Variation in Rates of ADHD Diagnoses Across Public Schools in Arkansas

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Abstract
The school context is important to diagnosing ADHD, but little is known about variation in rates of ADHD diagnosis across schools. This study analyzed 87,383 kindergartners who were not diagnosed with ADHD prior to kindergarten who attended at least one of 490 elementary schools in Arkansas. The study examined five kindergarten cohorts from the 2015/16 to 2019/20 academic years, assessing school-level variation in ADHD diagnosis rates. Schools were categorized by quintiles of their ADHD diagnosis rates. A mixed-effects logistic regression model was used to examine individual-level factors associated with new ADHD diagnosis. Diagnosis rates varied 570% across school quintiles. Schools with higher rates of ADHD diagnoses served a higher percentage of African American children, children from lower-income families, and children living in neighborhoods with lower Child Opportunity Index (COI) scores. Results of an individual-level logistic regression analysis indicated children in census tracts with very high or high social and economic COI scores had lower odds of having new ADHD diagnoses compared to those from very low COI neighborhoods. Children who were young-for-grade had higher odds of an ADHD diagnosis. Children who were in schools providing universal free school meals had lower odds of an ADHD diagnosis, despite these schools serving more children from families with lower incomes, a finding that warrants further exploration. Because the rate of new ADHD diagnoses in kindergarten varies so substantially across schools, future research is needed to better understand causes of school-level variability in ADHD diagnosis.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is the most common childhood neurodevelopmental disorder in the United States affecting ten percent of children of elementary school age (1). School systems play an important role in the identification and diagnosis of childhood ADHD. DSM-5 (2) criteria for diagnosis of ADHD require several symptoms to be present in two or more settings (e.g., home and school). School staff, such as teachers, can be influential in the referral of children for ADHD evaluation (5). Once referred, it is recommended that ADHD evaluations for children include perspectives from teachers or other school staff (3,4). Moreover, the classroom and school environment (e.g., level of structure, use of positive behavioral interventions) are important for outcomes of children with ADHD (3,5).

Existing literature documents geographic variation in the prevalence of ADHD in children in the United States (6), Norway (7), and Denmark (8). For example, Zgodic et al. found that county-level prevalence of parent-reported childhood ADHD diagnoses in the United States ranged from 11% or lower to 20% or higher (6). Other studies have examined variability in ADHD diagnosis at the primary care practice level; these have observed substantial variability in the ADHD diagnosis across primary care practices (9,10). However, little is known about the extent to which incident ADHD diagnoses varies across schools. This is an important gap in the literature because schools are an important context for the diagnosis and management of ADHD. If rates of ADHD diagnosis are distributed unevenly across schools, this may signal potential inequities in identification processes, school environments, and/or community-level factors that contribute to ADHD prevalence rates. Given educational resources required to manage ADHD are substantial (11), this also may have implications for the equitable distribution of resources to support students with ADHD.

Geographic variation in the prevalence of ADHD has been attributed to a wide range of factors, including those at the macro level such as education and health care system policy (12,13); those related to clinicians such as availability of trained providers, clinicians' attitudes and practice styles (14,15); and those related to population demographics and social determinants of health such as poverty rates and access to community resources (16,17). Multifactorial genetic and environmental risk factors are thought to interact to shape ADHD risk (18). Indeed, social determinants of health within residential neighborhoods have been shown to be associated with ADHD (35,36). These associations may reflect disparities in underlying risk as well as disparities in identification, diagnosis and treatment access processes, and have been attributed to a wide array of potential factors, including imbalanced community resources, exposure to stress, environmental exposures, healthcare access, and sociocultural expectations (19–22). Because schools tend to serve student populations grouped by geography, neighborhood-level factors may lead to school-level variation in ADHD diagnosis. At the school level, there are several factors that may be important for diagnosis and outcomes of children with ADHD and could lead to school-level variation in diagnosis rates (23,24). First, some children access preventive and diagnostic care directly through school-based health clinics (25). Second, In the United States, children obtain up to 58% of their daily caloric intake from school meals (26), which are required to conform to federal nutrition standards (27) and compare favorably to meals brought from home in terms of overall nutritional quality (28–30), but vary across schools (31–33). Based on recent systematic reviews, the evidence supporting a link between healthy diets (34,35), sugar consumption (36) and ADHD diagnosis is not conclusive. However, this literature primarily addresses individual dietary factors rather than school-level processes that facilitate participation in child nutrition programs. Using difference-in-differences designs, recent studies

have shown that disciplinary infractions decline when schools adopt policies that facilitate participation in child nutrition programs (37,38), which could impact diagnosis rates through lower referrals for screening. Third, there is strong evidence for relative age effects in ADHD diagnoses with younger children being more likely to receive an ADHD diagnosis than older children in a grade cohort (39–42). Teacher ratings for ADHD-related symptoms often diverge from parent ratings for children who are young-for-grade (40,42), highlighting the importance of developmental maturity within the school context in establishing ADHD diagnoses. School policies around discipline may also be relevant to ADHD diagnosis and management. Students with ADHD are more likely to receive referrals and sanctions that include exclusionary discipline (43), which is linked to a host of negative outcomes, such as involvement with the justice system and risky behaviors (44). Recent evidence also suggests that attending a school using a specific evidence-based positive behavior support framework (i.e., School-Wide Positive Behavioral Interventions and Supports) reduces the likelihood of a student receiving pharmacotherapeutic treatment for ADHD, especially for at-risk students in schools with high implementation fidelity(45). Although not definitive, these results raise the possibility that aspects of the school environment (e.g., level of proactive and positive behavioral support) may influence symptom presentation for children with a genetic predisposition for ADHD (46–48).

