse alcohol and drugs. *Health & Social Care in the Community*. 2007;15(4):360-368. doi:https://doi.org/10.1111/j.1365-2524.2007.00691.x

32. Agarwal SD, Landon BE. Patterns in Outpatient Benzodiazepine Prescribing in the United States. *JAMA Network Open*. 2019;2(1):e187399-e187399. doi:10.1001/jamanetworkopen.2018.7399

33. Krahn G, Farrell N, Gabriel R, Deck D. Access barriers to substance abuse treatment for persons with disabilities: An exploratory study. *Journal of Substance Abuse Treatment*. 2006;31(4):375-384. doi:10.1016/j.jsat.2006.05.011

34. Krahn G, Deck D, Gabriel R, Farrell N. A population-based study on substance abuse treatment for adults with disabilities: access, utilization, and treatment outcomes. *Am J Drug Alcohol Abuse*. 2007;33(6):791-798. doi:10.1080/00952990701653750

35. Hadland SE, Krieger MS, Marshall BDL. Industry Payments to Physicians for Opioid Products, 2013-2015. *Am J Public Health*. 2017;107(9):1493-1495. doi:10.2105/AJPH.2017.303982

36. Hadland SE, Rivera-Aguirre A, Marshall BDL, Cerdá M. Association of Pharmaceutical Industry Marketing of Opioid Products With Mortality From Opioid-Related Overdoses. *JAMA Netw Open*. 2019;2(1):e186007-e186007. doi:10.1001/jamanetworkopen.2018.6007

37. Jones CM, Campopiano M, Baldwin G, McCance-Katz E. National and State Treatment Need and Capacity for Opioid Agonist Medication-Assisted Treatment. *Am J Public Health*. 2015;105(8):e55-e63. doi:10.2105/AJPH.2015.302664

38. Drug Enforcement Administration. *2020 Drug Enforcement Administration National Drug Threat Assessment*. DEA; 2021:100. https://www.dea.gov/sites/default/files/2021-02/DIR-008-21%202020%20National%20Drug%20Threat%20Assessment_WEB.pdf

39. Krahn GL, Walker DK, Correa-De-Araujo R. Persons With Disabilities as an Unrecognized Health Disparity Population. *Am J Public Health*. 2015;105(S2):S198-S206. doi:10.2105/AJPH.2014.302182

40. National Institute on Alcohol Abuse and Alcoholism. Alcohol Use Disorder: A Comparison Between DSM–IV and DSM–5. Published online 2021. https://www.niaaa.nih.gov/publications/brochures-and-fact-sheets/alcohol-use-disorder-comparison-between-dsm

41. U.S. Centers of Disease Control and Prevention. Substance Use and Misuse. Published online 2018. https://www.cdc.gov/workplacehealthpromotion/health-strategies/substance-misuse/index.html

42. National Library of Medicine. Managing Chronic Pain in Adults With or in Recovery From Substance Use Disorders. Published online 2000. Accessed June 11, 2022. https://www.ncbi.nlm.nih.gov/books/NBK92053/table/ch2.t5/

43. National Library of Medicine. Drug Use and Addiction. Published online 2019. Accessed June 11, 2022. https://medlineplus.gov/druguseandaddiction.html

44. U.S. Department of Health and Human Services. Facing Addiction in America: The Surgeon General's Report on Alcohol, Drugs, and Health. Published online 2016. Accessed June 11, 2022. https://addiction.surgeongeneral.gov/sites/default/files/surgeon-generals-report.pdf

45. Hong YR, Xie Z, Yadav S, Tanner R, Striley C, Marlow NM. Opioid Use Behaviors Among People With Disability in the United States: An Analysis of the National Survey on Drug Use and Health. *Journal of Addiction Medicine*. Published online 9900. https://journals.lww.com/journaladdictionmedicine/Fulltext/9900/Opioid_Use_Behaviors_Among_People_With_Disability.26.aspx

