Title
Measuring socioeconomic adversity in early life

Journal
Acta Paediatrica, 108(7)

ISSN
0803-5253

Authors
Anand, Kanwaljeet JS
Rigdon, Joseph
Rovnaghi, Cynthia R
et al.

Publication Date
2019-07-01

DOI
10.1111/apa.14715

Peer reviewed

HHS Public Access

Author manuscript

Acta Paediatr. Author manuscript; available in PMC 2020 July 01.

Published in final edited form as:

Acta Paediatr. 2019 July ; 108(7): 1267–1277. doi:10.1111/apa.14715.

Measuring socioeconomic adversity in early life

Kanwaljeet J. S. Anand, MBBS, D.Phil.[a,b], **Joseph Rigdon, Ph.D.**[c], **Cynthia R. Rovnaghi, M.S.**[a,b], **FeiFei Qin, MPH.**[c], **Sahil Tembulkar, B.S.**[b], **Nicole Bush, Ph.D.**[d], **Kaja LeWinn, Sc.D.**[d], **Frances A. Tylavsky, Dr.P.H.**[e], **Robert Davis, MD, MPH**[f], **Donald A. Barr, MD, Ph.D.**[a], and **Ian H. Gotlib, Ph.D.**[g]

[a]Department of Pediatrics, Stanford University School of Medicine

[b]Pain/Stress Neurobiology Lab, Women & Child Health Research Institute, Stanford University School of Medicine

[c]Quantitative Sciences Unit, Stanford University School of Medicine, Stanford, CA

[d]Departments of Psychiatry and Pediatrics, University of California, San Francisco, CA

[e]Department of Preventive Medicine, University of Tennessee Health Sciences Center (UTHSC), Memphis, TN

[f]Department of Pediatrics, University of Tennessee Health Sciences Center (UTHSC), Memphis, TN

[g]Department of Psychology, Stanford University School of Humanities & Sciences, Stanford, CA.

Abstract

Aim: Early life adversity in leads to enduring effects on physical and mental health, school performance, and other outcomes. We sought to identify potentially modifiable factors leading to socioeconomic adversity in early life.

Methods: We enrolled 1,503 pregnant women aged 16–40 years, without pregnancy complications or pre-existing conditions from Shelby County, Tennessee. Social, familial, and economic variables were analyzed using principal components (PCs) analyses to generate the Socioeconomic Adversity Index (SAI). This was replicated using the National Survey of Children's Health (NSCH). Health and social outcomes were compared across the quintile groups defined by SAI values at the county, state, and national levels.

Results: Significant differences occurred across the SAI Quintile-1 to Quintile-5 groups in marital status, household structure, annual income, education, and health insurance. Significantly worse health and social outcomes occurred in the lower vs. higher SAI quintiles, including maternal depression, parental incarceration, child's birthweight, and potential for child abuse. Maternal age and race also differed significantly across the SAI quintiles.

Address correspondence to: Dr. K. J. S. Anand, 770 Welch Road, Suite 435, Stanford, CA 94304 MC: 5876. anandam@stanford.edu , Phone: (650) 498-6313 , Fax: (650) 736-9186.

Conflict of Interest: All authors have indicated they have no potential conflicts of interest to disclose.

Conclusion: Modifiable factors contributing to socioeconomic adversity in early life included marital status, household structure, annual income, education, and health insurance. Those exposed to greater socioeconomic adversity as defined by SAI values had significantly worse maternal and child outcomes.

Table of Contents Summary

Key factors determining socioeconomic adversity in early life were combined into a novel composite index, validated with publicly available data and associated with maternal/child outcomes.

The health of Americans has deteriorated, with widening disparities between rich and poor. Decades of social sciences research has demonstrated strong associations between poverty and increased risks for developing chronic non-communicable diseases and psychopathology(1, 2). Poverty is a major determinant of health and well-being, typically affecting those most vulnerable(2). Despite programs to alleviate poverty, the proportions of women and children living in poverty (groups that these policies were first meant to protect(3, 4)) increased from 15% to 35% between 1968 and 2012(1, 5). Statistical measures for defining poverty, from the Official Poverty Measure (OPM) devised by Mollie Orshansky in the Social Security Administration (poverty threshold = 3 × food budget)(3, 4) to the Supplemental Poverty Measure (SPM) created by the National Academy of Sciences(6) have been hotly debated.

Instead of focusing on poverty, we call for considering socioeconomic adversity more broadly, as that resulting from social, familial, *and* economic factors. Children below 5 years age are vulnerable to the lifelong effects of early adversity and least able to fend for themselves(7). Indeed, socioeconomic adversity contributes to under-5 mortality(8) and leads to intergenerational transfers of inequality(9, 10). We used the CANDLE study (**C**onditions **A**ffecting **N**eurocognitive **D**evelopment and **L**earning in **E**arly childhood) to identify factors associated with socioeconomic adversity in pregnant mothers and their children. We combined these into a composite numerical index, replicated using the National Survey of Children's Health (NSCH). This is a novel approach to identify high-risk populations (according to modifiable social, familial, economic factors) who may benefit from coordinated/holistic interventions to achieve sustained reductions in early life adversity.

Methods

The CANDLE Cohort

The CANDLE study enrolled 1,503 healthy 16–40 year-old women in their second trimester of pregnancy in Shelby County, Tennessee from December 2009 to July 2011 and continues to follow their children (Figure 1, Table S1). Women were recruited from hospital obstetric clinics and community sources (mailings, flyers at obstetric practices, friend referrals, television ads), to reflect the demographic characteristics of Shelby County. Exclusion criteria included existing chronic diseases (hypertension, diabetes, sickle cell disease), known pregnancy complications (e.g., placenta previa, oligohydramnios), women not planning to deliver at a participating hospital, and primary language other than English.

Institutional Review Boards at University of Tennessee Health Sciences Center (UTHSC) and participating hospitals approved this study. Participants or their legally authorized representatives gave informed consent prior to enrollment and received financial incentives during the study. Table 1 compares the CANDLE data (Shelby County) with the NSCH data for Tennessee (TN) and the United States (US).

Data Collection

Enrollment occurred at research clinics in the 2nd trimester (M1), or in the 3rd trimester (M2) at delivery hospitals (M3); with home visits at 4 weeks (HV1) and 2 years (HV2), and annual clinic visits centered around 1–4 years of age (CV1, CV2, CV3, CV4). Data collection included demographic, environmental, social, health, nutritional, cognitive, socioemotional, behavioral, and other measures(11). We selected 55 variables empirically related to socioeconomic adversity and measured at multiple points in time to develop a composite Socioeconomic Adversity Index (SAI).

Developing the Socioeconomic Adversity Index

To reflect dynamic changes in adversity, we divided all 55 variables into the perinatal (12 variables from M1, HV1), infant/toddler (23 variables from CV1, CV2, HV2), and preschool periods (20 variables from CV3, CV4) (Table S2). Some variables were recoded because of their graded socioeconomic impact resulting from legal regulations, social welfare programs, or other existing conditions in the US. For example, federal and state income taxes, insurance eligibility, court-ordered child support or alimony, and spousal death benefits are determined by marital status and number of dependents in the household(12). All recoded variables are listed online (Table S3).