Despite the myriad of factors that could lead to school-level variability in rates of ADHD diagnosis (48), no existing studies have investigated school-level variation in children receiving new ADHD diagnoses in their medical claims in the United States. Such studies are inherently difficult due to federal and state privacy laws and regulations for both educational and medical records, and the challenges in data access and linkage for epidemiologic studies. This study is the first to report findings from such data, which allow us to simultaneously adjust for both

individual- and school-level factors. Participation in kindergarten is the norm across the United States (49) and represents the first encounter with public-school systems for many children, which makes it the ideal setting to examine school-level variation in ADHD diagnoses. The aims of this cross-sectional study are to 1) describe school-level variation in rates of new ADHD diagnoses among kindergarteners across public elementary schools; 2) examine child-level, school-level, and neighborhood-level factors associated with kindergarten diagnosis rates.

Methods

Design, Setting & Participants

The study covered five first-time public-school kindergarten cohorts enrolled in Arkansas public schools during the 2015/16 through 2019/20 academic years. This time frame was selected to mitigate the influence of the COVID-19 pandemic, which caused disruptions to the delivery of academic programs, potentially introducing confounding factors that could bias estimation. The study involved the retrospective analysis of administrative datasets from the Arkansas Department of Education (ADE) that were linked by subject identifiers to the Arkansas All-Payer Claims Database (AR-APCD) through an honest data broker arrangement and were then de-identified. Claims data, such as those in the AR-APCD, reflect the billing system used in US healthcare, which is comprised of a fragmented, multi-payer system that encompasses private insurers, employer-sponsored insurance plans, and public insurance (e.g. Medicaid). Claims reflect billing information such as diagnostic codes (i.e., International Classification of Disease (ICD) codes and procedure codes recorded and billed by clinicians and prescriptions billed to insurance payers. Since the data available to the research team was de-identified, the study received a not human subject research determination by the Institutional Review Board (<<institution>> IRB# 275801).

Medical claims were evaluated over a 22-month period from September 1st of the year prior to the year of kindergarten enrollment through June 30th of the year after enrollment. This comprised a 12-month lookback period prior to entering kindergarten ending August 31st of the year of kindergarten enrollment and a 10-month study period corresponding to the kindergarten academic year. The validity of this approach is supported by earlier work showing positive predictive values for ADHD cases identified in claims data are high when cross checked against medical records (50).

We identified 116,350 first-time kindergartners during the study period (Figure 1). Children were excluded for the following reasons: 1) The child did not have continuous representation in the AR-APCD as defined by a coverage gap of no more than two consecutive months during the 22-month lookback and study period (28,569 excluded). 2) To identify incident ADHD, children with an ADHD diagnosis in the 12 months prior to September 1 of the kindergarten year (4,939 excluded). 3) The child attended very small schools that had fewer than 25 kindergartners enrolled during the five-year period (398 excluded). These small schools were excluded to avoid small-numbers bias in the school-level variations analysis. 4) The child was missing study measures (37 excluded).

Diagnoses

We identified an ADHD diagnosis as either 1) a diagnostic code on two or more distinct dates or 2) a diagnostic code plus a prescription for a psychotropic stimulant (51). This approach will identify cases where stimulants are not used to manage ADHD while reducing false positives that could have occurred in inpatient settings, probable but not confirmed cases, or because of "rule out" codes that may have been used prior to transitioning to the ICD-10-CM guidelines. Diagnostic codes that were used to define ADHD were ICD-9-CM codes of 314.00, 314.01,

314.0 and ICD-10-CM codes of F90.0, F90.1, F90.2, F90.8, F90.9. Psychotropic stimulants were defined as one or more prescriptions filled for amphetamine and mixed amphetamine salts, dexmethylphenidate, dextroamphetamine, lisdexamfetamine, methamphetamine, and methylphenidate (50). New cases diagnosed during kindergarten were defined as those where the first diagnostic code or prescription occurred on or after September 1st of the year the child entered kindergarten.

Co-occurring conditions (oppositional defiant disorder, other disruptive behavioral disorders, autism spectrum disorder, major depressive disorder, anxiety disorders, stress disorders, specific learning disorders, and tic disorders) were identified as one or more diagnostic codes within the 22-month combined lookback and study periods. Other disruptive behavioral disorders were comprised primarily by diagnostic code F91.9 ("conduct disorder unspecified"). A complete list of diagnostic codes for these conditions is provided in eTable 1 in supplement 1. To account for potential variation in diagnoses across medical providers, each child was assigned to a provider who appeared most frequently in their history of medical claims for ambulatory care during the 12-month lookback period. There were 3,579 distinct providers.