46. Marlow NM, Xie Z, Tanner R, et al. Association between functional disability type and suicide-related outcomes among U.S. adults with disabilities in the National Survey on Drug Use and Health, 2015–2019. *Journal of Psychiatric Research*. 2022;153:213-222. doi:10.1016/j.jpsychires.2022.07.014

47. Marlow NM, Xie Z, Tanner R, Jo A, Kirby AV. Association Between Disability and Suicide-Related Outcomes Among U.S. Adults. *American Journal of Preventive Medicine*. 2021;61(6):852-862. doi:10.1016/j.amepre.2021.05.035

48. Xie Z, Tanner R, Striley CL, Marlow NM. Association of functional disability with mental health services use and perceived unmet needs for mental health care among adults with serious mental illness. *Journal of Affective Disorders*. 2022;299:449-455. doi:10.1016/j.jad.2021.12.040

49. Xie Z, Tanner R, Striley CL, Marlow NM. Association of functional disability and treatment modalities with perceived effectiveness of treatment among adults with depression: a cross-sectional study. *Disability and Health Journal*. 2022;15(2):101264. doi:10.1016/j.dhjo.2021.101264

50. Glazier RE, Kling RN. Recent trends in substance abuse among persons with disabilities compared to that of persons without disabilities. *Disability and Health Journal*. 2013;6(2):107-115. doi:10.1016/j.dhjo.2013.01.007

51. Anderson ML, Chang BH, Kini N. Alcohol and Drug Use among Deaf and Hard-of-Hearing Individuals: A Secondary Analysis of NHANES 2013–2014. *Subst Abus*. 2018;39(3):390-397. doi:10.1080/08897077.2018.1442383

52. Moore D, McAweeney Mary. Demographic Characteristics and Rates of Progress of Deaf and Hard of Hearing Persons Receiving Substance Abuse Treatment. *American Annals of the Deaf*. 2006;151(5):508-512. doi:10.1353/aad.2007.0005

53. VanDerNagel JEL, Kiewik M, Didden R, et al. Substance Use in Individuals with Mild to Borderline Intellectual Disability: an Exploration of Rates and Risks in the Netherlands. *Advances in Neurodevelopmental Disorders*. 2017;1(4):283-293. doi:10.1007/s41252-017-0035-3

54. Yu J. Substance Use Among Young Adults With Disabilities. Published online 2008:13.

55. McGillicuddy NB. A review of substance use research among those with mental retardation. *Mental Retardation and Developmental Disabilities Research Reviews*. 2006;12(1):41-47. doi:10.1002/mrdd.20092

56. Moore D, Li L. Prevalence and Risk Factors of Illicit Drug Use by People With Disabilities. *The American Journal on Addictions*. 1998;7(2):93-103. doi:10.1111/j.1521-0391.1998.tb00324.x

57. Hayes V, Demirkol A, Ridley N, Withall A, Draper B. Alcohol-related cognitive impairment: current trends and future perspectives. *Neurodegenerative disease management*. 2016;6. doi:10.2217/nmt-2016-0030

58. Verdejo-Garcia A, Garcia-Fernandez G, Dom G. Cognition and addiction. *Dialogues in Clinical Neuroscience*. 2019;21(3):281-290. doi:10.31887/DCNS.2019.21.3/gdom

59. Hinson-Enslin AM, Nahhas RW, McClintock HF. Vision and hearing loss associated with lifetime drug use: NHANES 2013–2018. *Disability and Health Journal*. Published online February 26, 2022:101286. doi:10.1016/j.dhjo.2022.101286

60. Meara E, Horwitz JR, Powell W, et al. State Legal Restrictions and Prescription-Opioid Use among Disabled Adults. https://doi.org/10.1056/NEJMsa1514387. doi:10.1056/NEJMsa1514387

61. Peters JL, Durand WM, Monteiro KA, Dumenco L, George P. Opioid Overdose Hospitalizations among Medicare-Disability Beneficiaries. *J Am Board Fam Med*. 2018;31(6):881-896. doi:10.3122/jabfm.2018.06.180152

