Methods for Population Research on Substance Use and Consequences

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Abstract

This chapter reviews the array of methods used in contemporary research on population-level research on substance use and its consequences. We argue that there are critical questions that can best – or in some cases, only – be addressed at

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the level of a population. We then describe the major categories of data collection methods used in population research, including surveys, ecological momentary assessment, administrative data, audit methods, and unobtrusive assessment of substance use. Two categories of measures are then discussed: measures of an individual's use of substances and related problems and measures of harm to others caused by one's use. We then review factors that may be considered causes or correlates of substance use and consequences, including both individual and environmental factors. We close with a few thoughts on the accumulation of knowledge and its translation to policy and practice.

1   Introduction

This chapter reviews the array of methods used in contemporary research on population-level research on substance use and its consequences. These include methods that have been utilized for decades (such as population-based surveys and administrative data), as well as methods of more recent vintage (such as response-driven sampling and a variety of audit methods).

A useful starting point is to ask the question, "why is it important to examine substance use at the population level?" After all, there is an abundance of research on the dynamics of substance use in individuals and small, handpicked samples, as evidenced by many of the chapters in this volume. This research is extraordinarily useful for answering a number of key questions related to human drug-seeking, drug-taking, and physiological and psychological responses. However, there are also critical questions that can best – or in some cases, only – be addressed at the level of a population (we discuss alternative definitions of "populations," below). These include:

1. What is the incidence and prevalence of substance use in a population? Answering this question is not only important from a scientific standpoint but also important for informing public policy at local, state, national, and cross-national levels.
2. What are the relationships between population-level patterns of substance use and rates of negative consequences of use? From both scientific and policy standpoints, it is important to understand how rates of substance use translate into rates of problems.
3. What individual and environmental factors underlie rates of substance use and consequences in populations? Individual factors (as discussed below) may include age, race and ethnicity, gender, sexual identity, sexual orientation, socio-economic status, genetic makeup, personality, beliefs and attitudes, and life experiences. Environmental or contextual factors may include the availability of drugs with abuse potential, neighborhood factors (e.g., housing, socioeconomic status, crime rates), the presence or absence of relevant policies, and enforcement practices, among others.

It is also important to define what we mean by *substance use*. We define substance use as the intentional consumption of psychoactive drugs, which conventionally include alcohol, tobacco, marijuana, illicit drugs (such as cocaine, hallucinogens, heroin), inhalants, and prescription drugs that are either not used as prescribed or used by someone for whom they were not prescribed. We define consequences of substance use to include individual or group changes in health, behavior, family situation, economic status, educational status, legal status, or other outcomes which may be attributed, at least in part, to use of one or more substances.

Finally, it is important to define what we mean by a "population." As in all areas of science, the definition of a population is the subject of contention and debate (see Krieger 2012 for a recent summary of the issues). We use here a conventional (and conservative) definition of a population as the "inhabitants of an area" (see Krieger 2012), although we briefly reference other definitions, such as a geographically dispersed aggregation of people who are united by some other characteristic or feature, such as sexual identity.

In the following sections of this chapter, we review methods for population research on substance use and its consequences, focusing on data collection methods (including surveys, ecological momentary assessment, administrative data, electronic health records, audits, and unobtrusive methods) for producing data on (1) substance use, (2) consequences of use, and (3) contexts of use and environmental factors. We follow this with a discussion of future directions in methods.

2 Population Research on Substance Use and Consequences

2.1 Data Collection Methods

Below we review methods for population research on substance use and its consequences, focusing on data collection methods, including surveys, ecological momentary assessment, administrative data, electronic health records, audits, and unobtrusive methods.

2.1.1 Surveys

Dating back at least to the 1970s, there is a long history of national surveys on substance use. For example, the National Survey on Drug Use and Health (originally known as the National Household Survey on Drug Abuse), sponsored by what is now known as the Substance Abuse and Mental Health Services Administration (SAMHSA), was first fielded in 1971. Monitoring the Future, which includes annual national surveys of high school students and periodic follow-up surveys of subsamples of these students, was launched in 1974 (Bachman et al. 2001).

Table 1 displays information on basic characteristics of major survey datasets that include extensive data on substance use.

This table does not include surveys that are no longer active, such as the Harvard College Alcohol Study, conducted in a sample of over 100 college campuses in 1993, 1997, 1999, and 2001 (Wechsler and Nelson 2008).

Table 1 Major survey datasets that include extensive data on alcohol, tobacco, and other drug use and consequences

Survey name	Sample		Other sample characteristics	Years	Sponsor	Website
	Age range					
National Survey on Drug Use and Health	Age 12 and up		Random sample of households. Repeated cross-sectional design. Face-to-face interviews	1971–present	Substance Abuse and Mental Health Services Administration	https://nsduhweb.rti.org/respweb/homepage.cfm
Monitoring the Future	8th, 10th, and 12th grade students (12th graders since 1975 and 8th and 10th graders since 1991)		School-based survey. Repeated cross-sectional design with a longitudinal follow-up component	1975–present	National Institute on Drug Abuse	http://www.monitoringthefuture.org/
Behavioral Risk Factor Surveillance System	Adults aged 18 years or older		Multimode (mail, landline phone, and cell phone) health survey. Repeated cross-sectional design. Fifty-one projects used a disproportionate stratified sample (DSS) design for their landline samples. Guam, Puerto Rico, and the US Virgin Islands used a simple random sample design	1984–present	Centers for Disease Control and Prevention	https://www.cdc.gov/brfss/
Youth Risk Behavior Surveillance System	Students in grades 9–12		Cross-sectional school-based survey	1975–present	Centers for Disease Control and Prevention	https://www.cdc.gov/healthyyouth/data/yrbs/index.htm
National Longitudinal Study of Adolescent to Adult Health	Sample of adolescents in grades 7–12 in the United States during the 1994–1995 school year		Periodic longitudinal follow-up survey. In-home interview	Wave 1: 1994–1995 Wave 2: 1996 Wave 3: 2001–2002 Wave 4: 2008 Wave 5: 2016–2018	National Institute of Child Health and Human Development	https://www.cpc.unc.edu/projects/addhealth/