After recoding, principal components analyses (PCA) included 7 variables in the perinatal period, 13 in the infancy/toddler period, and 10 in the preschool period using the ‘svdImpute’ algorithm for missing data implemented in the R package ‘pcaMethods’(13) (Table S4). Variables and individuals with more than 40% missing data were excluded from analysis (Table S1). We chose the minimum number of PCs that explained ≥ 90% of data variability(14) and examined correlations of the input variables with each PC (Figure 2).

We weighted the scores for each PC by the percent variation explained by that PC and summed these scores to compute individual SAI values*. Based on SAI values, participants were split into quintile (Q) groups experiencing high (Q-1) to low (Q-5) degrees of socioeconomic adversity. The distribution of component variables across the SAI quintiles determined the face validity of SAI (Tables S5, S6, S7). To examine reproducibility, we conducted the same analyses in NSCH data. NSCH included cross-sectional data from 50,212 households randomly surveyed in 2015/16 (Tables S8, S9).

One-way ANOVA or Fisher’s exact tests were used to examine associations between the SAI quintiles and maternal/child outcomes matched in CANDLE and NSCH. For example, CANDLE measured child abuse using the Child Abuse Potential Inventory (CAPI)(15),

For example, if 3 PCs explained 90% of the variation such that PC1 explained 75%, PC2 10% and PC3 5%, and if Subject_001 scored 1 for each PC, then this individual’s weighted sum would be 1(0.75) + 1*(0.15) + 1*(0.05) = 0.95.

whereas NSCH asked participants if their child was exposed to child abuse or not. If CAPI Abuse Scale scores were >263 in any assessment performed at 1, 2, or 3 years in CANDLE (characteristic of adults with confirmed child abuse(16, 17), we assumed that child abuse was highly likely. Other maternal/child outcomes had comparable definitions in CANDLE and NSCH. Receiver Operating Characteristic (ROC) curves were plotted to compare the SAI vs. SES measures for maternal/child outcomes in the NSCH-US data (Figure 5).

Results

Sample characteristics

CANDLE enrolled 1503 pregnant mothers, with some attrition occurring in the infant/toddler (n=1241, 82.6%) and preschool (n=1208, 80.4%) groups because of missed clinic visits (Figure 1). The proportion of Non-Hispanic Blacks (NHB) ranged 61%−68% across all visits in CANDLE, contrasting with smaller NHB populations in Tennessee (8.6%) and the US (6.1%). Other demographic features from CANDLE and the NSCH data for Tennessee and USA are presented in Table 1.

Developing the Socioeconomic Adversity Index in CANDLE

In the perinatal period, three PCs explained 93% variability (PC1=67%, PC2=18%, PC3=8%) and included five variables: marital status, education, household structure, annual income, and health insurance (Figure 2A). During pregnancy, most mothers in Q-1 were from single-parent households, with high-school education or less, and income <$25,000 per year, whereas most mothers in Q-5 were from 2-parent households, with college or higher education, and income >$65,000 per year (Figure 3; Table S5).

In the infant/toddler period, five PCs explained 95% of the variance (PC1=50%, PC2=16%, PC3=12%, PC4=9%, PC5=6%; Figure 2B) and included 11 variables. In addition to variables identified in the perinatal period, parental employment at 2 years of age was correlated with infant/toddler PCs. At HV2, fewer than 50% of mothers and 44% of fathers were employed in Q-1 (most common occupation: service/sales), whereas 75% of mothers and 93% of fathers were employed in Q-5 (most common occupation: management/professional). All factors were differentially distributed between Q-1 and Q-5 groups as noted above (Figure 3; Table S6).

In the preschool period, four PCs explained 91% of the variability (PC1=60%, PC2=17%, PC3=8%, PC4=6%; Figure 2C) and included 10 variables. Similar differences in marital status, household structure, education, income, and health insurance were obtained between Q-1 and Q-5 as noted in the perinatal and infant/toddler periods (Figure 3; Table S7).

Across the perinatal, infant/toddler, and preschool periods, density plots showed bimodal distributions of SAI values in CANDLE (Figure 4), with redistribution of some individuals from the extremes (Q-1, Q-5) to the middle quintiles (Q-2, Q-3, Q-4). Some mothers completed education, entered/ended romantic relationships, found/lost jobs, thereby altering their socioeconomic adversity during the study, but differences between the highest and lowest quintiles remained significant.

Calculating the Socioeconomic Adversity Index in NSCH

We found more NSCH participants in the middle quintiles than at the extremes, peaking at Q-4 for both Tennessee and US populations (Figure 4). NSCH data showed that most individuals were from 2-parent households, had more education, and higher annual incomes than CANDLE participants (Tables S8, S9).

Socioeconomic Adversity and Maternal/Child Outcomes

To show the utility of SAI, we compared maternal/child outcomes across the quintiles at county, state, and national levels. Because data collection methods differed between CANDLE and NSCH, we did not compare the maternal/child outcomes across these two datasets.

Socioeconomic adversity was associated with maternal depression in CANDLE and NSCH ($p<0.015$), maternal anxiety in NSCH ($p\leq0.01$), parental incarceration in all populations ($p<0.0001$), sexually transmitted diseases in CANDLE ($p<0.0001$), and drug abuse in the CANDLE ($p=0.0005$) and NSCH-US populations ($p<0.0001$). Significant differences occurred across the SAI quintiles in all populations for birthweight ($p\leq0.002$) and child abuse potential ($p\leq0.0005$). SAI quintiles also differed according to demographic factors such as maternal age ($p<0.0001$) and race ($p<0.0001$) in the CANDLE and NSCH-US populations (Table 2a and Table 2b).

ROC curves using the SAI values vs. income-based SES showed greater association with maternal/child outcomes in the NSCH-US database for: maternal depression (AUC 0.62 vs. 0.56, $p<0.0001$), maternal anxiety (0.57 vs. 0.52, $p<0.0001$), parental incarceration (0.78 vs. 0.70, $p<0.0001$), maternal drug abuse (0.63 vs. 0.54, $p<0.0001$), and child abuse (0.71 vs. 0.66, $p<0.0001$). Association with low birthweight (dichotomized as ≤2500 or >2500 grams) was similar for the SAI vs. SES measures (0.55 vs. 0.55, $p=0.7224$; Figure 5).

Discussion

Any single indicator of adversity cannot estimate the cumulative burdens of those facing material, emotional, physical, and social deprivation. Assessments of socioeconomic adversity must include context-specific factors relevant for different phases of the lifespan (e.g., adolescents vs. elders) and geographically defined populations (e.g., Vermont vs. Texas). Using 55 variables from the CANDLE Study, we developed a composite numerical index measuring socioeconomic adversity in the perinatal, infant/toddler, and preschool age groups.