62. Song Z. Mortality Quadrupled Among Opioid-Driven Hospitalizations, Notably Within Lower-Income And Disabled White Populations. *Health Aff (Millwood)*. 2017;36(12):2054-2061. doi:10.1377/hlthaff.2017.0689

63. Bernert DJ, Ding K, Hoban MT. Sexual and Substance Use Behaviors of College Students With Disabilities. *American Journal of Health Behavior*. 2012;36(4):459-471. doi:10.5993/AJHB.36.4.3

64. Böckerman P, Hyytinen A, Maczulskij T. Devil in disguise: Does drinking lead to a disability pension? *Preventive Medicine*. 2016;86:130-135. doi:10.1016/j.ypmed.2016.03.008

65. Månsson NO, Råstam L, Eriksson KF, Israelsson B. Alcohol Consumption and Disability Pension among Middle-Aged Men. *Annals of Epidemiology*. 1999;9(6):341-348. doi:10.1016/S1047-2797(99)00014-9

66. White AM, Castle IJP, Hingson RW, Powell PA. Using Death Certificates to Explore Changes in Alcohol-Related Mortality in the United States, 1999 to 2017. *Alcoholism: Clinical and Experimental Research*. 2020;44(1):178-187. doi:10.1111/acer.14239

67. Anderson ML, Ziedonis DM, Najavits LM. Posttraumatic Stress Disorder and Substance Use Disorder Comorbidity Among Individuals With Physical Disabilities:Findings From the National Comorbidity Survey Replication. *Journal of Traumatic Stress*. 2014;27(2):182-191. doi:https://doi.org/10.1002/jts.21894

68. Burgard JF, Donohue B, Azrin NH, Teichner G. Prevalence and treatment of substance abuse in the mentally retarded population: An empirical review. *Journal of Psychoactive Drugs*. 2000;32(3):293-298.

69. Mahdi I, Tomedi LE, Gerrard CY, Lathrop S, Landen M. Excessive alcohol use and drug overdose deaths, New Mexico, 2015-2016. *Drug Alcohol Depend*. 2020;215:108175. doi:10.1016/j.drugalcdep.2020.108175

70. Kochanek KD, Murphy SL, Xu J, Arias E. Deaths: Final Data for 2017. *Natl Vital Stat Rep*. 2019;68(9):1-77.

71. Hedegaard H. Drug Overdose Deaths in the United States, 1999–2020. *NCHS data brief*. 2021;428.

72. SAMHSA. 2018 NATIONAL SURVEY ON DRUG USE AND HEALTH METHODOLOGICAL RESOURCE BOOK. Published online January 2019. https://www.samhsa.gov/data/sites/default/files/cbhsq-reports/NSDUHmrbSampleDesign2018/NSDUHmrbSampleDesign2018.pdf

73. SAMHSA. NSDUH - Confidentiality. Published 2021. Accessed September 27, 2021. https://nsduhweb.rti.org/respweb/confidentiality.html

74. SAMHSA. NSDUH - Frequently Asked Questions. Published 2021. Accessed September 27, 2021. https://nsduhweb.rti.org/respweb/faq.html#q6

75. SAMHSA. 2020 National Survey on Drug Use and Health Field Interview Manual. Published September 2019. Accessed October 16, 2021. https://www.samhsa.gov/data/sites/default/files/reports/rpt23261/NSDUHmrbFIManual2020.pdf

76. SAMHSA. 2019 National Survey on Drug Use and Health (NSDUH) Final CAI Specifications. 2019 National Survey on Drug Use and Health (NSDUH) Final CAI Specifications for Programming. Published October 18, 2018. Accessed June 5, 2021. https://www.samhsa.gov/data/sites/default/files/cbhsq-reports/NSDUHmrbCAISpecs2019.pdf

77. Siordia C, Young R. Methodological note: Allocation of disability items in the American Community Survey. *Disability and Health Journal*. 2013;6(2):149-153. doi:10.1016/j.dhjo.2012.11.007