Survey	Population	Methods	Years	Organization	URL
National Health and Nutrition Examination Survey	Noninstitutionalized civilian resident population. Adults and children	Multistage, unequal probability and cluster sampling methods. Interviews and physical examinations	1971–present	Centers for Disease Control and Prevention	https://www.cdc.gov/nchs/nhanes/index.htm
National Health Interview Survey	Aged 65 or older	Cross-sectional household interview survey	1957–present	Centers for Disease Control and Prevention	https://www.cdc.gov/nchs/nhis/index.htm
Pregnancy Risk Assessment Monitoring System	A sample of women who have had a recent birth	Population-based sampling frame "follows back" a stratified sample of women several months postpartum, surveying them about their own and their infant's prenatal, birth, and postpartum behavior and experiences	1988–present	Centers for Disease Control and Prevention	https://www.cdc.gov/prams/index.htm
General Social Survey	Noninstitutionalized adults who speak either English or Spanish	Repeated cross-sectional interview survey	1972–present	The University of Chicago	http://gss.norc.org/
National Alcohol Survey	Individuals ages 18 and over	Periodic national survey	1964–present	Alcohol Research Group	http://arg.org/center/national-alcohol-surveys/
National Epidemiologic Survey on Alcohol and Related Conditions	Ages 18 and over	Face-to-face interviews. Periodic cross-sectional survey	Wave 1: 2001–2002 Wave 2: 2004–2005 Wave 3: 2012–2013	National Institute on Alcohol Abuse and Alcoholism	https://www.niaaa.nih.gov/research/nesarc-iii
National Adult Tobacco Survey	Noninstitutionalized adults ages 18 and over	Landline and cell phone survey	2009–present	Centers for Disease Control and Prevention	https://www.cdc.gov/tobacco/data_statistics/surveys/nats/index.htm

Table 1 (continued)

Survey name	Sample		Other sample characteristics	Years	Sponsor	Website
	Age range					
National Youth Tobacco Survey	Middle school (grades 6–8) and high school (grades 9–12) students		School-based survey	2000–present	Centers for Disease Control and Prevention and Food and Drug Administration	https://www.cdc.gov/tobacco/data_statistics/surveys/nyts/index.htm
Population Assessment of Tobacco and Health	First wave of data collection included responses from over 32,000 adults and 13,000 youth		National longitudinal study of individuals ages 12 and over. In-person interviews	2013–present	National Institutes of Health and Food and Drug Administration	https://pathstudyinfo.nih.gov/UI/HomeMobile.aspx

The sponsoring agency or the organization that implements each of these surveys issues periodic reports on major findings from the surveys, usually related to prevalence of use of various substances, and changes in prevalence over time (e.g., Johnston et al. 2019; Mack et al. 2017). In addition, raw data (stripped of any personal identifiers) from these surveys are available to the research community. These datasets are widely used by researchers, who sometimes use them to contest the "official" findings (e.g., Borders 2018), as well as for a wide variety of studies examining such topics as the association of state recreational marijuana laws and adolescent marijuana use (Cerdá et al. 2017 using Monitoring the Future data), rankings of states on the prevalence of adolescent substance use (Moss et al. 2018 using National Survey on Drug Use and Health and Youth Risk Behavior Surveillance System data), and the relationship of initiation of e-cigarette use and smoking reduction and cessation (Berry et al. 2019 using Population Assessment of Tobacco and Health data).

In addition to these widely used national datasets, many states and local organizations (e.g., health departments) implement their own surveys to document more local conditions. In addition, researchers field their own, specially designed surveys, based on a need for a sample that is defined in different ways or that asks different questions than included in the existing national or state surveys. For example, a researcher may have an interest in alcohol use among LGBT youth (Newcomb et al. 2012), associations between the experience of racial discrimination and substance use (Gibbons et al. 2010), or ask about contexts or behaviors insufficiently addressed in standard surveys (e.g., adolescent alcohol and drug use at own home or someone else's (Egan et al. 2019)).

A fundamental question faced by organizations fielding surveys as well as individual researchers or research teams is how to draw a sample to be surveyed. A comprehensive review of sampling strategies for substance abuse research is beyond the scope of this chapter (see Gfroerer et al. 2017 for such a review). Major categories of these strategies include general population surveys (such as the National Survey on Drug Use and Health), student surveys (such as Monitoring the Future and the Youth Risk Behavior Survey), and "special population" surveys, such as surveys of individuals housed in prisons or jails (such as the National Inmate Survey; see Bronson et al. 2017; Gfroerer et al. 2017).

