



Original article

An Illustrative Review of Substance Use—Specific Insights From the National Longitudinal Study of Adolescent to Adult Health



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A B S T R A C T

Purpose: The purpose of this illustrative, thematic review was to demonstrate the utility of data from the National Longitudinal Study of Adolescent to Adult Health (Add Health) for substance use research and to describe substance use—specific insights gained from Add Health research over the past 2 decades.

Methods: We searched multiple electronic databases (PubMed, PsycInfo, and Web of Science) and selected an illustrative sample of 40 articles that used Add Health data and longitudinally examined a measure of alcohol, marijuana, or illicit drug use or prescription drug misuse as the exposure or outcome in association with diverse domains of additional factors assessed (social, emotional, behavioral, contextual, biological, and genetic).

Results: Included articles identified several key associations between substance use behaviors and additional factors from a wide range of domains. For example, results from several studies indicated that experiences of sexual violence, adolescent dating violence, and intimate partner violence are associated with an increased likelihood of later prescription opioid misuse, heavy drinking, and marijuana use, with some differences by biological gender and race/ethnicity. Results from other studies showed that bidirectional associations between substance use and mental health differ by specific type of substance and mental health condition.

Discussion: Existing research using Add Health data has provided valuable insights regarding substance use by leveraging the study's longitudinal design, the prospective nature of data collection, the breadth and depth of substance use questions assessed from adolescence to adulthood, the size and diversity of the cohort, and the wide range of additional factors measured over time.

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IMPLICATIONS AND CONTRIBUTION

This illustrative thematic review demonstrates that the National Longitudinal Study of Adolescent to Adult Health (Add Health) provides a unique data source for conducting substance use research given (1) the longitudinal design, (2) the breadth and depth of substance use—specific questions at each wave of data collection, (3) the rich social, emotional, behavioral, contextual, biological, and genetic data collected, and (4) the size and diversity of the Add Health cohort.

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The high prevalence of substance use and substance use disorders in the United States is a clear and pressing public health issue [1]. According to the National Survey on Drug Use and Health, in 2019, more than 52 million US adults used an illicit drug in the past year (e.g., marijuana, cocaine, heroin,

methamphetamine) and more than 19 million met criteria for a past year substance use disorder. Underlying these statistics are complex individual and structural conditions that contribute to substance use and the escalation of risk for overdose and other harms.

The magnitude of substance use in the United States underscores the urgent need for robust data and research to inform evidence-based policies and programs. The National Longitudinal Study of Adolescent to Adult Health (Add Health) has prospectively collected detailed social, contextual, emotional,

behavioral, biological, and genetic data from a nationally representative cohort and includes multiple measures of alcohol, marijuana, and illicit and prescription drug use across the life course (Table 1). The rich data available in Add Health represent a unique opportunity to conduct research to expand knowledge regarding substance use and identify actionable objectives for policies and programs. First, while other nationally representative data sources provide annual estimates of various substance use behaviors, Add Health has followed the same cohort from adolescence to adulthood, facilitating an examination of

Table 1

Substance use measures: Waves I–V of the National Longitudinal Study of Adolescent to Adult Health