Child-level factors

Child-level measures were assessed using the ADE's Statewide Information System (52). Based on enrollment records, gender was coded as male or female and four classifications were used for race/ethnicity: non-Hispanic White, non-Hispanic African American, non-Hispanic of another race (including more than one race), or Hispanic. Indicators were assigned to children using a school-based health center or receiving special education services any time during an academic year. An indicator for school mobility was used to flag children who attended more than one school during the year. For purposes of the analysis, the child flagged as mobile were assigned to

the school where they spent the most time during the academic year. Children were classified as young-for-grade if they had birthdays in May, June, July, or August and were born exactly five years before the year they entered kindergarten. An indicator was used to measure whether the child received one or more disciplinary referrals during the school year. Lastly, to measure socioeconomic status, indicators of eligibility for free or reduced-price meals, were used to identify students from families below 130% and 185% of the federal poverty threshold, respectively. For context, in 2018, the mid-year of our study, the federal poverty threshold for a family of four was $25,100 per annum and the median household income was $63,179 per annum (53).

Neighborhood-level factors

Childhood Opportunity Index (COI) scores were taken from the Child Opportunity Index 2.0 Database. Child opportunity was measured for the child's census tract using COI component scores across three subdomains: (1) education (2) health and environment, and (3) economic and social opportunities/resources, each ranging from 1 to 100, with higher numbers indicating higher opportunity (54). Region indicators used by the Arkansas Center for Health Improvement were used to capture broad differences in rurality and economic opportunity across the state (eFigure 1 and eTable 2 in supplement 1).

School-level factors

Data on school meal policies were obtained from ADE's Child Nutrition Unit and the Arkansas Hunger Relief Alliance. The study included two measures related to use of school meal-delivery options that have been shown to increase access and participation to school nutrition. Indicators were used to identify schools that provided universal free meals (UFM) to all enrolled children

and schools that provided “breakfast after the bell” (BAB), a meal delivery option that makes breakfast available after the instructional component of the school day begins.

Statistical methods

Descriptive statistics were computed across all children. Variation across schools was assessed by averaging study measures by school over the five academic years, which provided a rate of new ADHD diagnoses by school. In the school-level analysis five-year averages were used to ensure that a sufficiently large numbers of individuals were included to compute stable diagnosis rates by school. Schools were then assigned to quintiles based on this rate. Trend tests were used to assess significance in rates of ADHD diagnosis and the various child-level, neighborhood level, and school-level measures described above across lowest and highest incidence schools. The Cochran-Armitage test for trend was used for categorical variables and the Jonckheere–Terpstra test for trend was used for continuous variables.

A mixed-effects logistic regression model with random effects for school, region, and provider was used to examine the association between child-level ADHD diagnosis and the child-level measures described above. Co-occurring conditions, the use of prescription stimulants, and indicator for disciplinary infractions were excluded from this model because they were likely to be codetermined with an ADHD diagnosis. The estimated model was used to adjust school-level diagnoses rates. To align with the school-level analysis, conditional, model-adjusted, individual-level predictions were averaged by school and then compared to the unadjusted diagnosis rates.

All analyses were conducted using R version 4.4.0.

Sensitivity Analysis

Two sensitivity assessments were conducted. The first relaxed the 22-month continuous enrollment exclusion requirement. This requirement was to reduce false-negatives, but could impact sample composition. The second assessment involved estimation of two additional mixed-effects logistic regression models, one excluding provider random effects and the other excluding school random effects. These were to assess sensitivity to inclusion random effects for provider and school.

Results

Study Population

After applying the exclusion criteria (Figure 1), the analytic sample contained 87,383 kindergartners. Supplemental material shows that those excluded were less likely to qualify for free meals and were less likely to be racial and ethnic minorities (see eTable 3 in supplement 1). Three out of four Arkansas kindergartners were from families with incomes below 185% of poverty as indicated by eligibility for free or reduced-price school meals, with most kindergartners (68%) falling below the free-meal threshold (130% poverty; Table 1). Approximately 22% of kindergartners attended a school that offered UFM, 34% attended schools that offered BAB and 8% of kindergartners received one or more disciplinary referrals.

Variability in ADHD Diagnoses by School

Across all schools, 5.2% of kindergarteners were newly diagnosed with ADHD (Table 1). This varied from 1.7% in the lowest quintile of schools to 10.0% in the highest quintile of schools, a nearly six-fold difference (Table 2). Schools in the highest quintile served a higher percentage of students who qualified for free school meals and who lived in neighborhoods with lower child opportunity scores across all domains. African American children and children from the Mississippi Delta region were more prevalent in the highest quintile of schools. A smaller

percentage of students in the highest quintile received care through a school-based health clinic (1.6% versus 2.3%) while a higher percentage of students in the highest quintile were in schools that provided UFM (31.5% versus 16.9%). The prevalence of co-occurring conditions, especially ODD and CD, increased from the lowest to highest quintiles as did the use of stimulant medications. A similar trend across quintiles was observed with respect to disciplinary referrals and use of special education services.