In addition to sampling strategy, survey mode is also an important decision. Surveys may be conducted by in-person interviews, telephone interviews, Internet surveys, and paper-and-pencil questionnaires, among others (Johnson and VanGeest 2017). Choice of mode involves consideration of important feasibility and coverage issues (e.g., some households will lack a landline phone or cell phone coverage; see Livingston et al. 2013). In addition, researchers need to consider the potential influence of survey mode on responses to questions, especially questions involving sensitive behaviors such as illicit or underage drug use and harms caused to others. There is evidence that modes of data collection that require direct interaction with another individual (such as in-person or telephone interviewer) are associated with lower rates of self-reported drug use (especially illicit drug use; see Johnson and VanGeest 2017) and one's own drug use resulting in harms to others. Alternatively,

methods such as audio computer-assisted self-interviews (ACASI) appear to produce the highest rates of endorsement of substance use (McNeely et al. 2016).

The sampling approaches described above all have the potential of drawing what is known as a "probability sample" – that is, the likelihood of any individual being selected is known, which allows statistical inference to characterize the population as a whole. In addition, there are a variety of nonprobability samples that are used in research on substance use.

An approach known as respondent-driven sampling (RDS) is particularly useful for research on substance use. While probability sampling is the gold standard for ensuring generalizability of the sample to the larger population (Shadish et al. 2001), random selection is not feasible or efficient for many studies that focus on "hidden populations" with relatively rare behaviors (Heckathorn 1997). RDS is a non-probability, chain-referral approach to sampling in which participants recruit their peers, who often share some behaviors, from their own social networks. It provides a basis to calculate unbiased estimates of population parameters (Heckathorn 1997; Heckathorn et al. 2002). RDS relies on respondents (known as "seeds") who then recruit a limited number of subsequent respondents who are members of their social networks. RDS has been extensively used in research on people who inject drugs (McKnight et al. 2006) and other relatively rare or "hidden" populations, such as methamphetamine smokers (Kimani et al. 2014; see Leon et al. 2016 for an in-depth review of the theory and application of RDS).

Another approach to gathering data from populations that might not be adequately represented in standard probability samples is time-space sampling, which is a systematic approach to generating representative samples of populations defined by locations (Parsons et al. 2008). It has been used to gather data on the use of "club drugs" (e.g., MDMA, ketamine, GHB, cocaine, methamphetamine, and LSD) among young adults who frequent dance clubs (Ramo et al. 2010).

2.1.2   Ecological Momentary Assessment

While conventional surveys can be powerful tools for assessing substance use in populations, they are typically limited in their frequency, with many taking place annually. This makes assessment of alcohol and/or drug use in shorter time periods problematic, especially given the difficulties of accurate recall. In addition, it may be challenging in conventional surveys to accurately measure the settings in which alcohol and/or drug use takes place. An approach known as ecological momentary assessment (EMA) "is particularly suitable for studying substance use, because use is episodic and thought to be related to mood and context" (Shiffman 2009). EMA is a mobile health (mHealth) method that typically uses smartphones or other portable devices to collect data from individuals over short time periods (Linas et al. 2016).

2.1.3   Administrative Data

In addition to survey data, there are many administrative datasets – data routinely compiled by units of government or other organizations, such as hospitals and health systems – that are frequently used in research on substance use and consequences in populations (see Table 2).

Table 2 Major administrative datasets that include extensive data on alcohol, tobacco, and other drug use or consequences

Dataset name	Sample		Years	Sponsor	Website
	Age range	Other sample characteristics			
Treatment Episode Data Set	Aged 12 or older	Tracks annual admissions and discharges to public and private substance abuse treatment facilities receiving federal funding	1992–present	Substance Abuse and Mental Health Services Administration	https://wwwdasis.samhsa.gov/dasis2/teds.htm
Fatality Analysis Reporting System		Fatal injuries suffered in motor vehicle traffic crashes	1975–present	National Highway Traffic Safety Administration	https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars
Fatal injury data		Injury-related mortality data	1981–present	Centers for Disease Control and Prevention	https://www.cdc.gov/injury/wisqars/fatal.html
Public drug treatment and Medicaid systems		Drug treatment, deaths, hospitalization	1991–present	Centers for Medicare and Medicaid Services	https://www.medicaid.gov/medicaid/prescription-drugs/index.html
Health maintenance organization		Drug treatment		Health Maintenance Organization	
Social Security Administration		Social Security benefits		US Social Security Administration	https://www.ssa.gov/
Child welfare and public drug treatment system		Drug treatment		National Center on Substance Abuse and Child Welfare	https://ncsacw.samhsa.gov/default.aspx
Mental Health Systems		Mental health and drug and alcohol recovery services	1978–present	Mental Health Systems	https://www.mhsinc.org/
Uniform Crime Reporting Program		Law enforcement administration, operation, and management	1930–present	US Department of Justice, FBI	https://www.fbi.gov/services/cjis/ucr

For example, the Fatality Analysis Reporting System (FARS) has been extensively used to assess alcohol and other drug involvement in fatal motor vehicle crashes. It has been a central resource for research on the effects of state and national laws (e.g., the minimum legal drinking age, state "per se" laws, and administrative license revocation laws) on alcohol-involved fatal motor vehicle crashes (Voas et al. 2000; Fell et al. 2016). Other administrative databases that have been used extensively in population research on substance use include the Treatment Episode Data Set (TEDS), which tracks annual admissions and discharges to public and private substance abuse facilities. For example, TEDS has been used to estimate the percentage of individuals in need of substance abuse treatment who actually received it (the percentage was 8.3%; see Batts et al. 2014).

