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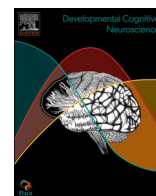
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Responsible research in health disparities using the Adolescent Brain Cognitive DevelopmentSM (ABCD) study

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ABSTRACT

Purpose: The Adolescent Brain Cognitive DevelopmentSM (ABCD) Study is the largest longitudinal study on brain development and adolescent health in the United States. The study includes a sociodemographically diverse cohort of nearly 12,000 youth born 2005–2009, with an open science model of making data rapidly available to the scientific community. The ABCD Study[®] data has been used in over 1100 peer-reviewed publications since its first data release in 2018. The dataset contains a broad scope and comprehensive set of measures of youths' behavioral, health, and brain outcomes, as well as extensive contextual and environmental measures that map onto the social determinants of health (SDOH). Understanding the impact of SDOH on the developmental trajectories of youth will help to address early lifecourse health inequities that lead to disparities later in life. However, the open science model and extensive use of ABCD data highlight the need for guidance on appropriate, responsible, and equitable use of the data.

Design Methods: Our conceptual framework integrates the National Institute on Minority Health and Health Disparities (NIMHD) Research Framework with strength-based and data equity perspectives. We use this framework to articulate best practices and methods for investigations that aim to identify the multilevel pathways by which structural and systemic inequities impact adolescent health trajectories.

Results: Using our conceptual model, we provide recommendations for equitable health disparities research using ABCD Study data. We identify over fifty ABCD measures that can encompass SDOH across five levels of influence: individual, interpersonal, school, community, and societal. We expand the societal level to acknowledge structural discrimination as the root cause of systemic and structural inequities resulting in health disparities among marginalized youth. We apply the methodological recommendations in an example data analysis using a multi-level approach that integrates strength-based and data equity perspectives to elucidate pathways by which social and structural inequities may influence cognitive decision making in youth. We conclude with recommendations for strengthening the utility of ABCD data for health disparities research now and in the future.

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Conclusion: Adolescence is a critical period of development with subsequent ramifications for health outcomes across the lifespan. Thus, understanding SDOH among diverse youth can inform prevention interventions before the emergence of health disparities in adulthood.

1. Introduction

The period of 14- to 24-years of age has been termed the “decisive decade,” with experiences during these formative years setting the course for later health and success in adulthood (The Brookings Institution, 2024). Importantly, exposure to adversity and fewer opportunities during adolescence may contribute to the emergence of health disparities. For example, poverty during adolescence has been linked to an increased risk for negative physical, social-emotional, and cognitive health outcomes that continue into adulthood, even more so among minoritized racial and ethnic adolescent groups (Butler, 2017; Francis et al., 2018). In 2018, the economic burden of education-related health inequities for adults not completing a 4-year college degree was estimated at \$978 billion. For health inequities related to minoritized racial and ethnic populations, it was \$451 billion (LaVeist et al., 2023). These influential factors are examples of social determinants of health (SDOH)—the social and environmental conditions where individuals are born, live, learn, work, play, worship, and age (Braveman et al., 2011; Office of Data Science Strategy, 2023; Office of Disease Prevention and Health Promotion, n.d.; World Health Organization, 2024).

These SDOH influence individual- and population-level risk and protective factors, functioning, and well-being, and they vary for young people across diverse groups. This is because the SDOH are measures of the inequitable distribution of resources and power that exists due to long-standing structural factors arising from racism, ableism, classism, sexism, homophobia, and other discriminatory systems, which impact societal-level laws and policies, as well as community-level conditions and healthcare systems (Churchwell et al., 2020; Yearby, 2020). These structural factors perpetuate oppression, which can in turn influence an individual’s health. As NIMHD (2023a) noted: “all populations with health disparities are socially disadvantaged due in part to being subject to racist or discriminatory acts and are underserved in health care.” Resources need to be allocated to communities in a way that is proportional to their needs, and barriers to supporting good health need to be removed (NIMHD, 2024). The consequences of inequitable access to resources that promote good health perpetuate health disparities that continue to hinder millions of Americans’ ability to reach their best health. Therefore, identifying the root causes of emerging health disparities to inform prevention and intervention programs during adolescence have the potential to improve a person’s life trajectory.

2. The ABCD study

2.1. ABCD study design

The Adolescent Brain Cognitive Development (ABCD) Study is the largest longitudinal study on brain development and adolescent health in the United States, following nearly 12,000 youth, born between 2005 and 2009, over 10 years starting at age 9 or 10. The cohort is socio-demographically diverse. Because of its open science model, data from the ABCD Study has been used in over 1100 peer-reviewed publications since its first data release in 2018. The ABCD Study is funded by the National Institutes of Health (NIH) and various federal partners with an interest in understanding the myriad factors that influence brain, cognitive, and social-emotional trajectories in adolescence. While the ABCD study was not originally designed for health disparities research, the breadth and depth of measures within the dataset can be used to investigate SDOH in relation to health outcomes and health disparities (Dick et al., 2021; Garavan et al., 2018; Volkow et al., 2018; Cardenas-Iniguez et al., 2024). Importantly, while studies have reported

on health disparities among groups historically marginalized by race and ethnicity, socioeconomic status, gender and sex, rural regions, and ableism (NIMHD, 2023b), studies must now aim to identify the root causes and pathways to health disparities, which can then be altered to achieve health equity.