Associations with ADHD Diagnoses

Table 3 presents the odds ratios (OR) and 95% confidence intervals (CIs) estimated from the mixed-effect logistic regression model to predict individual ADHD diagnoses. Female children, Hispanic children, non-Hispanic children of other races, children living in neighborhoods with very high COI levels in the social and economic domain, and children attending schools offering UFM had lower odds of being newly diagnosed with ADHD during kindergarten compared to their respective reference groups. Conversely, students eligible for free or reduced-price meals, those who transferred between schools, and those who were young-for-grade had significantly higher odds of being diagnosed with ADHD compared to their reference groups.

Figure 2 shows unadjusted (panel A) and model-adjusted (panel B) rates of ADHD diagnosis across the 490 schools. Figure 2 shows that the median observed ADHD diagnosis rate shows a 4.9-times difference between the 10^{th} and 90^{th} percentiles whereas the median model-adjusted ADHD diagnosis rate shows a 2.2-times difference between the 10^{th} and 90^{th} percentiles.

Sensitivity Analysis

A comparison of findings including children without continuous coverage in the 12-month lookback and 10-month study periods are reported in eFigure 2 and eTable 3-5 in Supplement 1.

As expected, diagnosis rates were lower without the continuous coverage requirement, but primary findings align with those reported above. Associations from mixed-effects logistic regression models were robust to the exclusion of provider effects or school effects. However, the model included both school and provider effects had a lower Akaike Information Criterion, indicating better model fit (eTable 6 in supplement 1).

Discussion

This study extends the literature on variability in ADHD diagnoses by examining school-level variability in new medical claims-based ADHD diagnoses among kindergarteners using a novel dataset with linked administrative educational and medical claims data for children in Arkansas. We found substantial school-level variability: Schools in the highest quintile of new ADHD diagnoses had a diagnosis rate nearly six times higher than those in the lowest quintile. Compared to schools in the lowest quintile, schools in the highest quintile included a higher proportion of African American children and children families eligible for free or reduced-price school meals. We also observed several factors to be significantly associated with child-level odds of receiving an ADHD diagnosis during kindergarten. After adjusting for these factors, the difference in diagnostic rates across the 10^{th} to 90^{th} percentile of schools was reduced by half. These results suggest potential factors to examine in future research designed to examine causal relationships between school-level factors and rates of ADHD diagnoses.

The current findings extend prior work demonstrating variability in rates of childhood ADHD diagnoses based on geography (6) and primary care practice (9) both within and outside of the United States. Previous research in Norway has demonstrated geographical variability in ADHD diagnoses with evidence that variability in this context may be driven by clinician attitudes and local practice styles (10,55–57). However, our findings that mixed-effect models

were robust to inclusion of provider effects suggest that the school-level variation observed in Arkansas is unlikely be explained solely by providers.

Although the associations observed here do not establish causal relationships, they do have potential implications for policies that may promote equity in diagnoses. The school-level variability in ADHD diagnoses observed here occurred in the context of school-level disparities in resources and child academic and disciplinary outcomes observed in the literature (58–61). Rates of ADHD diagnoses may interact with these school-level disparities in complex ways. Indeed, schools with the highest ADHD diagnosis rates also had higher rates of disciplinary referrals. Exclusionary discipline in elementary school contributes to an escalation of behavioral issues, which may predispose the child to an ODD or CD diagnoses and/or interactions with the juvenile justice system (62). Additionally, although UFM schools generally serve children from neighborhoods facing economic disadvantage, we also found that attending a school with UFM was associated with 21% lower adjusted odds of receiving an ADHD diagnosis, which is an intriguing finding. There is a need for further probe and test mechanisms through which school meal policy could impact diagnosis or outcomes for children with ADHD. Finally, our results also replicate well-established findings about relative age effects (39–42,63) on ADHD diagnosis, where children who are young for their grade level are more likely to be diagnosed, which highlights the potential importance of ensuring that ADHD screening protocols are cognizant of the child's developmental stage relative to their classroom peers.

This study has several limitations. Although it is the first to link claims data to educational records on school enrollment, it does not contain information on children who attended kindergarten in private schools, who did not have insurance, or who were covered under a self-insured employer plan that was not required to report to the AR-APCD. The use of claims

data poses limitations related to gaps in patient history, exclusion of cash payments, and inability to assess adherence to recommendations and medications. In particular socioeconomic status can affect medical coverage gaps and, in the data reported here, socioeconomic indicators were significant predictors of an ADHD diagnosis. Because we required continuous coverage for inclusion in the study, our data are likely over-represents children on public insurance and children who were consistently on private insurance at the lower and upper ends of the socioeconomic gradient, respectively. This study also did not capture related educational classifications (e.g., Other Health Impairment) or ADHD-related services that were not reflected in health insurance claims, which means that the overall rates of ADHD observed here may be an underestimate. While the study draws data from a diverse statewide school system including both urban and rural areas, findings from one state may not apply generally to other areas of the US or elsewhere in the world, especially as healthcare access and educational policy vary across states and countries. Finally, it is important to emphasize that the associations observed in this study are observational and may be influenced by unmeasured confounding, so these associations cannot be interpreted as causal.