	Wave I (grades 7–12)	Wave II (grades 8–12)	Wave III (18–26 years)	Wave IV (24–32 years)	Wave V (32–42 years)
Alcohol					
Lifetime alcohol use	X	x	x	x	x
Number of days of alcohol use in past 12 months	X	x	x	x	x
Number of drinks typical on days of drinking in past 12 months	X	x	x	x	
Number of days of binge drinking in past 12 months	X	x	x	x	x
Number of days drunk or very high on alcohol in past 12 months	X	x	x	x	
Number of days of alcohol use in past 30 days				x	x
Number of alcoholic drinks each day in past 30 days				x	x
Age at first alcoholic drink	x			x	
Lifetime alcohol dependence (DSM IV symptoms)				x	
Marijuana					
Lifetime marijuana use	x	x	x	x	x
Number of days of marijuana use in past 30 days	x	x	x	x	x
Age at first marijuana use	x			x	
Lifetime marijuana dependence (DSM IV symptoms)				x	
Inhalants					
Lifetime inhalant use (glue or solvents)	x				
Inhalant use in past 30 days	x	x			
Number of times of inhalant use in past 30 days	x	x			
Cocaine					
Lifetime cocaine use	x	x	x	x	
Cocaine use in past 30 days	x	x	x		x
Number of times of cocaine use in past 30 days	x	x	x		
Age at first cocaine use	x				
Crystal meth					
Lifetime crystal meth use			x	x	
Crystal meth use in past 30 days			x		x
Injection drug use					
Lifetime injection drug use (illicit drugs such as heroin or cocaine)	x	x	x	x	
Number of times of injection drug use (illicit drugs) in past 30 days	x	x	x	x	
Age at first injection drug use	x				
Heroin					
Heroin use in the past 30 days					x
Other illicit drugs					
Lifetime use of other illicit drugs	x	x	x	x	
Other illicit drug use in past 30 days	x	x	x		x
Number of times of other illicit drug use in past 30 days	x	x	x		
Age at first illicit drug use	x				
Lifetime other illicit drug dependence (DSM IV symptoms)				x	
Prescription drug misuse					
Sedatives or downers (barbiturates, sleeping pills, Seconal)			x	x	x
Tranquilizers (Librium, Valium, Xanax)			x	x	x
Stimulants or uppers (amphetamines, rx diet pills, Ritalin, speed)			x	x	x
Pain killers or opioids (Vicodin, OxyContin, Percoet, Demerol, Percodan, Tylenol with codeine)			x	x	x
Prescription drug use					
Prescription drugs taken in past 4 weeks				x	x
Tobacco					
Lifetime cigarette use (even 1 or 2 puffs)	x	x	x		
Ever smoked an entire cigarette			x	x	
Lifetime regular cigarette use (≥ 1 cigarette every day for 30 days)	x	x	x	x	x
Number of days of cigarette use in past 30 days	x	x	x	x	x
Number of cigarettes smoked each day in past 30 days	x	x	x	x	x
Chewing tobacco or snuff use in past 30 days	x	x	x		x
Use of chewing tobacco or snuff at least 20 times				x	

persistence or change in substance use behaviors over time. Second, although electronic health record and insurance claims data provide valuable information on substance use disorder diagnoses and treatment, these data are limited to what is documented during healthcare encounters and often lack information on a diverse set of substance use behaviors, such as timing of initiation or illicit substance use. Third, Add Health provides data on multiple social, contextual, emotional, behavioral, biological, and genetic factors across the life course, which are not often available in other data sources and allow for an assessment of the complex causes and consequences of various substance use behaviors over time. Fourth, while Add Health is nationally representative, geographic data are available that can facilitate the study of specific communities. Finally, the large size of the Add Health cohort facilitates analyses stratified by key characteristics, including biological sex, race/ethnicity, and sexual orientation, to further our understanding of differences in substance use behaviors for specific subgroups.

The purpose of this illustrative, thematic review was to demonstrate the utility of Add Health for substance use research and to describe substance use–specific insights gained from Add Health research over the past 2 decades. Of note, the Add Health data also include multiple measures of tobacco use across the life course (Table 1). While studies focused on tobacco use were beyond the scope of this review, co-use of tobacco and other substances may be of interest to both tobacco use and substance use researchers.

Methods

We conducted a comprehensive search of three electronic databases, PubMed, PsycInfo, and Web of Science, to identify relevant articles published from the Add Health start date through August 2021. We conducted searches using keywords specific to (1) substance use, including use of alcohol, marijuana, and illicit drugs (e.g., cocaine, heroin, methamphetamine) and misuse of prescription drugs (e.g., prescription opioids) and (2) the National Longitudinal Study of Adolescent to Adult Health. We identified 1,281 unduplicated articles.