2.2. Strengths of ABCD health disparities research

Rigorous health disparities research papers use comprehensive methodologies that delve into the interplay between different levels of influences, e.g., using multiple regression models and mediation analyses to elucidate various relationships (e.g., Feinstein et al., 2023; Loso et al., 2023; Ryan et al., 2023; Saxena and Dodell-Feder, 2022). Importantly, the ABCD dataset contains a multitude of SDOH measures, which allows researchers to interrogate more specific mechanisms and constructs, instead of using race, ethnicity, and coarse socioeconomic status measures as broad proxies (Cardenas-Iniguez and Gonzalez, 2024). Using variables that more directly measure specific sources and mitigators of environmental stress (e.g., air pollution, greenspace, social cohesion, presence of amenities and services), for example, can also lead to more specific points of intervention (Cardenas-Iniguez et al., 2024).

2.3. Limitations of existing ABCD health disparities studies

Among the studies using the ABCD dataset to investigate adolescent health disparities, few have effectively followed the research frameworks necessary to understand risk and resiliency factors that underlie health disparities. Studies that only report statistical group differences based on race, ethnicity, sex, and household income, without undertaking a thoughtful investigation of the true drivers of health disparities, such as contextualizing variables within the SDOH, are uninformative and moreover have the potential to perpetuate harm (Cardenas-Iniguez and Gonzalez, 2024; White et al., 2023). Some studies using ABCD data do examine interactions between SDOH and health outcomes; however, they tend not to explore mechanisms nor use established research frameworks to understand the pathways leading to differences in health outcomes.

2.4. Vision of ABCD Health Disparities Research

Researchers using the ABCD dataset can investigate the multi-level processes that may contribute to the emergence of health disparities in youth. However, such endeavors must apply thoughtful research approaches, supported by research frameworks that champion data equity and strength-based practices. Thus, this paper discusses the opportunities for investigators to apply equitable practices, and acknowledge limitations, in utilizing the breadth and depth of measures within the ABCD dataset to investigate the SDOH pathways to health disparities.

3. Proposed conceptual framework: SDOH among youth

To identify and intervene on the pathways by which structural and systemic inequities impact adolescent health trajectories, it is important to consider the most appropriate research framework to address the study design, whether it is one comprehensive, multilevel framework or a combination of multiple relevant frameworks. We propose a socio-ecological SDOH conceptual framework that integrates the NIMHD Research Framework with the data equity framework by We All Count (n.d.) and a strength-based approach that emphasizes narratives that represent the voices of the populations being studied. Strength-based

approaches for examining health outcomes among youth emphasize the importance of identifying protective factors that may promote resilience in the face of adverse conditions (Thimm-Kaiser et al., 2023). This combined approach synergizes the investigation of both risk and protective ecological contexts in understanding health inequities. See Fig. 1.

Similar to Bronfenbrenner's bioecological systems theory, the NIMHD Research Framework is a multidimensional socio-ecological model of how multi-level factors impact health and health disparities across the lifespan. It highlights levels and domains of influence to capture an array of descriptive contexts encompassing the microsystem (most proximal conditions and environments for youth, including family, home, and school factors), exosystem (distal community environments and conditions in which the youth does not directly participate but have influence), macrosystem (societal conditions and policies), and chronosystem (influences exerted over time and have developmental relevance). The Life Course Perspective (LCP), which is embedded within the NIMHD Research Framework, recognizes that people are influenced by physical, social, intergenerational, and environmental factors within their communities and supporting systems and aligns with health disparities frameworks by affirming how life experiences and exposures affect health outcomes from birth to end-of-life (Jones et al., 2019). Similarly, our proposed socio-ecological model echoes theories such as biological embedding (Bagby et al., 2019), minority stress theory (Meyer, 2003), and the weathering hypothesis (Geronimus, 1992, 2023) in underscoring the costs of adaptability to experiential stressors, particularly for historically minoritized communities.

Our conceptual model expands the NIMHD framework from four to five levels of influence to include school as a separate contextual level: (1) individual, (2) interpersonal (family and home), (3) school, (4) community, and (5) societal (Fig. 1). The school context is particularly important for adolescents, given the time they spend in this context and, therefore, the impact it can have on developmental outcomes (Roy et al., 2024). Within each of the levels of influence, we maintain the SDOH domain categories: biological, behavioral, sociocultural, physical/built environment, and the healthcare system.