In our analyses, five variables (marital status, household structure, education, income, health insurance) contributed to socioeconomic adversity in all three periods. Marital status played a particularly significant role. Associations among marital status, teen pregnancy, social adversity and subsequent birth outcomes are well-documented(9, 18, 19), but implementing policies or programs to improve pregnancy outcomes(20, 21) were hampered by ideological views that maternal adversities stem from individual choices and not social inequities. Children from single-parent families are five times more likely to be poor (45.8%) than children of married couples (9.2%)(22). In most families, two parents are expected to

provide greater financial, emotional, and other resources than one parent, and both parents play unique roles in raising children. Household structure is another important factor underlying social adversity, as documented previously(23–25) and confirmed by our results. Earning vs. dependent members in a household may account for individual taxation and other social benefits.

Having publicly-funded or no health insurance contributed to socioeconomic adversity in our study. If families are unable to pay medical bills, their ability to pay other bills deteriorates rapidly, necessitating multiple sacrifices to stay solvent(26) and accentuating socioeconomic adversity. Given that healthcare costs are being increasingly billed to consumers, lack of health insurance is likely to have a growing impact on socioeconomic adversity.

Income and education are well-documented determinants of social class(2, 5). CANDLE participants had lower educational attainments and incomes than NSCH participants. These patterns, as illustrated in Figure 4, highlight the social *and* economic differences for Shelby County vs. Tennessee and the USA. Despite these demographic differences, the proposed index *can* be validated using publicly available data to identify specific groups that differ in socioeconomic adversity.

Maternal and child outcomes differed significantly between the SAI quintiles in CANDLE and in NSCH (Table 2). In the lower SAI quintiles, more mothers had a history of depression, as also reported previously(27). Parental incarceration occurred more frequently in the lower SAI quintiles at the county, state, and national levels, reflecting historical trends(28, 29). Greater exposure to sexually transmitted diseases occurred in the lower SAI quintiles from CANDLE, also confirming previous associations(30). Birthweights increased across the SAI quintiles in all populations, likely reflecting differences in prenatal nutrition and prenatal care between these groups(9, 31, 32). Perinatal adversity is not only associated with lower birthweights and higher infant mortality(2, 33), but also with impaired brain growth, poor cognition and mental health(34), poorer child health, academic success, intergenerational inequities(9, 19) and risks of chronic non-communicable diseases(1, 2, 25).

We present a novel approach measuring socioeconomic adversity, to identify high-risk groups for social and health inequities(35). If socioeconomic adversity is a useful construct, it must predict the outcomes known to be associated with lower SES. On comparing the ability of SAI vs. SES to predict maternal and child outcomes in the NSCH database, we found that SAI statistically outperformed SES for every outcome except birthweight, perhaps because birthweight was dichotomized into low and normal birthweight groups. These results and other studies support the utility of this construct(36).

While examining the long-term consequences of early life adversity, it is important to distinguish between socioeconomic adversity and adverse childhood experiences (ACEs). Both may occur in similar populations, and socioeconomic adversity may increase the odds of experiencing ACEs. Slopen et al. found that poor children experienced twice as many ACEs as did children from high-income groups(37). Our data also showed higher child abuse potential in lower vs. higher SAI quintiles. Traditionally, ACEs include 10 indicators

of child abuse or household dysfunction(38), but Merskey et al. expanded the ACEs to include family financial problems, food insecurity, homelessness, parental absence, parent/sibling death, bullying, and violent crime(39). We believe that the construct of socioeconomic adversity must be kept separate from that of ACEs for fear that combining the two constructs may result in labeling impoverished families as abusive and/or dysfunctional. This is particularly important because socioeconomic adversity was associated with maternal age and race. Financial problems or food insecurity experienced by impoverished families cannot be equated with the ACEs like child abuse, domestic violence, or parental incarceration. Doing so may add different kinds of profiling to those practiced by law enforcement, immigration, or other public agencies(40, 41).

This study has several limitations. There was a relative lack of paternal data in CANDLE, thus precluding analysis. Future measures of socioeconomic adversity must include data from both parents. Maternal responses had fewer missing data (5–10%) and multiple imputation was used to estimate values for analysis. We used published evidence and expert opinion to select variables, rather than data-driven variable selection algorithms. We selected modifiable factors (not age/race), whereas data-driven approaches require a predefined construct and may also select irrelevant or non-modifiable factors. Some CANDLE variables did not have corresponding variables in NSCH, but all data elements required for calculating SAI values *were present* in NSCH. Despite these limitations, our approach for broadly defining socioeconomic adversity (to replace narrow income-based definitions of poverty) may be more useful for investigating the social determinants of health.

Conclusion

The Socioeconomic Adversity Index includes key social, familial, *and* economic variables associated with adversity in early life, identifies high-risk groups susceptible to the effects of early adversity, and more accurately predicts maternal/child outcomes than income-based SES measures. Measures of socioeconomic adversity should be developed specifically for different phases of the lifespan and for different geographically-defined populations.

We used CANDLE Study data to illustrate this principle, which includes those most vulnerable to the long-term effects of adversity, namely, pregnant women and young children. Composite indices for the perinatal, infancy/toddler and preschool periods included marital status, household structure, education, income, and health insurance. Various maternal and child-related outcomes differed significantly across the quintile groups defined by this index, and these differences were validated from a publicly available database. We propose further studies to establish the validity and utility of this novel approach.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial Disclosure: All authors have indicated that they have no financial relationships relevant to this article to disclose.

Funding Sources: Data collection for the CANDLE Study supported by The Urban Child Institute, Memphis, TN via grants to UTHSC and Dr. Tylavsky. The statistical analyses were supported by grants from the Women & Child Health Research Institute at Stanford University (to KJSA) and the National Institutes of Health (to KJSA, JR, NB, KL, RD, IHG).

Funding

The CANDLE Study was supported by grants from The Urban Child Institute to the UTHSC Department of Preventive Medicine (P.I. Tylavsky). The sponsors had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; and the preparation, review, approval, or decision to publish this manuscript.

Conflict of interest

The authors report no conflicts of interest. No honoraria, grants, or other forms of payment were given to the authors of this manuscript.