Finally, there has been substantial research using patients' electronic health records (EHRs) in recent years. These are records on patients that include information on medical diagnoses and treatments that are maintained by individual healthcare delivery organizations (Wu et al. 2016). For example, a number of researchers have used EHR to investigate the relationship between patients experiencing chronic pain and the development of opioid use disorder (Hser et al. 2017).

2.1.4 Audit Methods

An audit study is "a specific type of field experiment that permits researchers to examine difficult to detect behavior ... and decision-making in real-world scenarios" (Gaddis 2017).

The earliest audit studies focused on racial and gender discrimination in real-world settings, such as situations involving home rental or home buying (e.g., Wienk Ronald et al. 1979). Audit studies have been used in substance abuse research since the late 1980s. Examples include assessment of the willingness of retail outlets to sell or serve tobacco products, alcoholic beverages, or (in states where recreational use of marijuana is legal) cannabis products to underage individuals (e.g., DiFranza et al. 1987; Forster et al. 1996, 1997; Buller et al. 2016) or serve alcohol to intoxicated individuals (Toomey et al. 2016). With the rise of new products in alcohol and tobacco as well as the changing marijuana landscape, audits are not only conducted in these physical locations but are increasingly being conducted online as well (Williams et al. 2015). In addition to purchase attempts, audit studies often involve an assessment of the availability and marketing of a product, including the retail outlet density and proximity of retailers to specific locations, such as schools, daycares, and parks. These retail assessments may be conducted using a variety of methods. Data can be collected via paper-and-pencil forms or electronically using mobile technology like iPads or cellular phones. Sometimes, photographic documentation is needed so that a post-assessment content analysis of product advertising can be conducted, as analysis cannot reliably be completed during real-time data collection (i.e., while in the store) (Riffe et al. 2005). To do this, electronic devices or wearable imaging technology, such as glasses with built-in cameras, is needed (Cantrell et al. 2013; Widome et al. 2013; Wagoner et al. 2014, 2018). Wearable imaging technology allows advertisements to be photographically documented at

timed increments, making this method more efficient and less obtrusive than taking photos with tablets or mobile phones.

2.1.5 Unobtrusive Assessment of Substance Use

In addition to the methods described above, there are emerging methods that do not involve direct interaction with individuals or retail environments. One example is what is sometimes referred to as "sewage" or "wastewater" epidemiology, which involves laboratory assessment of excreted drug residues in wastewater to monitor community-level use of drugs of abuse in near real time (Zuccato et al. 2008; Tillett 2008). A recent wastewater measure of cannabis consumption provided evidence that there was a substantial increase in marijuana consumption in Washington state following legalization (Burgard et al. 2019).

A second unobtrusive approach to population health research involves the analysis of social media data, using "big data" approaches (Kim et al. 2017). For example, researchers have examined Twitter posts about JUUL, a popular brand of e-cigarette, and documented that adolescents were following the company's official Twitter account and sharing the messages with others (Chu et al. 2018).

3 Measures

There is an extensive literature on measurement of substance use and its correlates and consequences (see, e.g., Grigsby et al. 2018), of which we can only touch the surface here. Below we present a brief overview of the assessment of an individual's own use, proxy reports on someone else's use, and harm caused to others. We then touch on a few critical points related to measurement of correlates of use and problems, emphasizing the importance of research looking at both endogenous (intraindividual) and exogenous (extra-individual) factors associated with use and problems.

3.1 Measures of Own Use

One of two methods is typically used to measure an individual's use of substances: self-reports or biological measures (sometimes these are both used in the same study). Self-reports, as the name suggests, involve an individual reporting on his or her own substance use behaviors. There is a substantial empirical literature on the reliability and validity of self-reports, as substance use, settings, and consequences may be sensitive topics, with self-reports subject to social desirability as well as recall issues common to self-reported behaviors. A variety of methods have been developed in response to concerns about both social desirability and inaccurate reporting. These include survey methods minimizing or eliminating direct interaction with research staff (e.g., ACASI, described above), triangulation with biological measures, "bogus pipeline" methods, and "randomized response" methods.

Biological measures (sometimes known as "biomarkers") involve the collection of specimens from individuals followed by lab testing to detect the presence and concentration of drugs with abuse potential. Biomarkers from urine, hair, oral fluid, blood, sweat, and breath have been used in substance abuse research (Fendrich et al. 2017; Peterson 2004; Dick 2017; Sharma et al. 2016).

3.1.1 Type of Substance

Researchers almost always find it useful to try to ascertain the type of substance being used. That said, there is considerable variation in the granularity that is sought. For example, a researcher may include survey questions simply on alcohol use, with alcohol including any type. Or they may be interested in the type of alcohol used (e.g., beer, wine, or distilled spirits). For example, some researchers have examined the relationship between the type of alcohol used and the probability of negative consequences (Maldonado-Molina et al. 2010). Some recent work has gone beyond assessing type of alcohol used to actually ascertaining the brand of alcohol, motivated in part by an interest in understanding the connections between alcohol marketing and underage and adult alcohol use (Padon et al. 2018; for similar research on tobacco, see Perks et al. 2018). Researchers studying cannabis use face a host of challenges due to wide variation in strains, which are associated with differences in the concentration of active substances (e.g., THC, CBD) and the presence of contaminants or adulterants (National Academies of Sciences, Engineering, and Medicine 2017). These challenges are often present when assessing the type of illicit drug being used (Napper et al. 2010).