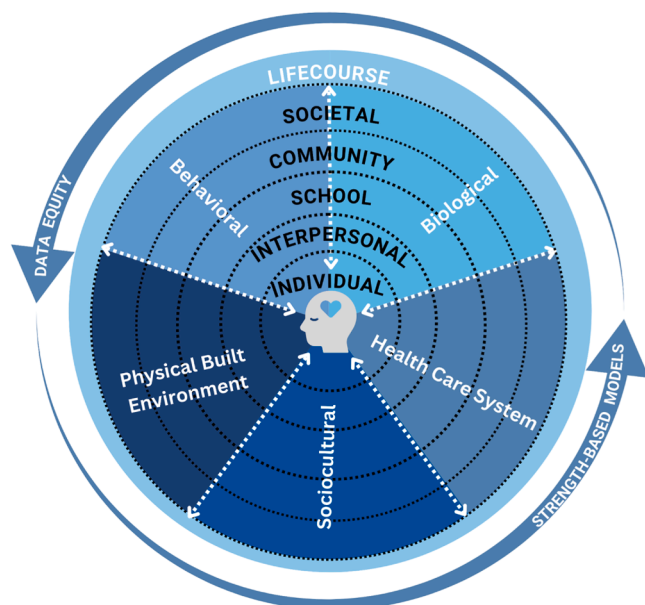


Fig. 1. Our adaptation of the NIMHD health disparities research framework consists of a conceptual model with five domains for the social determinants of health: biological, behavioral, sociocultural, physical/built environment, and the healthcare system, each spanning five contextual levels important for adolescent health: individual, interpersonal, school, community, and societal contexts, with such early exposures having an impact across the life course. In addition, the conceptual model advocates for strength-based models of resiliency and integration of a data equity approach to prioritize the voices and viewpoints of the populations and communities being studied.

environment, and health systems (NIMHD, 2023b). Further, we situate systemic discrimination as the root cause of structural and social inequities that result in health disparities among marginalized populations (Yearby, 2020).

Researchers should also consider an intersectional lens and identify how factors across different levels of influence (i.e., individual, interpersonal, school, community, and societal) combined with domains of influence (i.e., biological, behavioral, physical/built environment, socio-cultural environment, and health care system) lead to multilevel advantages or inequities that can shape health outcomes positively or negatively (NIMHD, 2023b). For example, racially minoritized youth with low socioeconomic status living in under-resourced rural communities have higher rates of health risk behaviors and face more barriers to accessing health care than youth from affluent urban areas (Mitchell et al., 2021; Zhao et al., 2023). When race and ethnicity interact with SDOH (economic stability, neighborhood and built environment, and social/community context), it can impact healthcare access, thus contributing to myriad potentially adverse or positive health outcomes. As such, multidimensional approaches are critical for illuminating the most grievous, and often interconnected, problems underlying inequities in population health and healthcare.

Thus, whether addressing the ongoing mental health and substance use crisis among youth (National Center for HIV, Viral Hepatitis, STD, and TB Prevention, 2018) or the intergenerational experiences of chronic conditions (Strompolis et al., 2019), using multiple frameworks to examine the levels of influence across domains and over time is essential for understanding the health disparities experienced by youth now and mitigating the health disparities that may compound in adulthood.

3.1. Theories supporting mechanistic pathways for SDOH

When identifying a research framework to support mechanistic pathways in health disparities research, there are numerous options. For example, the Fundamental Causes Theory (Link and Phelan, 1995) and Risk Environment Theory (Rhodes, 2009) both address SDOH, but approach these from different angles. The Fundamental Causes Theory posits that certain social conditions, such as poverty or racial and ethnic minoritization, are fundamental causes of disease because they influence multiple risk factors that affect multiple disease outcomes. Those social conditions limit access to resources that can be used to avoid risks or minimize the consequences of disease once it occurs. On the other hand, the Risk Environment Theory focuses on the immediate physical, social, economic, and policy environments in which individuals live. It suggests that these environments directly and indirectly influence health behaviors and outcomes. While both theories acknowledge the impact of broader social factors, the Fundamental Causes Theory emphasizes the root social causes that persist over time, whereas the Risk Environment Theory looks more closely at the immediate contextual factors. Supplementary Table 1 provides an overview of several theories and approaches for consideration.

4. Applying ABCD measures to the framework

4.1. SDOH measures in ABCD

The ABCD Consortium initially divided the non-imaging assessment measures of the main ABCD Study battery into seven domains, each overseen by a separate assessment workgroup (Auchter et al., 2018): Substance Use (Lisdahl et al., 2018), Neurocognition (Luciana et al., 2018), Mental & Physical Health [which have since split into separate Mental Health (Barch et al., 2017) and Physical Health (Palmer et al., 2021) domains], Culture & Environment (Zucker et al., 2018), Biospecimens (Uban et al., 2018) which have now been integrated into the relevant workgroups, Mobile Technology (Bagot et al., 2018), and Passive Data Collection (Fan et al., 2021). The specific rationale for the

selection of each domain's measures is described in detail elsewhere (Auchter et al., 2018). In addition, as the needs of the study have evolved, a workgroup focused on questions related to Gender Identity and Sexual Health was added (Potter et al., 2022). The Passive Data Collection Workgroup has also expanded to include Linked External Data - Environment/Policy (LED-E&P) and Schools Working Groups, which focus on measures external to the study that can be linked based on participants' residential histories (Fan et al., 2021) and schools, respectively. Together, these ABCD assessment domains provide researchers with insights across a variety of dimensions relevant to child and adolescent neurodevelopment (Fan et al., 2023; Wilson et al., 2023).

Many of the measures collected in the ABCD Study represent SDOH relevant to the study of health disparities and their causes. Using the domains of our proposed socio-ecological SDOH conceptual framework, we present measures that may be relevant to health disparity analyses. Among these SDOH measures, researchers can examine both risk and promotive factors so that researchers may take a strength-based approach. The selection of appropriate SDOH measures will depend on the outcome of interest and the context of the construct in relation to other levels of the socio-ecological system. Tables 1 and 2 summarize measures relevant for our SDOH framework and other health disparities research using ABCD Study data.