Conclusion

Although many studies have observed variation in ADHD diagnoses, our contribution lies in highlighting how this variation manifests at the school level in the United States and generates new approaches for equitable diagnoses. Schools with the highest incidence of ADHD diagnoses served children from less affluent families living in neighborhoods with lower economic opportunity, which is broadly consistent with the idea of social determinants of health risk factors that may interact with biological risk for ADHD (35). Across schools, higher incidences

aligned with a larger percentage of children being cited for one or more disciplinary infractions, highlighting the importance of initiatives that prevent escalation of behavioral problems.

References

1. Bitsko RH, Claussen AH, Lichstein J, et al.: Mental Health Surveillance Among Children - United States, 2013-2019. MMWR Suppl 71: 1–42, 2022.

2. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. American Psychiatric Association, 2013 [cited 2024 Sept 18]Available from: https://psychiatryonline.org/doi/book/10.1176/appi.books.9780890425596

3. Wolraich ML, Hagan JF, Allan C, et al.: Clinical Practice Guideline for the Diagnosis, Evaluation, and Treatment of Attention-Deficit/Hyperactivity Disorder in Children and Adolescents. Pediatrics 144: e20192528, 2019.

4. Martel MM, Eng AG, Bansal PS, et al.: Multiple informant average integration of ADHD symptom ratings predictive of concurrent and longitudinal impairment. Psychol Assess 33: 443–451, 2021.

5. Fabiano GA, Pyle K: Best Practices in School Mental Health for Attention-Deficit/Hyperactivity Disorder: A Framework for Intervention. School Ment Health 11: 72–91, 2019.

6. Zgodic A, McLain AC, Eberth JM, et al.: County-level prevalence estimates of ADHD in children in the United States. Ann Epidemiol 79: 56–64, 2023.

7. Hofstad T, Nyttingnes O, Bjelland I, et al.: Catchment area characteristics do not account for geographical variation in ADHD diagnoses. Eur Child Adolesc Psychiatry , 2025.Available from: https://link.springer.com/10.1007/s00787-025-02720-x

8. Madsen KB, Ersbøll AK, Olsen J, et al.: Geographic analysis of the variation in the incidence of ADHD in a country with free access to healthcare: a Danish cohort study. Int J Health Geogr 14: 24, 2015.

9. Mayne SL, Ross ME, Song L, et al.: Variations in Mental Health Diagnosis and Prescribing Across Pediatric Primary Care Practices. Pediatrics 137: e20152974, 2016.

10. Bannett Y, Feldman HM, Bentley JP, et al.: Variation in Rate of Attention-Deficit/Hyperactivity Disorder Management by Primary Care Providers. Acad Pediatr 20: 384–390, 2020.

11. Schein J, Adler LA, Childress A, et al.: Economic burden of attention-deficit/hyperactivity disorder among children and adolescents in the United States: a societal perspective. J Med Econ 25: 193–205, 2022.

12. Danielson ML, Claussen AH, Bitsko RH, et al.: ADHD Prevalence Among U.S. Children and Adolescents in 2022: Diagnosis, Severity, Co-Occurring Disorders, and Treatment. J Clin Child Adolesc Psychol Off J Soc Clin Child Adolesc Psychol Am Psychol Assoc Div 53 53: 343–360, 2024.

13. Fulton BD, Scheffler RM, Hinshaw SP: State Variation in Increased ADHD Prevalence: Links to NCLB School Accountability and State Medication Laws. Psychiatr Serv 66: 1074–1082, 2015.

14. Widding-Havneraas T, Markussen S, Elwert F, et al.: Geographical variation in ADHD: do diagnoses reflect symptom levels? Eur Child Adolesc Psychiatry 32: 1795–1803, 2023.

15. Lyhmann I, Widding-Havneraas T, Zachrisson HD, et al.: Variation in attitudes toward diagnosis and medication of ADHD: a survey among clinicians in the Norwegian child and adolescent mental health services. Eur Child Adolesc Psychiatry 32: 2557–2567, 2023.

16. Russell AE, Ford T, Williams R, et al.: The Association Between Socioeconomic Disadvantage and Attention Deficit/Hyperactivity Disorder (ADHD): A Systematic Review. Child Psychiatry Hum Dev 47: 440–458, 2016.

17. Bozinovic K, McLamb F, O'Connell K, et al.: U.S. national, regional, and state-specific socioeconomic factors correlate with child and adolescent ADHD diagnoses pre-COVID-19 pandemic. Sci Rep 11: 22008, 2021.

18. Rattay K, Robinson LR: Identifying Risk Factors for Attention-Deficit/Hyperactivity Disorder (ADHD): a Public Health Concern and Opportunity. Prev Sci 25: 195–202, 2024.

19. Bozinovic K, McLamb F, O'Connell K, et al.: U.S. national, regional, and state-specific socioeconomic factors correlate with child and adolescent ADHD diagnoses pre-COVID-19 pandemic. Sci Rep 11: 22008, 2021.

20. Morgan PL, Staff J, Hillemeier MM, et al.: Racial and ethnic disparities in ADHD diagnosis from kindergarten to eighth grade. Pediatrics 132: 85–93, 2013.