We screened the titles and abstracts of identified articles for potential eligibility as an illustrative example of substance use research using Add Health data. We included peer-reviewed articles that used Add Health data and examined a measure of substance use (e.g., past 30-day binge drinking) as a primary exposure or outcome (Table 1). We included articles that used data from multiple waves of Add Health or measures from multiple developmental periods to focus on research with a longitudinal design. From potentially eligible articles, the first author organized articles by substance type(s) and selected a random sample of 100 articles. The first author then organized the random sample of 100 articles by year of publication, substance type(s), and by domain of additional measures examined (i.e., genetic, biological, emotional, behavioral, social, and contextual). Based on this organization, the first author selected a sample of 40 articles spanning various disciplines, substance types, and additional measures examined to provide a comprehensive overview of key uses of Add Health data for substance use research and to highlight some of the insights gained from this research. This review was not intended to be representative of all Add Health research on substance use but was intended to

help illustrate the breadth and depth of existing research, orient those new to this data source, and inspire additional research.

We conducted an in-depth examination of the 40 selected articles using a data abstraction tool specific to the aims of the review, with abstraction fields including study aims, substance use measures examined as the exposure or outcome, non-substance use measures examined as the exposure or outcome, key results, and implications for research, policy, and practice. For each article, a primary reviewer extracted data and a secondary reviewer confirmed the extracted information.

Results

Below we describe results from the 40 selected articles selected by domain, organized from the inner (individual, interpersonal) to the outer (community, societal) levels of the socioecological model.

Genetic

Existing research suggests that there is a genetic component to the development of substance use disorders, with the dopamine system hypothesized as playing a role in early or excessive alcohol and marijuana use. Two included studies used the biospecimen data collected in the adult waves of Add Health to examine the influence of specific genetic polymorphisms on substance use outcomes [2,3]. In one study, a dopamine-system genetic risk score was not associated with trajectories of alcohol use from adolescence to adulthood or alcohol use disorder in early adulthood, although there was a weak association of the higher risk scores with more frequent episodes of drunkenness during the transition to adulthood [2]. In the other study, the dopamine receptor D4 (DRD4) polymorphism differentiated marijuana use trajectories from adolescence to adulthood, with the DRD4 polymorphism associated with a trajectory of increasing marijuana use over time [3]. The biospecimen data included in Add Health provide a unique opportunity to investigate genetic factors hypothesized as contributing to various substance use behaviors.

Biological

Six included studies examined substance use as a contributing factor to the development of chronic conditions or as a coping mechanism for existing chronic conditions, with several chronic conditions assessed using the biospecimen data collected in the adult waves of Add Health [4–8]. These studies showed that asthma in adolescence was associated with an increased frequency of drinking from adolescence to adulthood [4]. In addition, binge drinking in adolescence was associated with an increased likelihood of high blood pressure in adulthood, particularly among men [5], and frequent heavy drinking in adolescence was associated with an increased likelihood of diabetes in adulthood [6]. With respect to other substance types, prior marijuana use was not associated with reduced inflammation (measured by C-reactive protein) in adulthood, as commonly hypothesized [7], and chronic pain in adolescence was associated with an increased likelihood of prescription opioid misuse in adulthood [8]. These studies demonstrate the potential role of substance use as a coping mechanism for some

chronic conditions and underscore the potential impacts of persistent or heavy substance use on physical health over time.

Emotional

Multiple studies show that mental health and substance use are intricately linked across the life course. Four included studies focused on understanding bidirectional associations between substance use and mental health symptoms and diagnoses [9–12]. In childhood, symptoms of attention deficit hyperactivity disorder were associated with an increased likelihood of illicit drug use in adolescence and adulthood [9]. In adolescence, higher depressive symptoms were associated with higher initial levels of binge drinking and illicit drug use but not with increases in binge drinking and illicit drug use during the transition to early adulthood [10]. More frequent binge drinking and illicit drug use in adolescence were associated with higher levels of depressive symptoms across adolescence and adulthood [10]. From adolescence to adulthood, alcohol use was associated with an increased likelihood of later suicidal ideation, but suicidal ideation was not associated with an increased likelihood of later alcohol use [11]. In contrast, marijuana and illicit drug use were not associated with an increased likelihood of later suicidal ideation, but suicidal ideation was associated with an increased likelihood of later marijuana and illicit drug use [11]. In adulthood, depression, anxiety, and post-traumatic stress disorder diagnoses predicted later alcohol, cocaine, and methamphetamine use and prescription drug misuse for both male military veterans and civilians [12]. These studies emphasize that while mental health and substance use are intricately linked, these associations are nuanced, with differences by type of substance and mental health condition.