4.1.1. Individual-level factors

Individual-level factors include biological vulnerabilities and resiliency characteristics as well as biological and behavioral mechanisms mediating or moderating disparate health outcomes. Some examples of individual-level factors include physical and mental health conditions or states (i.e., blood pressure, sleep behavior/chronotype, medical history, nutrition, temperament, self-control of emotions, pubertal stage) that may be correlated with and/or interact with other factors to result in different health outcomes. These factors may be assessed, for example,

by biospecimen assays, questionnaires querying recent substance use or activities, or performance on neurocognitive tasks.

Sociodemographic variables measured in the ABCD Study such as race, ethnicity, household income, parental education attainment, and country of origin of participants and their family members are often used as proxies for individual experiences. While these may be useful for summarizing aggregate population trends, we caution researchers against using these sociodemographic variables as proxies and instead recommend addressing the intended individual-, interpersonal-, community-, or societal-level construct(s) whenever this is possible.

Individual-level social cultural and ethnic identity variables are available in ABCD (i.e., the Mexican American Cultural Values Scale, the Multi-Group Ethnic Identity Scale, the Vancouver Index of Acculturation), as well as gender identity and expression (i.e., Gender Identity Questionnaire), and sexual orientation. Given that substance use initiation questions were of particular interest in the formation of the ABCD Study, several individual-level substance use attitudes are also included. For some measures, caregiver-reported versions of the measures were collected at the beginning of the study, with youth-reported versions of the measures available at later time points.

4.1.2. Interpersonal-level factors

In our conceptual model, interpersonal-level factors consist of family, peer, and other social interactions influencing health disparities among youth. Measures at this level are different from those at the individual level, as they describe interactions between youth and other individuals. Interpersonal-level factors could serve as sources of stress or, in the case of social support, mitigate the negative effects of other factors. Some ABCD measures describe interactions within the home between youth and their caregivers, such as measures of family conflict or parental monitoring, while others are associated with behaviors of youth in social contexts, such as the Prosocial Behaviors Scale and the

Table 1

Examples of Youth- and Caregiver-provided SDOH Measures in ABCD.

Individual-level factors	
Physical or mental health conditions or states	
Blood pressure	Medical history
Sleep/chronotype	Nutrition
Pubertal stage	Temperament, Self-control of emotions
Self-attitudes towards the use of various substances	
Lifetime Use Interview	Alcohol, Cannabis, and Tobacco Expectancies Questionnaires Cannabis Effect and Vaping Effect Expectancies Questionnaires
Intention to Use Questionnaire	
Perceived Peer Tolerance of Use	Adolescence Smoking Consequences Questionnaire
Perceived Harm of Substance Use	Drinking, Cannabis, Tobacco, and Electronic Nicotine Motives Questionnaires
Perceived Peer Group Deviance	
Gender identity and expression	
Gender Identity Questionnaire	
Cultural and ethnic identity	
Mexican American Cultural Values Scale	Multi-Group Ethnic Identity Scale
Vancouver Index of Acculturation	
Interpersonal-level factors	
Interactions in the home between youth and their caregivers	
Family conflict	Parental monitoring
Youth perception of behaviors in social contexts	
Prosocial behaviors scale	Peer behaviors scale
Social context	
Mexican American Cultural Values Scale	Resource scarcity
Relationships of youth while at school	
School Risk and Protective Factors Questionnaire	
Risk and resilience factors of mental health	
Peer Experiences Questionnaire	Religion
Cyber-Bullying Questionnaires	Social responsiveness
Friendship	
Social attitudes specific to substance use	
Peer tolerance of use	Peer intention to use and access
Peer group deviance	Parent rules and approval relevant to substance use
Community-level factors	
Neighborhood Safety and Crime Questionnaire	

Peer Behaviors Scales.

Certain measures may be relevant to multiple levels of influence. For example, the Perceived Discrimination measure captures psychosocial processes at the individual and interpersonal levels. Other measures like the Mexican American Cultural Values Scale identify attitudes about interactions with important members of the participant’s community, while resource scarcity questions measure the interactions or experiences of parents related to family and social environments.

There are also measures of risk and resilience factors of mental health based on youth’s interactions with others (i.e., the Peer Experiences Questionnaire, Cyber-Bullying Questionnaires, other resilience items such as friendship or religion, and social responsiveness). Given that one of the main objectives of the ABCD Study is to understand contextual factors that may contribute to substance use, measures that explore youth’s social interactions specific to substance use are also included (i.e., Peer Tolerance of Use, Peer Group Deviance, Peer Intention to Use and Access, Parent Rules and Approval relevant to Substance Use).

4.1.3. School-level factors

Youth spend a considerable amount of time in school environments. The ABCD Study contains many measures of relationships and conditions youth experience at school like the School Risk and Protective Factors Questionnaire related to school environment, school

involvement, and disengagement. In addition, the Linked External Data - Schools Working Group has linked reported participant school information to the Stanford Education Data Archive (SEDA). The SEDA provides summary statistics related to school and district test scores and information about the socioeconomic characteristics of the school districts, counties, and metro areas in which participants’ schools are located, offering additional contextual information.