78. Chapman A, Verdery AM, Monnat SM. Opioid misuse and family structure: Changes and continuities in the role of marriage and children over two decades. *Drug and Alcohol Dependence*. Published online March 2021:108668. doi:10.1016/j.drugalcdep.2021.108668

79. Becker WC, Sullivan LE, Tetrault JM, Desai RA, Fiellin DA. Non-medical use, abuse and dependence on prescription opioids among U.S. adults: psychiatric, medical and substance use correlates. *Drug Alcohol Depend*. 2008;94(1-3):38-47. doi:10.1016/j.drugalcdep.2007.09.018

80. SAMHSA. *2019 National Survey on Drug Use and Health (NSDUH): Methodological Summary and Definitions NSDUH Methodological Report*.; 2020. Accessed October 18, 2021. https://www.samhsa.gov/data/sites/default/files/reports/rpt29395/2019NSDUHMethodsSummDefs/2019NSDUHMethodsSummDefs082120.htm#toc

81. Harrison LD, Martin SS, Enev T, Harrington D. Comparing Drug Testing and Self-Report of Drug Use Among Youths and Young Adults in The General Population: (637122007-001). Published online 2007. doi:10.1037/e637122007-001

82. Chatha H, Sammy I, Hickey M, Sattout A, Hollingsworth J. Falling down a flight of stairs: The impact of age and intoxication on injury pattern and severity. *Trauma*. 2018;20(3):169-174. doi:10.1177/1460408617720948

83. Johnston JJE, McGovern SJ. Alcohol related falls: an interesting pattern of injuries. *Emerg Med J*. 2004;21(2):185. doi:10.1136/emj.2003.006130

84. Stavro K, Pelletier J, Potvin S. Widespread and sustained cognitive deficits in alcoholism: a meta-analysis. *Addiction biology*. 2013;18(2):203-213. doi:10.1111/j.1369-1600.2011.00418.x

85. Winstanley EL, Mahoney JJ, Castillo F, Comer SD. Neurocognitive impairments and brain abnormalities resulting from opioid-related overdoses: A systematic review. *Drug and Alcohol Dependence*. 2021;226:108838. doi:10.1016/j.drugalcdep.2021.108838

86. U.S. Census Bureau. Mortality Disparities in American Communities (MDAC). Analysis File Reference Manual, Version 1.0. Published online May 30, 2019.

87. NIDA. Understanding Drug Use and Addiction. DrugFacts. Published June 6, 2018. Accessed December 11, 2021. https://www.drugabuse.gov/publications/drugfacts/understanding-drug-use-addiction

88. U.S. Centers of Disease Control and Prevention. Understanding Death Data Quality: Cause of Death from Death Certificates. https://www.cdc.gov/nchs/data/nvss/coronavirus/cause-of-death-data-quality.pdf

89. National Academies of Sciences E, Education D of B and SS and, Statistics C on N, et al. *U.S. Mortality Data: Data Quality, Methodology, and Recommendations*. National Academies Press (US); 2021. Accessed March 1, 2023. https://www.ncbi.nlm.nih.gov/books/NBK571933/

90. Council NR. Strengthening Forensic Science in the United States: A Path Forward. *CrimRxiv*. Published online July 1, 2009. doi:10.21428/cb6ab371.b2d683d2

91. National Center for Health Statistics. National Death Index. Published online January 10, 2022. Accessed August 7, 2022. https://www.cdc.gov/nchs/ndi/index.htm

92. U.S. Census Bureau. The American Community Survey 2008 Questionnaire. Published online 2008. https://www2.census.gov/programs-surveys/acs/methodology/questionnaires/2008/quest08.pdf

93. Siordia C, Hoepner LA, Lewis AN. Why Public Health Researchers Should Consider Using Disability Data from the American Community Survey. *Journal of Community Health*. 2018;43(4):738-745. doi:10.1007/s10900-018-0478-0