Behavioral

In the behavioral domain, prior Add Health research has examined the influence of adolescent substance use patterns on adult substance use, sexual risk behaviors, and crime [13–16]. Results indicated that adolescent initiation of substance use with inhalants was associated with a different trajectory of substance use in the transition to adulthood compared to initiation with alcohol or marijuana, with those who initiated with inhalants more likely to use cocaine and injection drugs and less likely to use alcohol and marijuana in adulthood [13]. Marijuana use, but not alcohol use, in adolescence was associated with an increased likelihood of cocaine and other illicit drug use in adulthood [14]. With respect to indicators of sexual risk behaviors, adolescent inhalant [13], cocaine [15], and injection drug use [15] were associated with an increased likelihood of laboratory-confirmed sexually transmitted infections in adulthood. Similarly, for both women and men, an earlier age at first intercourse and a quicker accumulation of multiple sex partners were associated with an increased likelihood of binge drinking in early adulthood [16]. Finally, inhalant use in adolescence was associated with an increased likelihood of damaging property, stealing, being injured in a fight, and selling drugs in adulthood [13]. Collectively, these results provide evidence in support of adolescent substance use as a potential precursor to later risk behaviors and delinquency.

Social

Existing Add Health research has examined associations of multiple factors within the social domain, including economic indicators, interpersonal relationships, violence victimization and perpetration, early life trauma, and self-identified race/ethnicity and sexual orientation, with a variety of substance use behaviors.

With respect to economic indicators, three included studies examined the association of educational attainment, financial losses, intergenerational social mobility, and economic capital with substance use outcomes [17–19]. Lower education levels by early adulthood and a decline in household income or assets during adulthood were associated with an increased likelihood of later binge drinking, prescription opioid misuse, and overall drug use, including use of illicit drugs and misuse of prescription drugs [17]. Based on comparisons of their parents' education and occupation to participants' own education and occupation in adulthood, downward social mobility (i.e., a loss in socioeconomic status relative to parents) was associated with an increased likelihood of subsequent illicit drug use, and the strength of this association increased as the loss of socioeconomic status increased [18]. Finally, research indicated notable differences in associations between economic factors and substance use by subgroups. For example, persistently low economic capital from adolescence to adulthood, measured by factors such as income, assets, public assistance, and material hardships, was associated with an increased likelihood of heavy episodic drinking among Black but not White adults [19]. Collectively, results from these studies showed that various measures of reduced economic resources, which are not often available in a single data source, were consistently associated with an increased likelihood of later substance use and that these associations may be particularly pronounced for specific subgroups, including subgroups disproportionately impacted by poverty due to structural racism.

Relationships are central to development in adolescence, and six included studies used Add Health data to examine the association of various relationships in adolescence, including relationships with parents, peers, and teachers, with substance use outcomes [20–24]. Two studies examined the association of social connectedness in adolescence, finding that high levels of school connectedness and social bonds to peers were associated with a lower likelihood of prescription drug misuse [20,21] and illicit drug use [20] in adulthood. Using the romantic partner data available in Add Health, one study showed that higher levels of alcohol use by a romantic partner in adolescence predicted higher alcohol use in later adolescence and adulthood, with these effects strongest when the level of alcohol use was highly incongruent in the relationship [22]. Two studies examined the impact of relationships with adults among adolescents on later substance use behaviors [23,24]. Specifically, parental warmth (i.e., responsiveness, emotional bonding, trust) in adolescence was associated with a reduced likelihood of alcohol problems, marijuana use, and illicit drug use in adulthood while parental control (i.e., degree to which parents granted autonomy) in adolescence was not associated with substance use in adulthood [23]. Considering relationships with nonparent adults, natural mentoring relationships in adolescence were not associated with a reduction in alcohol or drug problems or illicit drug use in early

adulthood among those identifying as lesbian, gay, or bisexual [24]. These results highlight the complexity of associations between interpersonal relationships and substance use, demonstrating that some aspects of relationships may increase the likelihood of substance use (e.g., use by a romantic partner) [22], while others may decrease the likelihood of substance use (e.g., parental warmth) [23]. Data in Add Health on multiple types of relationships, including unique data on romantic partners, can help facilitate these nuanced insights.