4.1.4. Community-level factors

Community-level factors comprise neighborhood and community mechanisms and pathways influencing disease risk and resilience. The Neighborhood Safety and Crime Questionnaire is a youth- and caregiver-reported measure of how safe they feel within their neighborhoods. By leveraging the residential histories provided by caregivers, the LED-E&P Working Group has linked external databases to ABCD data to capture a wide variety of variables about environmental context without additional burden to families involved in the study. While full details are described elsewhere (Cardenas-Iniguez et al., 2024; Fan et al., 2021), measures linked to ABCD Study participant addresses include urbanicity and city dynamics (e.g., walkability, road traffic, crime, population density, living in an area designated as urban or rural by the US Census), neighborhood social factors (e.g., job density, social mobility estimates, alcohol outlet density), air and noise pollution estimates, greenspace,

Table 2
School-, Community- and Societal-level Factors Based on Geocoded Data.

School-level factors	
Stanford Education Data Archive (SEDA) Reading/Language Arts Average Test Scores Math Average Test Scores	Child Opportunity Index 2.0 (COI) Education Subscale
Community-level factors	
Amenities & Services Parks Social Services Religious & Civic Organizations Performing Arts & Sports Recreation Orgs Alcohol Outlet Density Built Environment Building Density Population Density Walkability Proximity to Roads Urban/Rural Area County Crime Neighborhood Lead Risk Vehicle Density Traffic Density Neighborhood Social Factors Census Return Rates Number of Jobs and Job Density Opportunity Zones Investment Scores Rent and Mortgage Statistics Opportunity Atlas Mobility Estimates Air Pollution Satellite Annual Average Exposure (PM _{2.5} , O ₃ , NO ₂) Satellite PM components (Br, Ca, Cu, Fe, K, NH ₄ , Ni, NO ₃ , Pb, Si, SO ₄ , V, Zn, Organic C, Elemental C) Community Health Burden PLACES Behavioral Health Measures	Meteorology and Exposures Humidity Estimates Temperature Estimates Elevation Environmental Noise EJSCREEN: Diesel Exposure; Respiratory and Cancer Risk Natural Space and Satellite National Land Cover, Tree Canopy Normalized Difference Vegetation Index (NDVI) Normalized Difference Built Index (NDBI) Normalized Difference Water Index (NDWI) Nighttime Light Residential Segregation Multi-group Entropy Index Dissimilarity Index Exposure/Interaction Index Index of Concentration at the Extremes Gi* Racial/Ethnic Hotspot Statistics Neighborhood Composite Measures Area Deprivation Index (ADI) Social Vulnerability Index (SVI) Neighborhood Socioeconomic Status Household Composition & Disability Minority Status & Language Housing Type & Transportation Child Opportunity Index 2.0 (COI) Education Health & Environment Social & Economic Minority Health Social Vulnerability Index Health Care Infrastructure Medical Vulnerability
Societal-level factors	
Substance Use-related Policies Cannabis Legalization Categories by State Affordable Care Act Medicaid Expansion Data CDC Opioid Prescription Dispensing Rates Naloxone Policy Data Good Samaritan Policy Data	State-level Bias Measures Sexual Orientation Bias Race Bias Gender Bias Immigration Bias

community health burden, neighborhood deprivation, residential segregation, and presence of amenities and services. Additionally, the ABCD Study has linked a number of widely used composite indices of neighborhood conditions such as the Area Deprivation Index, Social Vulnerability Index, and Child Opportunity Index.

4.1.5. Societal-level factors

Societal-level factors consist of policies, laws, and structures that shape health outcomes. The ABCD Study includes linked data for measures of state-level structural stigma related to race, ethnicity, and gender biases. As of Public Release 5.0, the ABCD Study also includes policy variables related to substance use, compiled by the RAND-USC Schaeffer Opioid Policy Tools and Information Center, such as cannabis legalization by state, Medicaid expansion data, co-prescribing naloxone policies, Good Samaritan laws, naloxone policies data, and prescription drug monitoring program data.

5. Recommendations

5.1. Research purpose, framework, design & interpretation

Health disparity research is critically needed to identify means for promoting health equity. It is equally critical to ensure that such research is done responsibly and equitably. Our recommendations, summarized in Table 3, provide guidance to researchers analyzing and disseminating findings from ABCD data. In advocating for the responsible use of ABCD data, we implore researchers to refrain from making comparisons in a vacuum, which can result in inaccurate conclusions and harm to the communities involved. Papers emphasizing group comparisons, like those between a specifically minoritized group and non-minoritized counterparts, often lack diversity in samples and thorough examination of social determinants, which provide critical context that may explain observed differences. This lack of clarity surrounding group comparisons and the absence of diverse perspectives in these studies could produce interpretations of findings that bring harm to communities, either by making deficit assumptions or misconstruing social defined categories with innate characteristics, rather than acknowledging the root cause as structural racism (Cardenas-Iniguez and Gonzalez, 2024).

A well-designed health disparities research paper encompasses a conceptual or theoretical framework firmly grounded in SDOH data and measures. This foundation should lead to a detailed mechanistic pathway, offering a comprehensive understanding of the contextual factors contributing to health disparities, and culminating in a robust interpretation of the research findings. Crucially, the paper should extend beyond analysis to propose insightful recommendations aimed at effectively addressing and mitigating the identified inequities and their causes. Health disparities research requires a cautious and nuanced approach to explicitly investigate underlying reasons for disparities. Doing so exposes the intricate interplay of social determinants in order to foster meaningful advancements in understanding and addressing health disparities.