94. Kaufman JS. Statistics, Adjusted Statistics, and Maladjusted Statistics. *American Journal of Law & Medicine*. 2017;43(2-3):193-208. doi:10.1177/0098858817723659

95. Tøllefsen IM, Hem E, Ekeberg Ø. The reliability of suicide statistics: a systematic review. *BMC Psychiatry*. 2012;12(1):9. doi:10.1186/1471-244X-12-9

96. Dupont WD, Plummer W. PS: Power and Sample Size Calculation. Published online October 2018. https://biostat.app.vumc.org/wiki/Main/PowerSampleSize

97. What's Medicare? | Medicare. Accessed March 1, 2023. https://www.medicare.gov/what-medicare-covers/your-medicare-coverage-choices/whats-medicare#:~:text=Medicare%20is%20the%20federal%20health,a%20transplant%2C%20sometimes%20called%20ESRD

98. Master Beneficiary Summary File (MBSF) LDS | CMS. Accessed March 1, 2023. https://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/LimitedDataSets/MBSF-LDS

99. Dwyer-Lindgren L, Bertozzi-Villa A, Stubbs RW, et al. US County-Level Trends in Mortality Rates for Major Causes of Death, 1980-2014. *JAMA*. 2016;316(22):2385-2401. doi:10.1001/jama.2016.13645

100. Bozorgi P, Porter DE, Eberth JM, Eidson JP, Karami A. The leading neighborhood-level predictors of drug overdose: A mixed machine learning and spatial approach. *Drug and Alcohol Dependence*. 2021;229:109143. doi:https://doi.org/10.1016/j.drugalcdep.2021.109143

101. Berman BA, Streja L, Guthmann DS. Alcohol and other Substance Use among Deaf and Hard of Hearing Youth. *J Drug Educ*. 2010;40(2):99-124. doi:10.2190/DE.40.2.a

102. SAMHSA. National Survey on Drug Use and Health | CBHSQ Data. National Survey on Drug Use and Health (NSDUH). Published 2021. Accessed June 10, 2021. https://www.samhsa.gov/data/data-we-collect/nsduh-national-survey-drug-use-and-health

103. SAMHSA. 2020 NSDUH Field Interviewer Manual. Published online 2019.

104. RTI International. NSDUH - About the Survey. About the Survey. Published 2021. Accessed June 10, 2021. https://nsduhweb.rti.org/respweb/about_nsduh.html

105. U.S. Department of Health and Human Services. HHS Poverty Guidelines for 2022. Published online 2022. Accessed July 30, 3033. https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines

106. Morano LH. Occupational Patterns in Unintentional and Undetermined Drug-Involved and Opioid-Involved Overdose Deaths — United States, 2007–2012. *MMWR Morb Mortal Wkly Rep*. 2018;67. doi:10.15585/mmwr.mm6733a3

107. US Census Bureau. Mortality Disparities in American Communities (MDAC). Census.gov. Published 2022. Accessed March 18, 2022. https://www.census.gov/mdac

108. US Census Bureau. What is the difference between the universes for the American Community Survey, the Decennial Census, and the Current Population Survey? Accessed August 27, 2022. https://ask.census.gov/prweb/PRServletCustom?pyActivity=pyMobileSnapStart&ArticleID=KCP-5955

109. US Census Bureau. American Community Survey Information Guide. Published online October 2017. https://www.census.gov/content/dam/Census/programs-surveys/acs/about/ACS_Information_Guide.pdf

110. U.S. Census Bureau. American Community Survey Design and Methodology. Published online January 2014.

111. U.S. Census Bureau. Response Rates - American Community Survey. Published online 2021. Accessed October 9, 2021. https://www.census.gov/acs/www/methodology/sample-size-and-data-quality/response-rates/index.php

112. Gabella B. *State Special Emphasis Report: Instructions Drug Overdose Death Data*. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2014:26. Accessed May 29, 2021. https://cdn.ymaws.com/www.cste.org/resource/resmgr/Injury/2012-Drug-Deaths-SER-Instruc.pdf