3.1.2 Mode of Consumption

While national surveys often ask about the use of different categories of drugs, many drugs can be consumed in different ways, with important implications for use patterns, progression to addiction, and other consequences of use (Novak and Kral 2011). Examples of modes of consumption include injection, inhalation, and smoking. Even within any one of these categories, there may be important variations – for example, injection directly into a vein ("mainlining") or injection under the skin ("skin-popping"). A further complication is the use of clean needles or reusing needles when injection drugs. For example, a 2015 HIV outbreak in Indiana that stemmed from reuse of needles while injecting the opioid analgesic oxymorphone drew national attention (Conrad et al. 2015). Large increases in rates of acute hepatitis C infection over the past decade in the United States have been linked to injection of heroin and prescription opioid analgesics using contaminated needles (Zibbell et al. 2018). Efforts to identify the mode of consumption are reflected in recent research on heroin, methamphetamine, cocaine (Novak and Kral 2011), and marijuana use (Johnson et al. 2016).

3.1.3 Quantity and Frequency of Use

Quantity and frequency of drug use are typically assessed in research, given their association with impairment and downstream consequences (Grigsby et al. 2018). That said, assessing each of these features of substance use can pose a number of

challenges. For example, the quantity of alcohol use is typically measured by asking questions about the number of drinks that a respondent has consumed during a given time period or drinking occasion. This is sometimes accompanied by definitions of a "standard drink": 12 fluid ounces of beer, 8–9 fluid ounces of malt liquor, 5 fluid ounces of wine, and 1.5 fluid ounces of distilled spirits (National Institute on Alcohol Abuse and Alcoholism 2019). However, individuals typically have little idea of the actual size of the drink they have consumed (Greenfield and Kerr 2008). There are continuing efforts to improve upon and standardize assessment of quantity, using particular sequences of questions that have been shown to elicit more accurate estimates of the quantity of alcohol consumed (such as the quantity-frequency instrument and the beverage-specific quantity-frequency instrument (see Greenfield and Kerr 2008; Nugawela et al. 2016; Vichitkunakorn et al. 2018)).

In the United States, there has been a long history of using a measure of "binge drinking" as a marker of a heavy drinking occasion (the National Institute on Alcohol Abuse and Alcoholism definition of binge drinking is four or more drinks for females and five or more drinks for males in a 2 h period; this level of consumption typically elevates blood alcohol levels to 0.08 g/dl (NIAAA 2015)). Recent research has demonstrated that use of an additional, higher threshold for "high-intensity drinking" – eight or more drinks for females and ten or more for males – is useful for identifying particularly risky drinking occasions (Patrick 2016; Cox et al. 2019).

The emergence of new tobacco products (e.g., e-cigarettes) presents unresolved challenges for measurement. As noted by Wong et al. (2019), the reliability and validity (as well as comparability across studies) of quantity measures such as the number of puffs, vaping episodes, cartridges, and quantity of e-liquid consumed has not been established and may make more or less sense depending on the particular features of the product (also see Cooper et al. 2016).

Similarly, a variety of methods have been used to assess the history or frequency of substance use (often using combined measures of quantity and frequency). This is motivated by researchers' interests in specifying, and understanding the consequences associated with, different patterns of substance use over time. As mentioned earlier, social desirability, as well as recall issues, can pose challenges to accurate measurement of use patterns over a period of time. One often-used method for increasing the accuracy of retrospective self-reports of substance use is the timeline followback method (TLFB; Robinson et al. 2014). The TLFB approach uses a calendar to assist individuals in providing retrospective estimates of their drinking over a specified time period, which can range from a week to 12 months preceding the time of the survey or interview. There are continuing debates about the optimal period of time to measure use using TLFB (e.g., 30-day versus 7-day periods; Hoeppner et al. 2010).

3.1.4 Setting

National surveys often ask questions about substance use without consideration of the context or setting of use. This may provide an incomplete and inadequate understanding of use, since (1) patterns of use may vary considerably across settings

and (2) different settings may be associated with variation in the types and likelihood of consequences. An example of the former is cigarette smoking by young adults in public settings, such as bars, which tends to be more episodic than smoking in private settings, such as in homes (Guillory et al. 2017). An example of the latter is research on underage alcohol use in party settings. Alcohol use by young people at parties is associated with higher rates of negative consequences, including sexual assaults, subsequent drinking and driving, and violence, than drinking in many other settings (Wagoner et al. 2012). Moreover, heightened risk of negative consequences is associated with characteristics of parties, such as whether there is adult presence or supervision, the number of individuals at the party, and whether illicit drugs, such as marijuana, are also being used (Egan et al. 2019; Cox et al. 2019). In recognition of the importance of understanding setting, many studies now try to assess the setting or context in which substance use takes place and analyze the relationship of various settings to patterns of consumption and problems (Grüne et al. 2017; Dunbar et al. 2010; Padilla et al. 2015).

3.1.5 Source

Historically, up until about the 1990s, the source from which a substance with abuse potential was obtained was not an important focus of research. However, in the late 1980s and the 1990s, studies showing the ease with which youth could obtain cigarettes (DiFranza et al. 1987; Forster et al. 1997) and alcohol (Forster et al. 1995) from retail outlets led to an important focus on source that has continued to this day. For example, recent work has focused on the sources of opioid analgesics used without a prescription (Daniulaityte et al. 2014). Research on sources of drugs has the potential to inform effective prevention efforts, such as efforts to restrict youth access to tobacco and alcohol and efforts to reduce inappropriate prescribing of opioid analgesics (Forster and Wolfson 1998; Barglow 2018).