Abbreviations:

AUC	area under the curve
CANDLE	Conditions Affecting Neurocognitive Development and Learning in Early childhood
CAPI	Child Abuse Potential Inventory
CV	Clinic Visit
HV	Home Visit
NHB	Non-Hispanic Blacks
NHW	Non-Hispanic Whites
NSCH	National Survey of Children’s Health
OPM	Official Poverty Measure
PCs	principal components
PCA	principal components analysis
Q-1	Quintile-1
Q-5	Quintile-5
ROC	Receiver Operating Characteristic curves
SAI	Socioeconomic Adversity Index
SES	socioeconomic status
SPM	Supplemental Poverty Measure
TN	Tennessee
US	United States

References

1. Bor J, Cohen GH, Galea S. Population health in an era of rising income inequality: USA, 1980–2015. Lancet 2017; 389:1475–90 [PubMed: 28402829]
2. Singh GK, Daus GP, Allender M, Ramey CT, Martin EK, Perry C, et al. Social Determinants of Health in the United States: Addressing Major Health Inequality Trends for the Nation, 1935–2016. Int J MCH AIDS 2017; 6:139–64 [PubMed: 29367890]
3. Orshansky M Children of the poor. Social Security Bulletin 1963; 26:3–13
4. Orshansky M Who's who among the poor: a demographic view of poverty. Social Security Bulletin 1965; 28:3–32
5. Haveman R, Blank R, Moffitt R, Smeeding T, Wallace G. The war on poverty: Measurement, trends, and policy. Journal of Policy Analysis & Management 2016; 34:593–638
6. Citro CF, Michael RT, Panel on Poverty and Family Assistance (United States). Measuring poverty : a new approach Washington, D.C: National Academy Press; 1995
7. Ungar M, Ghazinour M, Richter J. Annual Research Review: What is resilience within the social ecology of human development? J Child Psychol Psychiatry 2013; 54:348–66 [PubMed: 23215898]
8. Zylbersztejn A, Gilbert R, Hjern A, Wijlaars L, Hardelid P. Child mortality in England compared with Sweden: a birth cohort study. Lancet 2018;
9. Aizer A, Currie J. The intergenerational transmission of inequality: maternal disadvantage and health at birth. Science 2014; 344:856–61 [PubMed: 24855261]
10. Chetty R, Hendren N, Jones MR, Porter SR. Race and economic opportunity in the United States: An intergenerational perspective Cambridge, MA: National Bureau of Economic Research; 2018
11. Tylavsky FA, Somes G. CANDLE (Conditions Affecting Neurocognitive Development and Learning in Early childhood) Memphis, Tennessee: The Urban Child Institute; 2007
12. Eichener A, Robbins G. National snapshot: Poverty among women & families, 2014 Accessed from https://nwlc.org/resources/national-snapshot-poverty-among-women-families-2014/. Washington, DC2015
13. Stacklies W, Redestig H, Scholz M, Walther D, Selbig J. pcaMethods--a bioconductor package providing PCA methods for incomplete data. Bioinformatics 2007; 23:1164–7 [PubMed: 17344241]
14. Choi Y, Taylor J, Tibshirani R. Selecting the number of principal components: Estimation of the true rank of a noisy matrix. Annals of Statistics 2015; arXiv:1410.8260
15. Milner JS. The Child Abuse Potential Inventory: Manual (2nd edition). Webster, NC: Psytec., Inc ; 1986
16. Milner JS, Dopke C. Child physical abuse: Review of offender characteristics. In: Wolfe RJM DA, deV Peters R, editor Child abuse: New directions in prevention and treatment across the life span Thousand Oaks, CA: Sage Publications, Inc; 1997
17. Milner JS. Assessing physical child abuse risk: The Child Abuse Potential Inventory. Clinical Psychology Review 1994; 14:547–83
18. Ackerman BP, Brown ED. Income poverty, poverty co-factors, and the adjustment of children in elementary school. Adv Child Dev Behav 2006; 34:91–129 [PubMed: 17120803]
19. Meade CS, Kershaw TS, Ickovics JR. The intergenerational cycle of teenage motherhood: an ecological approach. Health Psychol 2008; 27:419–29 [PubMed: 18642999]
20. Smith-Battle L Moving policies upstream to mitigate the social determinants of early childbearing. Public Health Nurs 2012; 29:444–54 [PubMed: 22924567]
21. Brady D, Burroway R. Targeting, universalism, and single-mother poverty: a multilevel analysis across 18 affluent democracies. Demography 2012; 49:719–46 [PubMed: 22403034]
22. U.S. Census Bureau, "2013 Poverty Tables," POV02. People in Families by Family Structure, Age, and Sex, Iterated by Income-to-Poverty Ratio and Race, All Races Washington, DC: U.S. Government; 2013
23. Cancian M, Meyer DR, Cook ST. The evolution of family complexity from the perspective of nonmarital children. Demography 2011; 48:957–82 [PubMed: 21671198]

24. Ackerman BP, D'Eramo KS, Umylny L, Schultz D, Izard CE. Family structure and the externalizing behavior of children from economically disadvantaged families. J Fam Psychol 2001; 15:288–300 [PubMed: 11458634]
25. Curtis LJ, Dooley MD, Lipman EL, Feeny DH. The role of permanent income and family structure in the determination of child health in Canada. Health Econ 2001; 10:287–302 [PubMed: 11400252]
26. Hamel L, Norton M, Pollitz K, Levitt l, Claxton G, Brodie M . The burden of medical debt: Results from the Kaiser Family Foundation/New York Times Medical Bills Survey Menlo Park, CA: Henry K Kaiser Family Foundation; 2016
27. Toy S, Tripodis Y, Yang K, Cook J, Garg A. Influence of Maternal Depression on WIC Participation in Low-Income Families. Matern Child Health J 2016; 20:710–9 [PubMed: 26645615]
28. Morenoff JD, Harding DJ. Incarceration, Prisoner Reentry, and Communities. Annu Rev Sociol 2014; 40:411–29 [PubMed: 25400321]
29. Graff G Redesigning Racial Caste in America via Mass Incarceration. J Psychohist 2015; 43:120–33 [PubMed: 26462404]
30. Stoltey JE, Li Y, Bernstein KT, Philip SS. Ecological analysis examining the association between census tract-level incarceration and reported chlamydia incidence among female adolescents and young adults in San Francisco. Sex Transm Infect 2015; 91:370–4 [PubMed: 25609259]
31. Smith MV, Gotman N, Yonkers KA. Early childhood adversity and pregnancy outcomes. Matern Child Health J 2016; 20:790–8 [PubMed: 26762511]
32. Reichman NE, Hamilton ER, Hummer RA, Padilla YC. Racial and ethnic disparities in low birthweight among urban unmarried mothers. Matern Child Health J 2008; 12:204–15 [PubMed: 17570044]
33. Gabbe PT, Reno R, Clutter C, Schottke TF, Price T, Calhoun K, et al. Improving Maternal and Infant Child Health Outcomes with Community-Based Pregnancy Support Groups: Outcomes from Moms2B Ohio. Matern Child Health J 2017; 21:1130–8 [PubMed: 28074311]
34. Hackman DA, Farah MJ, Meaney MJ. Socioeconomic status and the brain: mechanistic insights from human and animal research. Nat Rev Neurosci 2010; 11:651–9 [PubMed: 20725096]
35. Woolf SH. Progress in achieving Health Equity requires attention to root causes. Health Aff (Millwood) 2017; 36:984–91 [PubMed: 28583955]
36. Bright MA, Knapp C, Hinojosa MS, Alford S, Bonner B. The Comorbidity of Physical, Mental, and Developmental Conditions Associated with Childhood Adversity: A Population Based Study. Matern Child Health J 2016; 20:843–53 [PubMed: 26694043]
37. Slopen N, Shonkoff JP, Albert MA, Yoshikawa H, Jacobs A, Stoltz R, et al. Racial Disparities in Child Adversity in the U.S.: Interactions With Family Immigration History and Income. Am J Prev Med 2016; 50:47–56 [PubMed: 26342634]
38. Felitti VJ, Anda RF, Nordenberg D, Williamson DF, Spitz AM, Edwards V, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. Am J Prev Med 1998; 14:245–58 [PubMed: 9635069]
39. Mersky JP, Janczewski CE, Topitzes J. Rethinking the measurement of adversity. Child Maltreat 2017; 22:58–68 [PubMed: 27920222]
40. Sabo S, Shaw S, Ingram M, Teufel-Shone N, Carvajal S, de Zapien JG, et al. Everyday violence, structural racism and mistreatment at the US-Mexico border. Soc Sci Med 2014; 109:66–74 [PubMed: 24705336]
41. Smiley C, Fakunle D. From "brute" to "thug:" the demonization and criminalization of unarmed Black male victims in America. J Hum Behav Soc Environ 2016; 26:350–66 [PubMed: 27594778]