21. Zhang N, Gao M, Yu J, et al.: Understanding the association between adverse childhood experiences and subsequent attention deficit hyperactivity disorder: A systematic review and meta-analysis of observational studies. Brain Behav 12: e32748, 2022.

22. Dimitrov LV, Kaminski JW, Holbrook JR, et al.: A Systematic Review and Meta-analysis of Chemical Exposures and Attention-Deficit/Hyperactivity Disorder in Children. Prev Sci Off J Soc Prev Res 25: 225–248, 2024.

23. DuPaul GJ, Gormley MJ, Laracy SD: School-Based Interventions for Elementary School Students with ADHD. Child Adolesc Psychiatr Clin N Am 23: 687–697, 2014.

24. Felt BT, Biermann B, Christner JG, et al.: Diagnosis and management of ADHD in children. Am Fam Physician 90: 456–464, 2014.

25. Zwiebel H, Thompson LA: What Are School-Based Health Clinics? JAMA Pediatr 176: 428, 2022.

26. Cullen KW, Chen T-A: The contribution of the USDA school breakfast and lunch program meals to student daily dietary intake. Prev Med Rep 5: 82–85, 2017.

27. Tiehen L: The Food Assistance Landscape: Fiscal Year 2019 Annual Report. U.S. Department of Agriculture, Economic Research Service, 2020 [cited 2022 Oct 10]Available from: https://www.ers.usda.gov/webdocs/publications/99026/eib-218.pdf?v=3168.2

28. Hubbard KL, Must A, Eliasziw M, et al.: What's in Children's Backpacks: Foods Brought from Home. J Acad Nutr Diet 114: 1424–1431, 2014.

29. Farris AR, Misyak S, Duffey KJ, et al.: Nutritional Comparison of Packed and School Lunches in Pre-Kindergarten and Kindergarten Children Following the Implementation of the 2012–2013 National School Lunch Program Standards. J Nutr Educ Behav 46: 621–626, 2014.

30. Caruso ML, Cullen KW: Quality and Cost of Student Lunches Brought From Home. JAMA Pediatr 169: 86, 2015.

31. Schneider KR, Oslund J, Liu T: Impact of the community eligibility provision program on school meal participation in Texas. Public Health Nutr 24: 6534–6542, 2021.

32. Joyce JM, Rosenkranz RR, Rosenkranz SK: Variation in Nutritional Quality of School Lunches With Implementation of National School Lunch Program Guidelines. J Sch Health 88: 636–643, 2018.

33. Joyce JM, Rosenkranz RR, Rosenkranz SK: Evaluation of Variability in Dietary Quality of School Lunches Meeting National School Lunch Program Guidelines by Socioeconomic Status and Rurality. Int J Environ Res Public Health 17: 8012, 2020.

34. Del-Ponte B, Quinte GC, Cruz S, et al.: Dietary patterns and attention deficit/hyperactivity disorder (ADHD): A systematic review and meta-analysis. J Affect Disord 252: 160–173, 2019.

35. Chaulagain A, Lyhmann I, Halmøy A, et al.: A systematic meta-review of systematic reviews on attention deficit hyperactivity disorder. Eur Psychiatry 66, 2023.Available from: https://www.cambridge.org/core/product/identifier/S0924933823024513/type/journal_article

36. Farsad-Naeimi A, Asjodi F, Omidian M, et al.: Sugar consumption, sugar sweetened beverages and Attention Deficit Hyperactivity Disorder: A systematic review and meta-analysis. Complement Ther Med 53: 102512, 2020.

37. Gordon N, Ruffini K: Schoolwide Free Meals and Student Discipline: Effects of the Community Eligibility Provision. Educ Finance Policy 16: 418–442, 2021.

38. Cuadros-Meñaca A, Thomsen MR, Nayga RM: School breakfast and student behavior. Am J Agric Econ 105: 99–121, 2023.

39. Evans WN, Morrill MS, Parente ST: Measuring inappropriate medical diagnosis and treatment in survey data: The case of ADHD among school-age children. J Health Econ 29: 657–673, 2010.

40. Elder TE: The importance of relative standards in ADHD diagnoses: Evidence based on exact birth dates. J Health Econ 29: 641–656, 2010.

41. Layton TJ, Barnett ML, Hicks TR, et al.: Attention Deficit-Hyperactivity Disorder and Month of School Enrollment. N Engl J Med 379: 2122–2130, 2018.

42. Frisira E, Holland J, Sayal K: Systematic review and meta-analysis: relative age in attention-deficit/ hyperactivity disorder and autism spectrum disorder. Eur Child Adolesc Psychiatry , 2024.

43. Martin AJ: The role of ADHD in academic adversity: disentangling ADHD effects from other personal and contextual factors. Sch Psychol Q Off J Div Sch Psychol Am Psychol Assoc 29: 395–408, 2014.

44. Gerlinger J, Viano S, Gardella JH, et al.: Exclusionary School Discipline and Delinquent Outcomes: A Meta-Analysis. J Youth Adolesc 50: 1493–1509, 2021.