3.1.6 Problems Associated with Use

Problems stemming from substance use are, of course, a critical focus of research. It is important to document the prevalence and extent of such problems and to analyze relationships between patterns of use, individual characteristics, environmental characteristics, and the occurrence of problems.

Many substances have the potential for users to become addicted, so, appropriately, addiction or dependence is an important problem to be measured. If assessment takes place in an interview format, validated instruments commonly used to assess alcohol and drug misuse include the Substance Dependence Severity Scale, the Addiction Severity Index, the Comprehensive Addiction Severity Index for Adolescents, and DSM 5 SCID (see Grigsby et al. 2018 for a review). If an assessment is to be self-administered (e.g., a self-administered survey), validated brief instruments used to assess misuse include the CAGE, CRAFFT, Michigan Alcohol Screening Test (MAST), the Drug Abuse Screening Test (DAST), and the Alcohol Use Disorders Identification Test (AUDIT), among others (see Grigsby et al. 2018). Choices of the particular instrument to be used typically depend on the

population being assessed, the logistics of assessment (e.g., interviewer- or self-administered), and the particular interests of the researchers.

The introduction of new products can present challenges for researchers. For example, efforts are ongoing to adapt existing, validated tools, such as the Fagerström Test for Nicotine Dependence (FTND) and the Nicotine Dependence Syndrome Scale (NDSS) for assessing dependence on e-cigarettes (González et al. 2017) and water pipe tobacco smoking (Myers et al. 2016).

Of course, researchers may be interested in a variety of consequences of substance use that may not be adequately assessed in existing tools, including particular health, educational, social, and legal outcomes. Administrative data sources are also an important tool for examining such outcomes. To cite just one example, the Fatality Analysis Reporting System has been a critical resource for understanding the nature, extent, and societal impact of alcohol-impaired driving (Fell et al. 2009).

3.2 Harming Others

An individual's use of substances can result in a variety of harms to others, ranging from minor annoyances to serious injury and death (Giesbrecht et al. 2010). This is another topic that, until recent years, has been underemphasized in population research on substance use and consequences (Rossow 2016). One line of research that has emerged is the examination of individuals providing substances to others, by way of sharing, gift, or sale. For example, Wolfson et al. (1997) found that more than two-thirds of adolescent smokers had provided tobacco to another adolescent in the previous 30 days, underscoring the importance of social as well as commercial availability of tobacco products.

More generally, in recent years, there has been a proliferation of efforts to assess the harms associated with alcohol and other drugs in college populations (Rhodes et al. 2009a, b) and a number of nation-states, including Australia (Laslett et al. 2014), New Zealand (Casswell et al. 2011), and the United States (Greenfield et al. 2009).

4 Causal Factors and Correlates of Substance Use and Consequences

Accurate and comprehensive description of patterns of use and consequences is critical. But in order to advance the development and implementation of effective prevention, harm reduction, and treatment strategies, population research must also identify causes or correlates of substance use and consequences. This, of course, is a broad topic and has been the focus of 1,000s of scientific articles and books. For the purposes of this chapter, we provide an overview of the kinds of variables that have been examined for the potential role they may play in understanding patterns of substance use and associated problems. We group these factors into two categories, (1) individual and (2) environmental, and, for each, provide some examples of the

ways in which the factors have been conceptualized and measured in population research on substance use.

4.1 Individual Causal Factors and Correlates

In this section, we discuss individual-level factors – usually characteristics or attributes of individuals.

4.1.1 Sociodemographic Factors

Sociodemographic factors, including age, race and ethnicity, gender, and socioeconomic status, are typically assessed in population research on substance use and problems. This enables researchers to examine differences in the incidence and prevalence of use and the associations of use with problems across categories of age (e.g., young adolescents, older adolescents, young adults, and older adults), race and ethnicity, and gender. Of particular concern are disparities in exposure to prevention, harm reduction, and treatment by race, ethnicity, and income (e.g., Melnick 2011), as well as disproportionate legal sanctioning of African Americans for drug offenses (Mooney et al. 2018).

4.1.2 Sexual Orientation and Identity

Increasingly, research on substance use and problems includes assessment of sexual orientation and examination of differences in substance use and problems by this attribute (Kerr and Oglesby 2017; Rhodes et al. 2009a, b). Several studies suggest that LGBT populations are at higher risk for substance use and substance use disorders (Marshal et al. 2008; Azagba et al. 2019).

4.1.3 Personality and Attitudinal Factors

A wide variety of personality factors has been assessed and analyzed in population research on substance use and problems. For example, the five-factor model of personality (the factors are neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness) has been applied in research on community samples (Terracciano et al. 2008). Other factors that have been extensively examined in population research on substance use include time attitudes, self-efficacy, and sensation seeking (McKay et al. 2016). Finally, favorable attitudes about specific substances have been found to predict later use of those substances (Guo et al. 2001).

4.1.4 Personality and Attitudinal Factors

Religiosity, as defined by religious beliefs and attendance at religious services, has been found to be negatively associated with substance use in a large number of studies (Edlund et al. 2010), although there is variation in this relationship by denomination (Michalak et al. 2007).

4.1.5 Mental Health

The co-occurrence of mental health problems and substance misuse has been a mainstay of population research. It is estimated that as many as half of individuals who experience a mental health episode will also experience substance misuse. Santucci (2012) suggests that the substantial overlap between mental health problems and substance abuse may involve some combination of four reasons: risk factors common to both disorders, substance use precipitating mental disorder, self-medication hypothesis, and the presence of either mental illness or SUD contributing to the development of the other.