Prior research shows that violence and substance use often co-occur. Five included studies examined various types of violence victimization and perpetration in association with substance use outcomes [25–29], with two studies examining bidirectional associations [27,28]. Three studies found that experiences of interpersonal violence across the life course were associated with an increased likelihood of later substance use [25–27]. Specifically, sexual violence experienced from childhood to early adulthood was associated with an increased likelihood of prescription opioid use and misuse in adulthood among both men and women [25], and adolescent dating violence was associated with heavy drinking in early adulthood among women and marijuana use among men [26]. While experiences of multiple types of intimate partner violence (IPV), including minor and major physical violence, injury, and sexual coercion, were associated with later substance use among women, prior substance use was not associated with later experiences of IPV and there were differences in associations by race/ethnicity [27]. For example, IPV was associated with an increased likelihood of marijuana use among Hispanic women but not Black non-Hispanic women [27]. Two additional studies examined the association of other types of violence, including being threatened with a weapon and being shot or stabbed, with substance use. One study documented bidirectional associations between both violence victimization and perpetration from adolescence to adulthood with heavy drinking and marijuana use, with the strength of associations differing by developmental stage [28]. For example, associations between violence victimization and perpetration and heavy drinking increased in magnitude from adolescence to early adulthood and then decreased in later adulthood [28]. In contrast, in another study, violence victimization in adolescence was not associated with alcohol problems, marijuana use, or illicit drug use in early adulthood [29]. Differences in results from these two studies may be related to differences in the measures of substance use used (e.g., heavy drinking vs. alcohol problems, any marijuana use vs. past month marijuana use), emphasizing the importance of considering the multidimensional nature of substance use in this research. Overall, results from these five studies highlight that while experiences of violence are generally associated with an increased likelihood of multiple substance use outcomes, there are differences in associations for specific subgroups, suggesting that some populations may have different coping strategies following violence.

In alignment with the large body of research on the life course implications of adverse childhood experiences, results from five included studies examined the impact of early trauma on substance use outcomes in adolescence and adulthood [30–34]. In three studies, cumulative trauma prior to age 18 years, including experiences of neglect, physical, sexual, and emotional abuse, parental incarceration and binge drinking, and witnessing, being threatened with, or experiencing violence, was associated with an increased likelihood of prescription opioid misuse [31],

cocaine use [32], injection drug use [31], an earlier onset of marijuana use [30], an increased frequency of marijuana use in adolescence and adulthood [30], and marijuana use disorder symptoms in adulthood [30]. Notably, in these studies, as the number of traumas experienced increased, the likelihood of each substance use outcome also increased [30–32]. Similarly, in another study, physical or sexual abuse and experiences of homelessness prior to age 18 years were associated with an increased likelihood of prescription opioid misuse and marijuana, cocaine, and methamphetamine use in early adulthood, with the risk for each substance use outcome highest for those with experiences of both abuse and homelessness [33]. Finally, having a biological father incarcerated was associated with a greater frequency of marijuana use and an increased likelihood of illicit drug use in the transition from adolescence to early adulthood among both men and women [34]. These results underscore the potential implications of early adversity for the development of a range of substance use behaviors and highlight the importance of longitudinal study designs, possible with the multiple waves and prospective nature of Add Health data collection, to substance use research.