Key Notes

- Traditionally, measures of socioeconomic status used economic data to assign social status, occasionally including education or employment.
- Social and familial factors significantly contribute to early life adversity, which leads to worse long-term physical/mental health outcomes.
- Factors predicting socioeconomic adversity in early life included: marital status, household structure, annual income, education, and health insurance; these were combined to develop composite numerical indices measuring adversity in the perinatal, infant/toddler, and preschool periods.

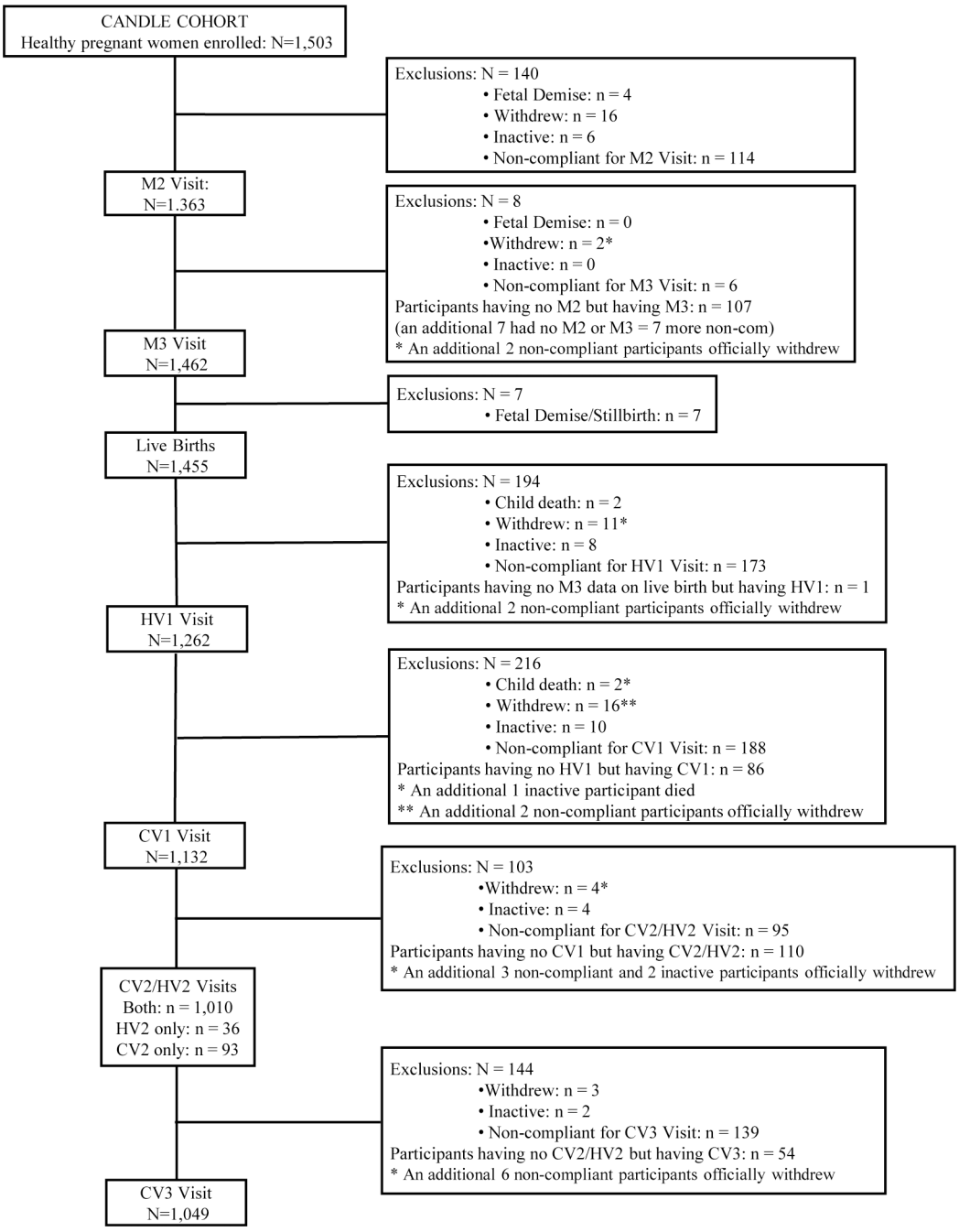

Figure 1:

CONSORT diagram for the CANDLE Study, showing the numbers of subjects enrolled and those evaluated at each follow-up visit. CANDLE enrolled 1503 women in the second trimester of pregnancy, with 1455 live births and some attrition in the infant/toddler (n=1241, 82.6%) and preschool (n=1208, 80.4%) groups because of missed clinic visits.

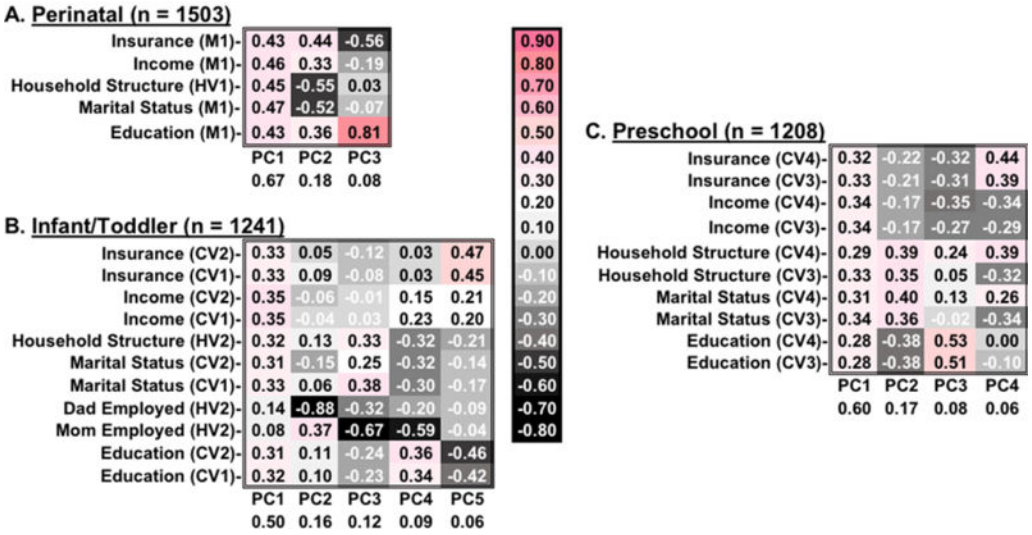

Figure 2:

Heatmap of the variables with absolute correlations of >0.1 with the SAI principal components at the perinatal (3 PCs), infant/toddler (5 PCs), and preschool (4 PCs) periods for the CANDLE cohort. Numbers below the PCs denote proportions of the total variation explained by that corresponding PC.