4.2 Environmental Causal Factors and Correlates

In this section, we examine extra-individual or "environmental" factors that have been the subject of population research on substance use and problems. Many of these factors are of particular interest because they are potentially modifiable.

4.2.1 Situational Factors

Situational factors refer to characteristics of a particular drinking event. These may include the physical location, the social occasion, the day of the week and the time of day, and the presence of, and relationship to, other individuals participating in or observing the event (Jackson et al. 2016). Situational factors are usually measured by survey respondent self-reports, for example, using some variant of the TLFB method described earlier, or ecological momentary assessment (Freisthler et al. 2014).

4.2.2 Family Factors

As one might expect, parenting practices and family dynamics have been the focus of a considerable amount of research on substance use and problems among youth and young adults. For example, high family conflict and low family bonding have been found to increase the risk of initiation of illicit drugs as a child moves through adolescence into young adulthood (Guo et al. 2001). Parental use of drugs is also a risk factor for initiation by youth. Most often, scales of parenting practices and family dynamics are based on self-reports of youth. However, some studies incorporate direct parental reports, which are then linked with data on the child, into measurement of parenting style and family climate and functioning (Rusby et al. 2018). In recent years, researchers have examined how drinking with parents, parents hosting parties, and parents providing alcohol to their adolescents are associated with adolescents' drinking practices and alcohol-related problems (Foley et al. 2004; Reboussin et al. 2012; Cox et al. 2019).

4.2.3 Peer Networks

Having peers who use alcohol, drugs, and tobacco products is also associated with adolescent use (Trucco et al. 2011). This is most often assessed by asking questions about parental behavior on surveys or interviews. However, in some cases, researchers have used social network analysis (SNA) methods to directly ascertain

alcohol, tobacco, and drug use within an individual's social networks. For example, Fujimoto and Valente (2012) used data on social networks from the national Add Health survey. The In-School Survey had students nominate their five best male and five best female friends from a school roster, who were also participants in the survey. Thus, the investigators were able to examine the characteristics of social networks and the association of these characteristics and a youth's position in the network with his or her substance use behaviors.

4.2.4   Availability of Substances

Availability of substances, to both youth and adults, has been extensively examined, using a variety of methods, in recent years. One dimension of this is availability in the home. Broman (2016) used subjective questions to assess this among youth: "Is alcohol easily available to you in your home?" "Are illegal drugs easily available to you in your home?"

Availability of drugs with abuse potential from commercial outlets is also an important focus of research. This can also be assessed using a measure of perceived availability, for example, youth perceptions of the availability of alcohol from bars, grocery stores, or package stores (Foley et al. 2004). But researchers have also used other, objective, measures to assess availability. One is the density or proximity of stores that sell alcohol, tobacco, or marijuana products (in states where medical and/or recreational marijuana can be legally sold) (Mair et al. 2015). In states that require licensing of such stores, density can be computed by geocoding the location of licensed outlets. In states that do not have such a licensing requirement, researchers may generate their own lists of outlets, using a combination of online business listing services (Lee et al. 2016) or physical inspection ("ground-truthing") (Feld et al. 2016). The Centers for Disease Control and Prevention have published a guide on methods for measuring alcohol outlet density (Centers for Disease Control and Prevention 2017).

Using audit methods described earlier in this chapter, researchers have assessed alcohol, tobacco, and marijuana outlets' propensity to sell or serve alcohol, tobacco, or marijuana products to youth, using the outcomes from these audits as a measure of availability (Forster et al. 1997). In addition, they have assessed retailer attitudes and practices (e.g., server or seller training) by conducting systematic observations or surveys of store owners or managers (Wolfson et al. 1996).

Availability of prescription drugs with abuse potential, such as prescription opioid analgesics, has become an important focus of research coinciding with the advent of the opioid crisis in the United States. Availability has been measured by calculating the number of prescriptions of a drug of interest (e.g., an opioid analgesic) divided by the population of a geopolitical unit (e.g., a state), as well as by the rate of high-dose prescribing (defined as a daily dose of 90 morphine milligram equivalents or higher) per capita (Schuchat et al. 2017). County-level data on rates of prescribing are published by many states, based on their prescription drug monitoring program. State-level and national data are published by the CDC (Schuchat et al. 2017).

4.2.5 Price

The price of legal and illicit drugs, which is sometimes considered to be an aspect of availability, is another "environmental" factor that has received substantial attention. Increasing the price of legal substances, often by way of tax increases, is a key tool in efforts to reduce use and harms from alcohol and tobacco use (Sharma et al. 2017). For both alcohol and tobacco research, there are debates about the best kind of data to use to measure price (Ruhm et al. 2012). Data can be person-level survey data (i.e., asking people the price they pay for products), aggregate data from secondary data sources available at the state or national level, or local retail "scanner" data from supermarkets (Adhikari et al. 2012). For illicit drugs, there is not a nationwide consistent and sustained source of reliable data on price, which creates challenges for researchers interested in this dimension of the environment for illicit drugs (Johnson and Golub 2007).