113. SAMHSA. Substance Use Disorder Treatment for People With Physical and Cognitive Disabilities. Published online 2019. Accessed June 1, 2022. https://store.samhsa.gov/sites/default/files/d7/priv/pep19-02-00-002_508_022620.pdf

114. Kposowa AJ. Marital status and HIV/AIDS mortality: evidence from the US National Longitudinal Mortality Study. *International Journal of Infectious Diseases*. 2013;17(10):e868-e874. doi:10.1016/j.ijid.2013.02.018

115. Austin PC, Lee DS, Fine JP. Introduction to the Analysis of Survival Data in the Presence of Competing Risks. *Circulation*. 2016;133(6):601-609. doi:10.1161/CIRCULATIONAHA.115.017719

116. Kouimtsidis C, Bosco A, Scior K, et al. A feasibility randomised controlled trial of extended brief intervention for alcohol misuse in adults with mild to moderate intellectual disabilities living in the community; The EBI-LD study. *Trials*. 2017;18(1):216. doi:10.1186/s13063-017-1953-0

117. Humphreys K, Blodgett JC, Wagner TH. Estimating the Efficacy of Alcoholics Anonymous without Self-Selection Bias: An Instrumental Variables Re-Analysis of Randomized Clinical Trials. *Alcoholism: Clinical and Experimental Research*. 2014;38(11):2688-2694. doi:10.1111/acer.12557

118. Carter-Pokras O, Baquet C. What is a "Health Disparity"? *Public Health Rep*. 2002;117(5):426-434. doi:10.1093/phr/117.5.426

119. U.S. Department of Transportation. Complete Streets. Published online August 24, 2015. https://www.transportation.gov/mission/health/complete-streets

120. Community Preventive Services Task Force. CPSTF Findings for Excessive Alcohol Consumption. Published online 2009. https://www.thecommunityguide.org/content/task-force-findings-excessive-alcohol-consumption

121. Substance Abuse and Mental Health Services Administration. *Key Substance Use and Mental Health Indicators in the United States: Results from the 2019 National Survey on Drug Use and Health*. Center for Behavioral Health Statistics and Quality, Substance Abuse and Mental Health Services Administration; 2020:114. Accessed October 6, 2021. https://www.samhsa.gov/data/sites/default/files/reports/rpt29393/2019NSDUHFFRPDFWHTML/2019NSDUHFFR1PDFW090120.pdf

122. Varadaraj V, Deal JA, Campanile J, Reed NS, Swenor BK. National Prevalence of Disability and Disability Types Among Adults in the US, 2019. *JAMA Network Open*. 2021;4(10):e2130358-e2130358. doi:10.1001/jamanetworkopen.2021.30358

123. Symptoms Matter—Leading Causes of Disability. NCCIH. Accessed March 1, 2023. https://www.nccih.nih.gov/about/symptoms-matterleading-causes-of-disability

124. Dawson DA, Li TK, Chou SP, Grant BF. Transitions In and Out of Alcohol Use Disorders: Their Associations with Conditional Changes in Quality of Life Over a 3-Year Follow-Up Interval†. *Alcohol and Alcoholism*. 2009;44(1):84-92. doi:10.1093/alcalc/agn094

125. Cabello M, Caballero FF, Chatterji S, Cieza A, Ayuso-Mateos JL. Risk factors for incidence and persistence of disability in chronic major depression and alcohol use disorders: Longitudinal analyses of a population-based study. *Health and Quality of Life Outcomes*. 2014;12(1):186. doi:10.1186/s12955-014-0186-0

126. CDC. *CDC's State Unintentional Drug Overdose Reporting System (SUDORS)*.; 2022. https://www.cdc.gov/drugoverdose/fatal/sudors.html

127. Parsons MA. Thinking about Social Determinants of Health through the Relationality of Work and Drug Use. *Medical Anthropology Quarterly*. 2022;36(2):272-289. doi:10.1111/maq.12690