In addition to avoiding overtly harmful analysis, users of ABCD Study data should also consider the potential unintended consequences of analysis (e.g., potential bias resultant from social determinants that are unmeasured or not modeled, which may impact observed variables) and identify ways to mitigate harm. It is also important for researchers to consider how a specific analysis may in fact benefit the identified populations of focus. This approach encourages the examination of salutogenic factors from a strength- rather than deficit-based perspective, which can directly inform the development of data-driven interventions that leverage these protective factors.

5.1.1. Community-engaged research approach

To support the entire process of health disparities research and implementation of these recommendations, it is important to develop an

Table 3
Summary of Recommendations for Health Disparities Research.

	Recommendation	Description
Conceptualization of Health Disparity Research Question	Clearly Identify SDOH	Identify and include SDOH measures relevant to the health outcome of interest. Avoid misleading assumptions and selection of measures not specific to the SDOH.
	Contextualize Health Disparities	Consider multi-level factors impacting health, beyond racial, ethnic, or SES trends. Understand causes, pathways to inform potential prevention and intervention strategies.
Research Framework & Assumptions	Incorporate Developmental Approaches	Include theories addressing physical, social, behavioral, and mental aspects of children's development, adopting a life course perspective.
	Apply Intersectional Lens	Address health disparities in youth across levels and domains of influence, identifying causes and potential interventions (e.g. NIMHD Research Framework).
	Focus on Strength-Based and Solution-Focused Models	Utilize a health disparity conceptual/theoretical framework rooted in SDOH with clear mechanistic pathways to investigate protective factors, strengths, and salutogenic factors to avoid an exclusively deficit-based understanding of disparities and inform prevention and intervention strategies.
Study Design & Interpretation	Select Appropriate Measures for SDOH	Choose measures representing SDOH based on outcome and context, acknowledging their multi-level nature within the socio-ecological system.
	Avoid Using Sociodemographic Variables as Proxies	Caution against using sociodemographic variables as proxies and instead address individual, interpersonal, community, or societal-level constructs directly.

advisory team of health disparities researchers, research oversight committees, and community experts who are members of the communities of focus. Specifically, the community engaged research approach encompasses meaningful partnerships between researchers and the communities that are being studied, that is, community members and organizations (Luger et al., 2020; Aguilar-Gaxiola et al., 2022). Our recommendations and implementation of our community-engaged research approach were informed by the Community-led Transformation (CLT) Principles, which support interactions that are (1) community-led, (2) codesigned, (3) partnership-based and trust-driven, (4) approached with cultural humility, (5) healing centered and trauma informed, (6) holistic and strength-based, (7) adaptive and responsive, (8) share funding, and (9) sustainable to establish equitable partnership between researchers and communities (Meigs et al., 2024). Meaningful engagement with expert advisors, especially community experts, should occur at every stage of the study, from conception to analysis and dissemination of findings. When using secondary data like the ABCD dataset, there are numerous opportunities to incorporate community

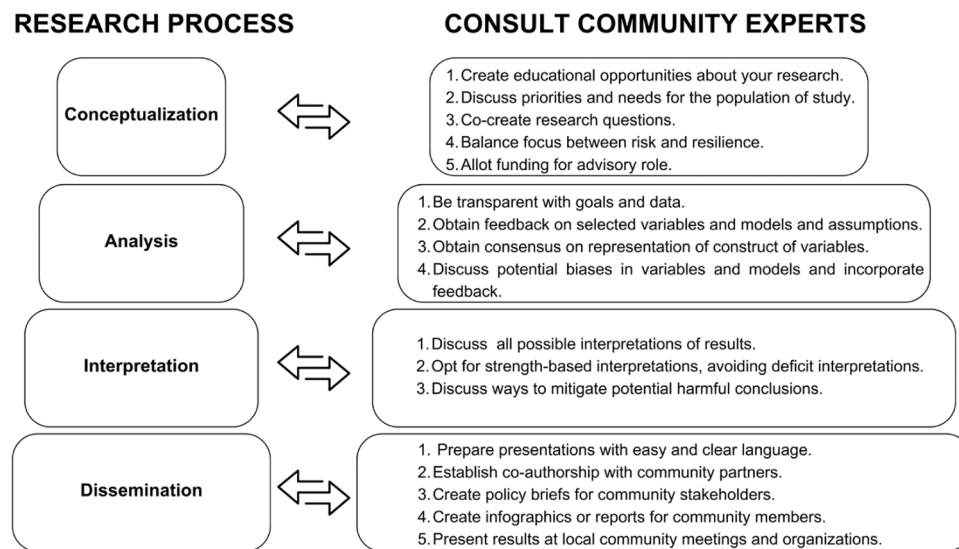


Fig. 2. Recommendations for incorporating community expert feedback in the research process with secondary data analysis of ABCD Study data.

input into the study and apply a data equity perspective in prioritizing the voices of the populations of study (See Fig. 2). This helps researchers to check assumptions, ensure the inclusion of appropriate SDOH, and identify community priorities and issues that may shape their study design and analytic plans. It is also important for the interpretation of data and to ensure the dissemination of results back to the community of interest, thereby supporting a data equity perspective. In turn, researchers can be responsive to the priorities and interests of the community through co-led and codesigned funding proposals.