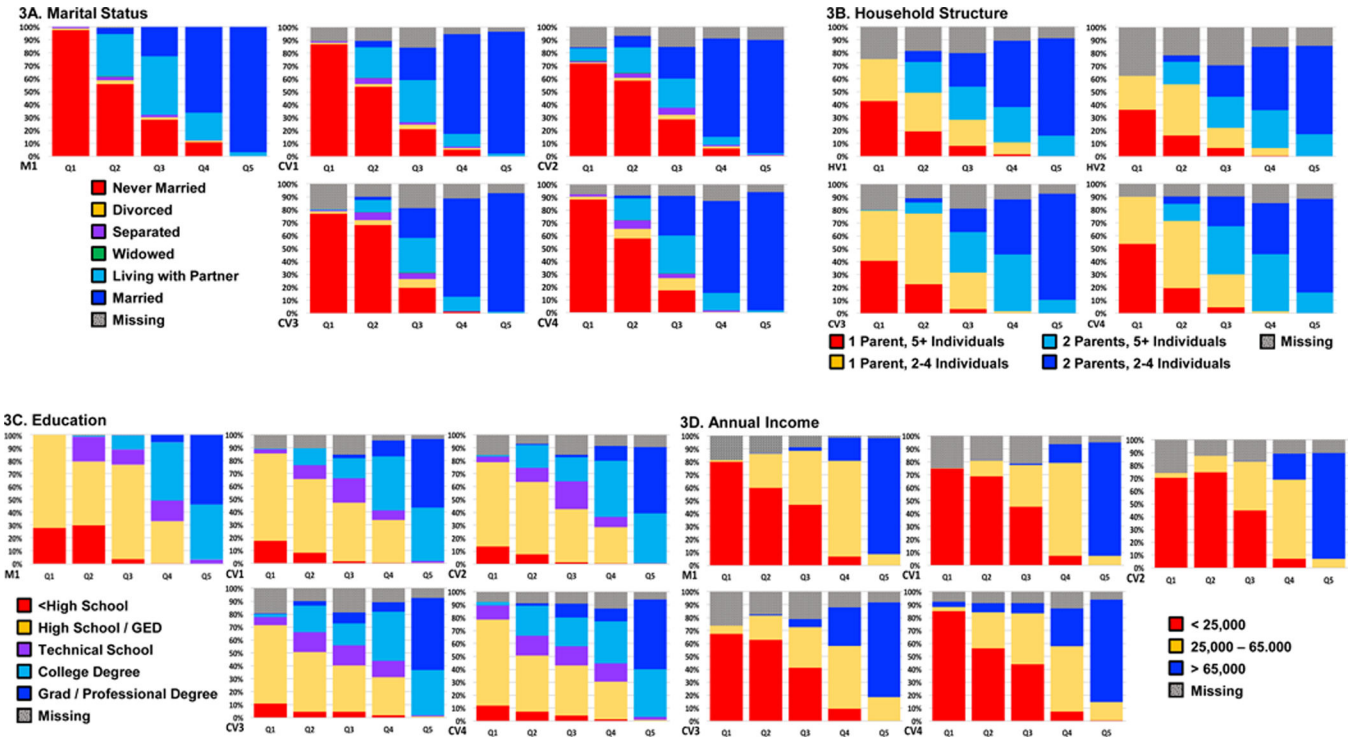

Figure 3:

Distribution of salient factors assessed at different contact points within CANDLE across the quintile (Q1-Q5) groups assigned by the ranks of their SAI scores; (2A) marital status, (2B) household structure, (2C) maternal education, and (2D) maternal income. Mothers in the lower quintile groups were more often unmarried, had more dependents, received less education, and had lower annual incomes than those in the higher quintile groups.

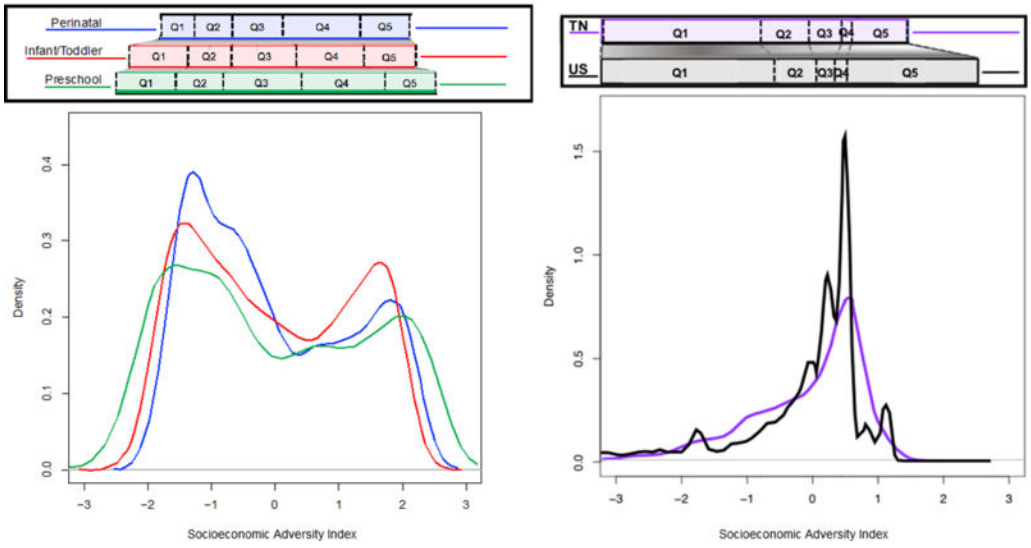

Figure 4:

Density plots showing the bimodal distribution of SAI values for the Perinatal (blue), Infant/Toddler (red), and Preschool (green) time periods in the CANDLE Study, and unimodal distributions of SAI scores for the US (black) and Tennessee (purple) populations in NSCH.