45. Borgen NT, Frønes I, Raaum O: Impact of the School Environment on Medical Treatment of Attention Deficit Hyperactivity Disorder: A Population-Wide Register Data Study of School-Wide Positive Behavioral Interventions and Supports. Child Dev 92: 2089–2105, 2021.

46. Zhao X, Hayes T, Timmons AC, et al.: Unpacking Inequities in ADHD Diagnosis: Examining Individual-Level Race/Ethnicity and State-Level Online Information-Seeking Patterns. Adm Policy Ment Health Ment Health Serv Res 50: 576–590, 2023.

47. Winders Davis D, Jawad K, Feygin Y, et al.: Disparities in ADHD Diagnosis and Treatment by Race/Ethnicity in Youth Receiving Kentucky Medicaid in 2017. Ethn Dis 31: 67–76, 2021.

48. Bozinovic K, McLamb F, O'Connell K, et al.: U.S. national, regional, and state-specific socioeconomic factors correlate with child and adolescent ADHD diagnoses pre-COVID-19 pandemic. Sci Rep 11: 22008, 2021.

49. Fabina J, Hernandez E, McElrath K: School Enrollment in the United States: 2021. 2023Available from: https://www.census.gov/content/dam/Census/library/publications/2023/acs/acs-55.pdf

50. Straub L, Bateman BT, Hernandez-Diaz S, et al.: Validity of claims-based algorithms to identify neurodevelopmental disorders in children. Pharmacoepidemiol Drug Saf 30: 1635–1642, 2021.

51. Morkem R, Handelman K, Queenan JA, et al.: Validation of an EMR algorithm to measure the prevalence of ADHD in the Canadian Primary Care Sentinel Surveillance Network (CPCSSN). BMC Med Inform Decis Mak 20: 166, 2020.

52. Arkansas Center for Health Improvement: Arkansas All-Payer Claims DatabaseAvailable from: https://www.arkansasapcd.net/Home/

53. Semega J, Kollar M, Creamer J, et al.: Income and Poverty in the United States: 2018. Washington, DC, U.S. Census Bureau, 2019Available from: https://www.census.gov/library/publications/2019/demo/p60-266.html

54. Acevedo-Garcia D, Noelke C, McArdle N, et al.: Racial And Ethnic Inequities In Children's Neighborhoods: Evidence From The New Child Opportunity Index 2.0: Study uses the Child Opportunity Index 2.0 to examine geographic and racial/ethnic inequities children are exposed to in the one hundred largest metropolitan areas of the United States. Health Aff (Millwood) 39: 1693–1701, 2020.

55. Widding-Havneraas T, Markussen S, Elwert F, et al.: Geographical variation in ADHD: do diagnoses reflect symptom levels? Eur Child Adolesc Psychiatry 32: 1795–1803, 2023.

56. Lyhmann I, Widding-Havneraas T, Zachrisson HD, et al.: Variation in attitudes toward diagnosis and medication of ADHD: a survey among clinicians in the Norwegian child and adolescent mental health services. Eur Child Adolesc Psychiatry 32: 2557–2567, 2023.

57. Arruda MA, Arruda R, Guidetti V, et al.: Associated Factors of Attention-Deficit/Hyperactivity Disorder Diagnosis and Psychostimulant Use: A Nationwide Representative Study. Pediatr Neurol 128: 45–51, 2022.

58. Skiba RJ, Chung C-G, Trachok M, et al.: Parsing Disciplinary Disproportionality: Contributions of Infraction, Student, and School Characteristics to Out-of-School Suspension and Expulsion. Am Educ Res J 51: 640–670, 2014.

59. Welsh RO, Little S: The School Discipline Dilemma: A Comprehensive Review of Disparities and Alternative Approaches. Rev Educ Res 88: 752–794, 2018.

60. Jain S, Cohen AK, Huang K, et al.: Inequalities in school climate in California. J Educ Adm 53: 237–261, 2015.

61. Owens J: Parental intervention in school, academic pressure, and childhood diagnoses of ADHD. Soc Sci Med 1982 272: 113746, 2021.

62. Jacobsen WC, Pace GT, Ramirez NG: Punishment and Inequality at an Early Age: Exclusionary Discipline in Elementary School. Soc Forces 97: 973–998, 2019.

63. Schnorrbusch C, Fabiano GA, Aloe AM, et al.: Attention Deficit Hyperactivity Disorder and Relative Age: A Meta-Analysis. Sch Psychol Rev 49: 2–19, 2020.