5.2. Future science

The recommendations provided herein can also be used by funding agencies, policymakers, large-scale/population-level study design teams, peer reviewers, and journal editors. Funding agencies and policymakers may consider how funding announcements and research regulations can be structured to encourage the implementation of these recommendations by research teams moving forward. This may also include identifying and addressing funding disparities to support more diverse researchers and research topics (Lauer et al., 2021). Scientists involved in population-level or large-scale study design can proactively identify advisory teams for future end users of study data. Furthermore, these teams can identify specific frameworks for rigorous health disparities research and utilization of SDOH. Finally, integration of these recommendations into the editorial and peer review process as critical elements of quality research in health disparities can ensure that no harm is done to already marginalized communities but rather, that ongoing dissemination of existing and future large-scale studies meets the highest standards of health disparities research, which can ultimately benefit those communities.

6. Example using the framework for health disparities research

6.1. Conceptualization of health disparity research question

Here we present a practical application of our health disparities conceptual framework, SDOH constructs available in ABCD, and recommendations using the ABCD study dataset (5.1 release, doi: <https://doi.org/10.15154/z563-zd24>). We investigated the multi-level SDOH impact on the behavioral health measure of propensity for a “risky” decision-making strategy, a neurocognitive risk factor for substance use during adolescence (Nawi et al., 2021). Our population with health disparities for the study was youth growing up in low-income

households ($\leq 200\%$ of the federal poverty level). Our rationale was based on previous literature documenting the negative impact of low socio-economic status on youth development (See Table 3, Purpose). More specifically, youth from low-income families are more likely to experience higher family conflict, an interpersonal factor, due to structural discrimination that creates unequal access to resources. Youth from low-income families are also more likely to experience higher inequity in school and community contexts.

6.2. Research framework and assumptions informed by community experts

For the development of the research question, model, and implementation, we sought feedback from our community expert panel, composed of members of the Comité Organizador Latino de City Heights (COLCH) who were also mothers of youth ages 12–16 years, and residents of a neighborhood with economic disadvantage. Informed by the literature and discussions with the community expert panel, we applied the Fundamental Causes Theory (Link and Phelan, 1995) to test a strength-based hypothesis that lower family conflict, as well as higher opportunity scores at the educational (school) and neighborhood economic level (community), would be associated with decreased propensity for risky behavior (i.e. higher number of safe choices relative to risky choices) among youth from low-income families (See Table 3, Framework & Fig. 2).

We drew from the existing literature and discussed with our community expert panel the known risk factors for youth development (See Table 3, Study Design & Interpretation, & Fig. 2) and converged on the interpersonal factor of family conflict as a key driver of adopting a risky decision making strategy (Mulvaney-Day et al., 2007). From here, through a review of literature and iterative discussions with our community expert panel, we expanded beyond the interpersonal context to include structural-level factors at the school and community levels, contexts equally important for adolescent development (See Table 3, Framework & Fig. 2).

6.3. Study design

We used an expanded multilevel model to investigate the SDOH for decision making strategies across three contexts: interpersonal, school, and community. We defined low income as $\leq 200\%$ of the federal poverty level (FPL) and used household income and family size at baseline to calculate an income-to-needs ratio indexing the FPL

(Gonzalez et al., 2020). Family conflict was measured using the family conflict subscale of the PhenX Family Environment Scale (PhenX Toolkit, 2024). For educational opportunities, we used SEDA, a dataset that provides standardized test scores from 3rd to 8th grade for schools across the nation (Reardon, 2019). We use the SEDA intercept scores, which are the average standardized scores (across math and English Language Arts) for children in third grade for each school (Cardenas-Iniguez et al., 2024). It is known that these scores are influenced by school contextual factors, including school resources and teacher proficiency, and are therefore interpreted as educational opportunities. Neighborhood economic opportunities were measured by the Childhood Opportunity Index 2.0 subindex for socioeconomic opportunities, comprised of economic indicators such as unemployment rates (Cardenas-Iniguez et al., 2024). We assessed the propensity for risky decision-making strategies using the Game of Dice at the 4-year follow-up visit. We implemented a mixed-effects linear regression with family conflict, educational opportunities, and neighborhood economic opportunities as predictors of Game of Dice performance on decision making strategies, including covariates for age, sex at birth, family group, and site identification. We must note that although a full treatment of possible mediators and moderators are needed to comprehensively model the interactions between the factors explaining decision-making strategies, they are outside of the scope of the present example.

6.4. Interpretation of results and next steps

The results of the model depicted in Fig. 3 indicate that for the analyzed sample of youth from low-income families, lower family conflict and higher educational opportunity scores at ages 9–10 years (baseline) were significant predictors of less risky decision-making strategies at ages 12–15 years (4-year follow-up visit). Educational opportunity scores showed a stronger effect on risky decision-making strategies than did family conflict, suggesting that while there is a multi-level influence of contextual factors on adolescent behavioral health, the school context is a key area in which to focus interventions such as increased school funding to create more educational opportunities. The full model results are presented in Supplementary Table 2. Importantly, through discussions with our community expert panel, we conceptualize the behavioral outcomes from the *Game of Dice* as a

decision-making strategy that is an adaptation in response to exposure to high or low opportunity environments. This is in contrast to the assumption that risky decision making is a behavior associated with an individual level trait as suggested in previous literature (for example, Upton et al., 2011).

6.5. Dissemination

We plan to continue engaging with the community expert panel regarding interpretation and dissemination of these results and established co-authorship on this manuscript for their contributions (See Fig. 2). Furthermore, ongoing conversations with the community expert panel will provide insights on possible moderators and mediators that can be explored with this model. We plan to present the results to the community through workshops and easy to read reports.