4.2.6 Marketing

Industry marketing, including advertising and promotions by manufacturers and retailers, is an important influence on alcohol and tobacco use, including initiation of use by individuals under the legal age to purchase and use these products (Tanski et al. 2015). With the advent of legal medical and recreational cannabis in some states, researchers have begun to document similar patterns for marijuana (D'Amico et al. 2018). Exposure to marketing is typically measured using self-reports in surveys, which can either be cued (by showing part of an ad but without brand information) or un-cued (simply asking individuals whether they have seen ads). While conventional television and magazine advertising has been most often assessed, recent work focused on marketing via channels involving the Internet (McClure et al. 2016). Recent work has also used EMA (described earlier) to measure exposure to marketing using real-time self-reports (Roberts et al. 2019).

4.2.7 Policy

Federal, state, and local public policy, as well as institutional policy (i.e., policy instituted by nongovernmental organizations, such as healthcare systems, alcohol and tobacco manufacturers and retailers, and social service organizations), are important topics for substance abuse research. There is now a considerable literature on methods for assessing and characterizing policy related to substance use and problems (e.g., see Wagenaar and Burris 2013). In some cases, there are existing databases that indicate which states or localities have a particular policy of interest. For example, NIAAA's Alcohol Policy Information System (APIS) contains extensive information about federal and state alcohol policies, as well as recreational cannabis policies. If an existing database is not used, researchers may rely on online federal, state, or local codes or statutes, although sometimes responsible officials (such as city clerks) are simply asked in surveys about the existence of particular policies (e.g., Forster et al. 1996). Often researchers are interested in assessing whether or not a policy achieved its intended impact; however, it is also important to investigate potential unintended consequences of policy (Wolfson and Hourigan 1997).

4.2.8 Enforcement Practices

Once policies are put in place, they may or may not be enforced. Moreover, there may be considerable variation across jurisdictions in the ways in which policies, such as the minimum legal drinking age, are enforced. Researchers have used both observational and survey methods to collect data on law enforcement agencies regarding their policies, priorities, and practices with respect to enforcement of laws related to illicit substance use, possession, and other behaviors, such as driving while impaired by alcohol or drugs (Montgomery et al. 2006; Bernat et al. 2014).

4.2.9 Community Characteristics

Researchers may have interests in more general features of communities and their relationship to substance use and related problems. These may include whether communities are rural or urban; the composition of the population with respect to race, ethnicity, and income; the presence of concentrated poverty; and the age distribution of a community, among others. The US Census and American Community Survey data are often used for studies exploring these questions. States, cities, or more granular units, such as census tracts, may be used as a unit of aggregation (see Song et al. 2009; Reboussin et al. 2010). There has also been a long-standing interest in exploring the relationship between social determinants of health and substance use and related problems; this interest has intensified with the now widespread attention to the opioid crisis and awareness that certain areas, such as rural communities and Appalachia, have been particularly hard hit (Dasgupta et al. 2018).

5 Summary and Conclusion

5.1 Accumulation of Knowledge

Population research on substance use and related problems has a long history as a vibrant, interdisciplinary field of inquiry. However, it is fair to ask how successful it has been in integrating and accumulating knowledge. One potential obstacle to knowledge accumulation and integration is the use of a multiplicity of measures, which can constitute an obstacle to the development of generalizable knowledge. Recently, federal funders of substance abuse research and others have examined the extent to which common or commensurate measures are used across research studies. One examination of the commonality of shared measurement, based on a sample of applications for funded grants involving human subjects research supported by the National Institute on Drug Abuse (NIDA) and the National Institute on Alcohol Abuse and Alcoholism (NIAAA), found that commonality of measures was generally low, although research on prevention and treatment had somewhat greater commonality than research involving epidemiology and services (Conway et al. 2014). This raises concerns about the generalizability of findings and the cumulative nature of research. A couple of different strategies have emerged in response to this concern. One response is intentional curating measures into compendia, whose use is subsequently promoted by funding agencies. A prominent

example of this is NIDA's support for the development and promotion of the PhenX Toolkit (Hendershot et al. 2015; also see https://www.drugabuse.gov/researchers/research-resources/data-harmonization-projects). A second response to the problem of non-common measures is "data harmonization." This term describes efforts to combine data from different surveys or data sources, where questions may not be exactly the same or difference in methods (sometimes also referred to as "integrative data analysis"; Mun et al. 2015). In addition, in recent years, there has been a movement toward publishing more meta-analyses and systematic reviews (e.g., Hulme et al. 2018; Duke et al. 2018), which can promote accumulation and integration of knowledge.

5.2 Translation of Knowledge

A second important macro question is the extent to which research in a field of study gets translated into policy and practice. Some have argued that substance misuse research is not optimally aligned with the needs of treatment, harm reduction and prevention policymakers and practitioners. One potential, partial remedy that has been suggested is establishing a closer connection between policymakers, practitioners, and researchers in all stages of research – i.e., in the formulation of research problems, implementation of the research, and interpretation and dissemination of results (Dick 2017; Wolfson et al. 2017).

5.3 Limitations

In this chapter, we have attempted to survey a large, complex field within the relatively brief compass of a single chapter. Inevitably, the first limitation is that we were of necessity selective and may have neglected some areas of particular interest to readers. Specific limitations worth acknowledging are that we have for the most part drawn on literature based on research conducted in the United States. We also have mainly discussed observational research. However, throughout the chapter, we refer the reader to other volumes that explore the wide variety of research designs, including large-scale experiments (e.g., community trials and natural experiments), which can be powerful vehicles of knowledge generation in population research on substance use and related problems. Despite these shortcomings, we hope the reader will find some facts, references, or opinions of value in this chapter.

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