Several Add Health studies have examined substance use trajectories among diverse racial and ethnic groups. Of the included studies, one examined potential differences in trajectories of alcohol and marijuana use for White and Black men and women [35] and two examined alcohol use among Asian American [36] and Mexican American participants [37]. Results indicated that White participants had a higher average number of drinks per drinking session and were more likely to engage in heavy drinking in adolescence and adulthood than Black participants among both men and women [35]. While there were no differences in overall marijuana use or frequency of use in adolescence and adulthood between Black and White men, White women were more likely to use marijuana than Black women in adolescence and early adulthood and Black women had a higher frequency of use than White women in later adulthood [35]. Among Asian American participants being born in the United States were associated with increases in heavy drinking and frequency of drunkenness from adolescence to adulthood [36]. In contrast, among Mexican American participants, alcohol use did not vary by immigration status [37]. Finally, of the included studies, one examined differences in trajectories of heavy drinking and marijuana use among men and women who identified as lesbian, gay, or bisexual compared to those who identified as heterosexual [38]. Results revealed consistently higher levels of heavy drinking and marijuana use from adolescence to adulthood among those who identified as lesbian, gay, or bisexual compared to those who identified as heterosexual, with particularly large differences among women [38]. Collectively, these studies indicate a need for continued substance use research stratified by biological sex, gender identity, race/ethnicity, and sexual orientation to understand differences and tailor prevention and intervention approaches accordingly.

Contextual

Accumulating evidence indicates that the neighborhoods and communities in which people learn, work, and live have important implications for health and wellbeing. Three included studies examined the associations between contextual factors, including community and school composition in adolescence,

with substance use outcomes in adulthood [39–41]. Results showed that adolescents living in communities characterized by higher levels of disadvantage, defined by factors such as the unemployment rate and the percent of households with income below the federal poverty level, were less likely to engage in substance use, including alcohol, marijuana, and cocaine use, in adolescence and early adulthood compared to those living in less disadvantaged communities [39]. Additional research explored the association of adolescent neighborhood composition, defined by measures of socioeconomic status, race/ethnicity, and urbanicity, with trajectories of marijuana use from adolescence to early adulthood, revealing differences in longitudinal patterns of marijuana use by neighborhood composition [40]. For example, residence in a middle class White urban neighborhood was associated with a greater likelihood of marijuana use by age of 12 years compared to residence in a working class White rural neighborhood and increased marijuana use over time compared to residence in poor Black urban or rural neighborhoods [40]. At the school level, attending a school with a higher percentage of White students was associated with an increased likelihood of drug-related problems (e.g., problems at work or school or with friends because of drug use) in adulthood for Black participants and alcohol-related problems in adulthood for White participants but no difference in any substance-related problems for Hispanic participants [41]. These results reinforce the need to consider varied aspects (e.g., racial and ethnic composition, socioeconomic status) of the neighborhood and community contexts simultaneously to understand complex associations with substance use behaviors. The large size of the Add Health cohort and comprehensive contextual information available can facilitate these nuanced investigations.

Discussion

Add Health provides a unique data source for conducting substance use research. The longitudinal design of Add Health has facilitated life course research on changes in patterns of substance use from adolescence to adulthood and the breadth and depth of substance use-specific questions at each wave of data collection (Table 1) has allowed researchers to assess multiple aspects of substance use, including the type, quantity, frequency, and recency of use. The rich social, emotional, behavioral, contextual, biological, and genetic data collected in Add Health have contributed to the evidence base regarding the multiple causes and consequences of substance use and the prospective nature of the data collection has allowed researchers to establish temporality between these factors and specific substance use behaviors, furthering our understanding of bidirectional associations and complex causal pathways. The size and diversity of the Add Health cohort has also allowed researchers to focus on understudied populations and to conduct subgroup analyses to identify priority populations for tailored prevention and intervention.