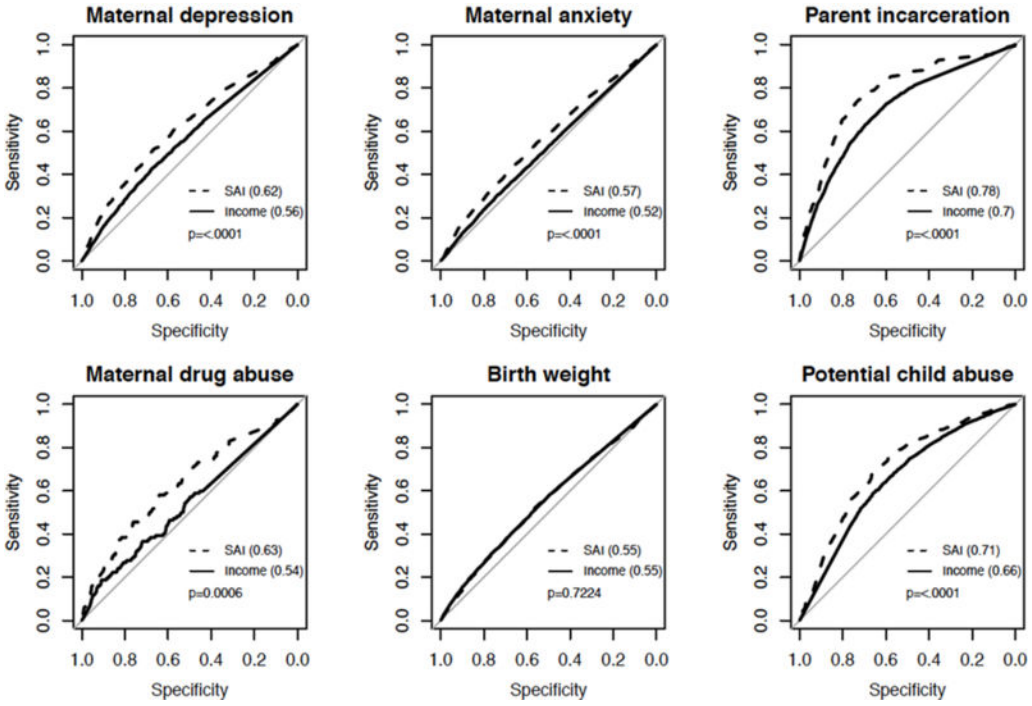

Figure 5:

Receiver Operating Characteristic (ROC) curves comparing the SAI vs. SES measures in predicting maternal/child outcomes in the US NSCH data, with significant differences for maternal depression ($p<0.0001$), maternal anxiety ($p<0.0001$), parental incarceration ($p<0.0001$), maternal drug abuse ($p<0.0001$) and potential child abuse ($p<0.0001$).

Table 1:

Demographic characteristics of the CANDLE and NSCH participants

	CANDLE N=1503	NSCH-TN N=885	NSCH-US N=50212
Maternal age	26 (21·5 – 30)	29 (25 – 33)	30 (26 – 34)
Race[1]			
White	467 (31·1%)	715 (80·8%)	38,961 (77·6%)
Black	962 (64·1%)	76 (8·6%)	3,075 (6·1%)
Asian	19 (1·3%)	29 (3·3%)	2,769 (5·5%)
American Indian	33 (2·2%)	3 (0·3%)	374 (0·7%)
Native Hawaiian	5 (0·3%)	0 (0·0%)	148 (0·3%)
Other	15 (1·0%)	62 (7·0%)	4885 (9·7%)
Maternal Education			
< High School	184 (12·3%)	18 (2·0%)	1,096 (2·2%)
High School/GED	709 (47·2%)	164 (18·5%)	6,020 (12·0%)
Technical School	138 (9·2%)	210 (23·7%)	11,027 (22·0%)
College Degree or Higher	470 (31·3%)	468 (52·9%)	30,872 (61·5%)
Marital status			
Never married	614 (40·9%)	38 (4·3%)	2,163 (4·3%)
Divorced	23 (1·5%)	94 (10·6%)	4,381 (8·7%)
Separated	16 (1·1%)	17 (1·9%)	863 (1·7%)
Widowed	1 (0·1%)	16 (1·8%)	717 (1·4%)
Living with partner	285 (19·0%)	38 (4·3%)	2,124 (4·2%)
Married	563 (37·5%)	661 (74·7%)	38,754 (77·2%)
Household structure			
1 parent, 5+ individuals	234 (18·8%)	37 (4·2%)	1,768 (3·5%)
1 parent, 1–4 individuals	281 (22·5%)	163 (18·4%)	7,172 (14·3%)
2 parents, 5+ individuals	261 (20·9%)	161 (18·2%)	10,865 (21·6%)
2 parents, 2–4 individuals	471 (37·8%)	491 (55·5%)	28,432 (56·6%)
Income			
<25,000	599 (43·8%)	114 (12·9%)	5,030 (10·0%)
25,000–65,000	450 (32·9%)	249 (28·1%)	11,778 (23·5%)
>65,000	319 (23·3%)	522 (59·0%)	33,404 (66·5%)
Insurance			
Medicare, Medicaid, None	878 (58·4%)	275 (31·1%)	13,321 (26·5%)
VA, Employer, or Private	625 (41·6%)	608 (68·7%)	36,703 (73·1%)

NA: not assessed; CANDLE: Conditions Affecting Neurocognitive Development and Learning in Early childhood; NSCH: National Survey of Children's Health; GED: General Educational Development; VA: Veterans' Administration·

[1]Mother's race was recorded in CANDLE, whereas child's race was reported in NSCH· Maternal Age is listed as Medians (IQR).

Table 2a:

Maternal/child outcomes by SAI quintiles in the CANDLE cohort

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P-value
	CANDLE n=383	CANDLE n=219	CANDLE n=301	CANDLE n=318	CANDLE n=282	
Maternal age	22.0 (19.0 – 25.0)	22.0 (20.0 – 26.0)	25.0 (21.0 – 28.0)	28.0 (25.0 – 31.0)	31.0 (29.0 – 34.0)	<0.0001
Maternal race: White	15 (3.9%)	20 (9.1%)	55 (18.3%)	162 (50.9%)	215 (76.2%)	<0.0001
Black	353 (92.2%)	186 (84.9%)	226 (75.1%)	145 (45.6%)	52 (18.4%)	
Asian	0 (0.0%)	1 (0.5%)	2 (0.7%)	3 (0.9%)	13 (4.6%)	
American Indian	11 (2.9%)	8 (3.7%)	10 (3.3%)	3 (0.9%)	1 (0.4%)	
Native Hawaiian	1 (0.3%)	1 (0.5%)	2 (0.7%)	1 (0.3%)	0 (0.0%)	
Other	2 (0.5%)	3 (1.4%)	5 (1.7%)	4 (1.3%)	1 (0.4%)	
Post-natal depression	17 (4.4%)	15 (6.8%)	14 (4.7%)	6 (1.9%)	7 (2.5%)	<0.0001
Maternal anxiety	38.0 (38.0 – 45.0)	38.0 (38.0 – 45.0)	38.0 (38.0 – 51.0)	38.0 (38.0 – 45.0)	38.0 (38.0 – 49.5)	0.7
Parent ever in jail	103 (26.9%)	69 (31.5%)	46 (15.3%)	18 (5.7%)	3 (1.1%)	<0.0001
STD history[a]	167 (43.6%)	97 (44.3%)	115 (38.2%)	72 (22.6%)	29 (10.3%)	<0.0001
Drug abuse history[b]	73 (19.1%)	64 (29.2%)	98 (32.6%)	98 (30.8%)	83 (29.4%)	0.0005
Birth Weight (grams)	3101.0 (2812.5 – 3354.0)	3120.0 (2906.0 – 3460.0)	3203.2 (2913.2 – 3512.5)	3380.0 (3085.0 – 3684.5)	3413.5 (3098.5 – 3726.5)	<0.0001
Child abuse likely	38 (9.9%)	19 (8.7%)	25 (8.3%)	12 (3.8%)	2 (0.7%)	<0.0001