7. Strengths and limitations of using ABCD data for health disparities research

There are several strengths to using ABCD data for health disparities research including its sample and overall design. The large sample of nearly 12,000 youth from 21 study sites represents diverse experiences and environments. To evaluate the diversity of its participants, the NIH-funded All of Us Research Program formally designated diversity categories of groups historically underrepresented in biomedical research (UBR) (Mapes et al., 2020). Adapting those categories to the ABCD sample, 71 % of the ABCD cohort is UBR in at least one category, including race and ethnicity, household income, sexual orientation, and gender identity.

Another strength of the study is the breadth of its measures, which span multiple assessment domains. As previously described in Table 1, ABCD measures also span multiple levels of influence (i.e., individual, interpersonal, school, community, and societal levels) in our socio-ecological SDOH conceptual framework. The inclusion of measures at various levels makes the ABCD Study uniquely suited for investigating the complex mechanisms underlying youth health disparities (Gordon et al., 2024).

The ABCD Study was not specifically designed for health disparities research which may be due, in part, to the lack of diversity and health disparities research expertise among principal investigators as well as concerns from the NIH that broadening the scope of an already ambitious study may hinder its success. While it did include some measures of proximal environments at the outset, as the ABCD study matured, LED variables were added to enrich the dataset, making health disparities research more feasible.

Aspects of the study design and measures also represent significant limitations that must be considered. While measures are routinely reviewed and revised, the study design is set, which precludes fully community-based participatory research. However, there are opportunities to implement community engagement in other processes of the study such as determining appropriate measures, interpreting the results in a community context, and disseminating results to the populations of study.

Some ABCD measures are quite complex, and while there is a dedicated Wiki website to help distill important details, a superficial review of measures may overlook key aspects of the more nuanced measures (e.g. LED measures). Additionally, despite the hundreds of measures in ABCD, there may not be an exact measure to describe a specific SDOH of interest, the phenomenon driving a health disparity, or an exact health outcome. For example, ABCD lacks adequate disability status measures, making it difficult to understand issues affecting this population that experiences health disparities. Instead, there may be an associated measure that can be used as a proxy. In those cases, it is best to acknowledge when the chosen measures are proximal; their limitations, e.g. any bias in measurement or psychometrics, sampling, catchment, etc. (Cardenas-Iniguez and Gonzalez, 2024); and alternative

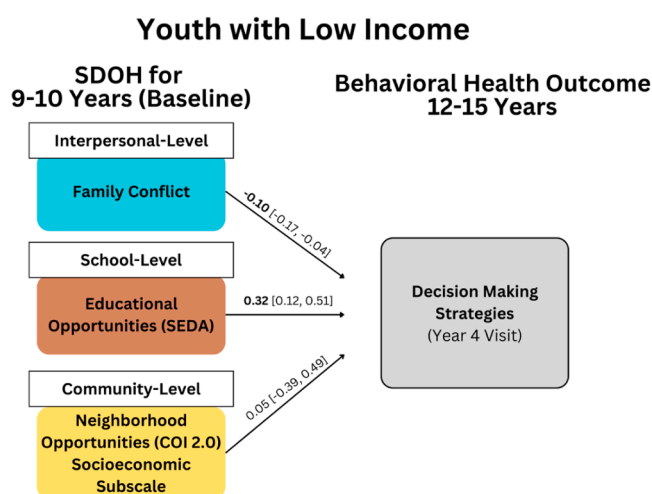


Fig. 3. Model testing interpersonal, school, and community-level SDOH in association with our behavioral health measure for decision making strategies for $N = 968$ youth ages 12–15 years who were in low-income households, at or below 200 % of the federal poverty line, with available data in the ABCD 5.1 data release for baseline and Year 4 measures. We show the standardized beta coefficients and confidence intervals for each predictor, with significant associations in bold.

explanations that may result from unmeasured variables.

8. Conclusion

Adolescence is an important developmental period that influences health throughout the lifespan. Identifying and intervening on emerging health disparities during this period can significantly improve a person's overall health and life trajectory. Though the ABCD Study was not originally designed for health disparities research, the vast breadth of its measures allows researchers to explore numerous health disparities research questions. However, there is a risk of causing harm when studies simply make comparisons or identify differences between populations without exploring the underlying causes. Data users are encouraged to employ responsible, equitable approaches to understand how SDOH impacts health disparities and developmental trajectories.

To do so, we proposed a health disparities conceptual model that expands on the NIMHD Research Framework to include a separate school level given the time youth spend in this environment and its impact on developmental outcomes. We also integrated a strength-based model of resiliency and a data equity perspective to ensure the voices of populations experiencing health disparities are heard and prioritized. We provide recommendations for responsible health disparities research using ABCD data for secondary data analysis and highlight key opportunities to incorporate rigorous research frameworks with meaningful engagement with community experts in defining the purpose, framework, and design and interpretation of the study.

In summary, understanding how health disparities affect youth and their development requires researchers to explore the impact of multiple levels of influence and domains. We encourage all members of the research enterprise including journal editors, peer reviewers, and policymakers to support responsible, equitable health disparities research practices as we work together to eliminate health disparities.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Declaration of Competing Interests

The authors declare no competing interests.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.dcn.2024.101497](https://doi.org/10.1016/j.dcn.2024.101497).

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