While the individual studies included in this review provide specific insights (Table 2), collectively this body of Add Health research, including studies not selected for this review, provides multiple overarching insights for the field. First, results demonstrating changes in substance use behaviors from adolescence to adulthood highlight the importance of considering the development of various substance use behaviors as an ongoing process. Second, associations of childhood and adolescent

Table 2

Key insights from reviewed substance use research: National Longitudinal Study of Adolescent to Adult Health (n = 40 studies reviewed)

Domain: Genetic (n = 2 studies reviewed)
• Dopamine-specific polymorphisms may be associated with marijuana, but not alcohol, use [40,41].
Domain: Biological (n = 6 studies reviewed)
• Alcohol use in adolescence is associated with a variety of chronic conditions, including high blood pressure and diabetes, in adulthood [36,37].
Domain: Emotional (n = 2 studies reviewed)
• Bidirectional associations between substance use and mental health differ by type of substance and mental health condition [25,26].
Domain: Behavioral (n = 4 studies reviewed)
• Type of substance(s) used in adolescence has implications for later substance use behaviors [28,29].
• Substance use is associated with an increased likelihood of sexual risk behaviors [30,31].
Domain: Social (n = 21 studies reviewed)
• Reduced economic resources, as measured by income, assets, education, and material hardships, are associated with an increased likelihood of substance use, with some differences by race/ethnicity [2–4].
• School connectedness, social bonds, and parental warmth in adolescence are associated with a decreased likelihood of substance use [5–7].
• Experiences of sexual violence, adolescent dating violence, and intimate partner violence are associated with an increased likelihood of substance use, with some differences by biological gender and race/ethnicity [10–12].
• Accumulating trauma in childhood is associated with an increased likelihood of substance use [15–18].
• Substance use behaviors and trajectories from adolescence to adulthood show notable differences by race/ethnicity and sexual orientation [20–23].
Domain: Contextual (n = 3 studies reviewed)
• Neighborhood and school composition, as defined by socioeconomic status, race/ethnicity, and urbanicity, are associated with differences in substance use patterns and types by race/ethnicity [32–34].

experiences with later substance use reinforce the importance of strategies implemented early in the life course for mitigating potential long-term substance use-related harms. For example, recognition and appropriate pharmacological and non-pharmacological treatment of chronic pain in adolescence may help to reduce the risk for prescription opioid misuse in adulthood [39]. Third, evidence regarding associations of social, emotional, behavioral, contextual, biological, and genetic factors with various substance use measures underscores the need for coordinated, integrated approaches to prevention and intervention. For example, bidirectional associations between mental health and substance use indicate a need for integrated mental health and substance use disorder services [25,26] and associations of life course adversities and violence with substance use [10–19] show the importance of ensuring these integrated services are trauma-informed. Fourth, differences observed in associations and substance use trajectories for specific subgroups provide information for tailoring prevention and intervention efforts to maximize impact. For example, differences in the association of school racial/ethnic composition with alcohol-related and drug-related problems among Black, White, and Hispanic youth have implications for educational policies and emphasize the critical importance of addressing contextual factors, namely structural racism and discrimination, that contribute to differences in substance use outcomes by race/ethnicity. Overall, this research has enhanced the evidence base by identifying factors across multiple domains that are amenable

to programmatic and policy intervention and that may be effective targets for reducing potential harms of substance use.

Future research with the Add Health data can continue to advance our knowledge of the causes and consequences of specific substance use behaviors across the life course. As the Add Health cohort ages, future research is needed to examine change or persistence in previously observed associations and to examine shifts in types of substances used, including a specific focus on polysubstance use. With additional waves of data collection, age-period-cohort analyses may provide insights into the time-varying phenomena affecting specific substance use behaviors (i.e., age effects linked to biological and social processes, period effects linked to external factors such as economic trends, cohort effects linked to experiences unique to a specific group) [42]. Future research can also continue to build on this body of knowledge by examining interactive and synergistic effects of factors across multiple domains and levels of influence (i.e., individual, interpersonal, community) in shaping substance use trajectories. These studies can leverage the contextual data available in Add Health data files from sources such as the American Community Survey regarding state, county, census tract, and block group characteristics of participants' residence at multiple waves. Finally, future Add Health research can help to illuminate transitions across the continuum of substance use risk, from initiation of substance use to active and potentially harmful use to the development of a substance use disorder [43] and factors predicting these transitions for various subgroups to further inform key points for intervention across the life course.

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