Notes: One-way ANOVA for continuous variables, Fisher's exact test for categorical variables comparing differences across SAI quintiles within the CANDLE databases;

[a] STD: sexually transmitted diseases included herpes, gonorrhea, chlamydia, or trichomonas

[b] Drug abuse included injected drugs, marijuana, cocaine, or other recreational drug abuse; Child Abuse in the CANDLE cohort was likely if the CAPI Abuse Scale scores were >263 in any of the assessments performed at 1, 2, and 3 years.

Table 2b:

Maternal/child outcomes by SAI quintiles in the NSCH-TN cohort

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P-value
	NSCH-TN n=177	NSCH-TN n=177	NSCH-TN n=213	NSCH-TN n=213	NSCH-TN n=105	
Maternal age	39.0 (28.0 – 50.0)	40.0 (34.0 – 48.0)	42.0 (36.0 – 48.0)	42.0 (37.0 – 47.0)	44.5 (37.0 – 50.0)	0.075
Maternal race: White	126 (71.2%)	147 (83.1%)	173 (81.2%)	176 (82.6%)	93 (88.6%)	<0.0001
Black	40 (22.6%)	12 (6.8%)	13 (6.1%)	10 (4.7%)	1 (1.0%)	
Asian	1 (0.6%)	3 (1.7%)	6 (2.8%)	12 (5.6%)	7 (6.7%)	
American Indian	1 (0.6%)	0 (0.0%)	1 (0.5%)	1 (0.5%)	0 (0.0%)	
Native Hawaiian	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Other	9 (5.1%)	15 (8.5%)	20 (9.4%)	14 (6.6%)	4 (3.8%)	
Post-natal depression	10 (5.6%)	6 (3.4%)	5 (2.3%)	3 (1.4%)	9 (8.6%)	0.014
Maternal anxiety	15 (8.5%)	17 (9.6%)	18 (8.5%)	8 (3.8%)	16 (15.2%)	0.01
Parent ever in jail	47 (26.6%)	27 (15.3%)	7 (3.3%)	3 (1.4%)	3 (2.9%)	<0.0001
STD history[a]	NA	NA	NA	NA	NA	NA
Drug abuse history[b]	2 (1.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.053
Birth Weight (grams)	3203.5 (2891.7 – 3472.8)	3189.3 (2948.4 – 3543.7)	3345.2 (3005.0 – 3685.4)	3345.2 (3005.0 – 3628.7)	3458.6 (3033.4 – 3855.5)	0.002
Child abuse likely	15 (8.5%)	7 (4.0%)	5 (2.3%)	1 (0.5%)	4 (3.8%)	0.0005

Notes: National Survey of Children's Health data are presented for Tennessee (NSCH-TN)); One-way ANOVA for continuous variables, Fisher's exact test for categorical variables comparing differences across SAI quintiles within the NSCH-TN

[a] STD: sexually transmitted diseases included herpes, gonorrhea, chlamydia, or trichomonas

[b] Drug abuse included injected drugs, marijuana, cocaine, or other recreational drug abuse; Child Abuse in the CANDLE cohort was likely if the CAPI Abuse Scale scores were >263 in any of the assessments performed at 1, 2, and 3 years.

Table 2c:

Maternal/child outcomes by SAI quintiles in the NSCH-US cohort

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P-value
	NSCH-US n=10046	NSCH-US n=10061	NSCH-US n=10033	NSCH-US n=14793	NSCH-US n=5279	
Maternal age	41.0 (33.0 – 52.0)	41.0 (35.0 – 48.0)	42.0 (37.0 – 48.0)	42.0 (36.0 – 48.0)	42.0 (36.0 – 48.0)	<0.0001
Maternal race: White	6,666 (66.4%)	7,791 (77.4%)	8,196 (81.7%)	12,325 (83.3%)	3,983 (75.4%)	<0.0001
Black	1,490 (14.8%)	598 (5.9%)	355 (3.5%)	434 (2.9%)	198 (3.8%)	
Asian	336 (3.3%)	504 (5.0%)	574 (5.7%)	796 (5.4%)	559 (10.6%)	
American Indian	131 (1.3%)	97 (1.0%)	60 (0.6%)	52 (0.4%)	34 (0.6%)	
Native Hawaiian	60 (0.6%)	24 (0.2%)	33 (0.3%)	24 (0.2%)	7 (0.1%)	
Other	1,363 (13.6%)	1,047 (10.4%)	815 (8.1%)	1,162 (7.9%)	498 (9.4%)	
Post-natal depression	773 (7.7%)	472 (4.7%)	384 (3.8%)	417 (2.8%)	173 (3.3%)	<0.0001
Maternal anxiety	1,251 (12.5%)	921 (9.2%)	851 (8.5%)	1,082 (7.3%)	396 (7.5%)	<0.0001
Parent ever in jail	1,650 (16.4%)	666 (6.6%)	227 (2.3%)	196 (1.3%)	129 (2.4%)	<0.0001
STD history[a]	NA	NA	NA	NA	NA	NA
Drug abuse history[b]	47 (0.5%)	20 (0.2%)	18 (0.2%)	17 (0.1%)	10 (0.2%)	<0.0001
Birth Weight (grams)	3316.9 (2920.0 – 3628.7)	3345.2 (3005.0 – 3685.4)	3401.9 (3033.4 – 3713.8)	3401.9 (3033.4 – 3713.8)	3373.6 (3005.0 – 3713.8)	<0.0001
Child abuse likely	752 (7.5%)	321 (3.2%)	203 (2.0%)	186 (1.3%)	83 (1.6%)	<0.0001

Notes: Outcomes are presented for the CANDLE cohort and National Survey of Children's Health data for Tennessee (NSCH-TN) and all 50 states (NSCH-US); One-way ANOVA for continuous variables, Fisher's exact test for categorical variables comparing differences across the SAI quintiles within the

[a] CANDLE

[b] NSCH-TN, and

[c] NSCH-US databases

[d] STD: sexually transmitted diseases included herpes, gonorrhea, chlamydia, or trichomonas

[e] Drug abuse included injected drugs, marijuana, cocaine, or other recreational drug abuse; Child Abuse in the CANDLE cohort was likely if the CAPI Abuse Scale scores were >263 in any of the assessments performed at 1, 2, or 3 years (this cut-off value is characteristic of adults associated with confirmed child abuse); in the NSCH database, participants were asked if their child was exposed to child abuse or not.