Figure 1. Subject Attrition diagram

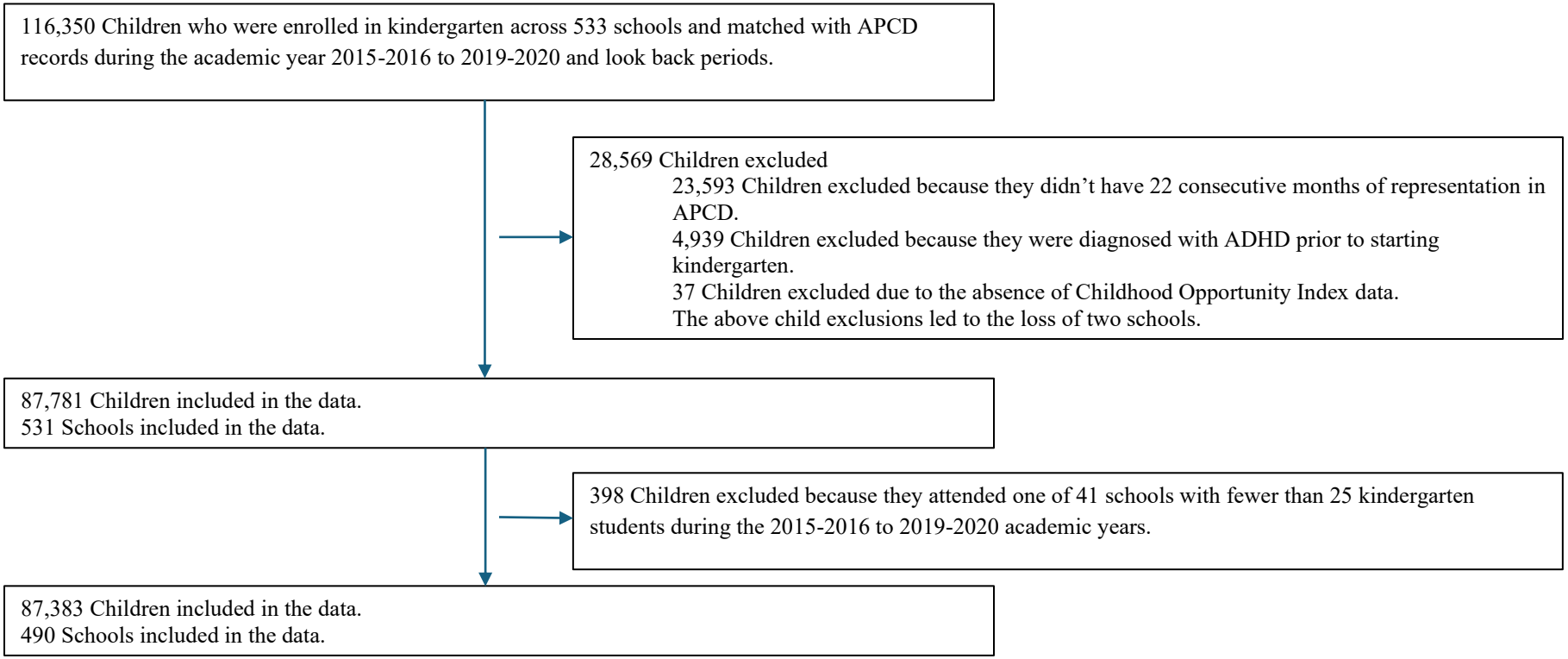
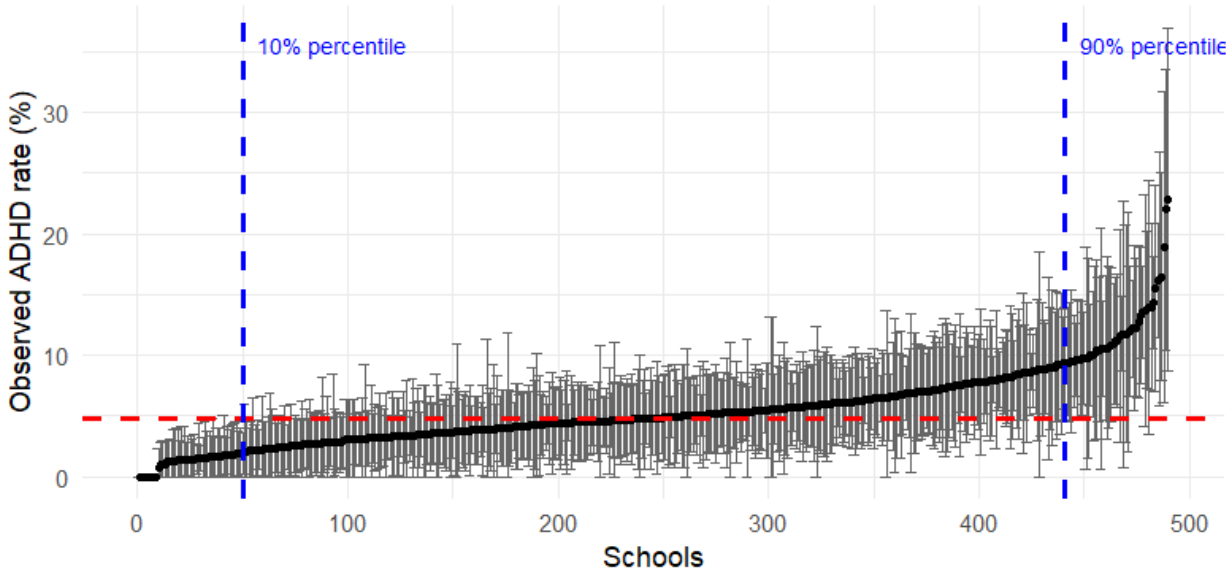
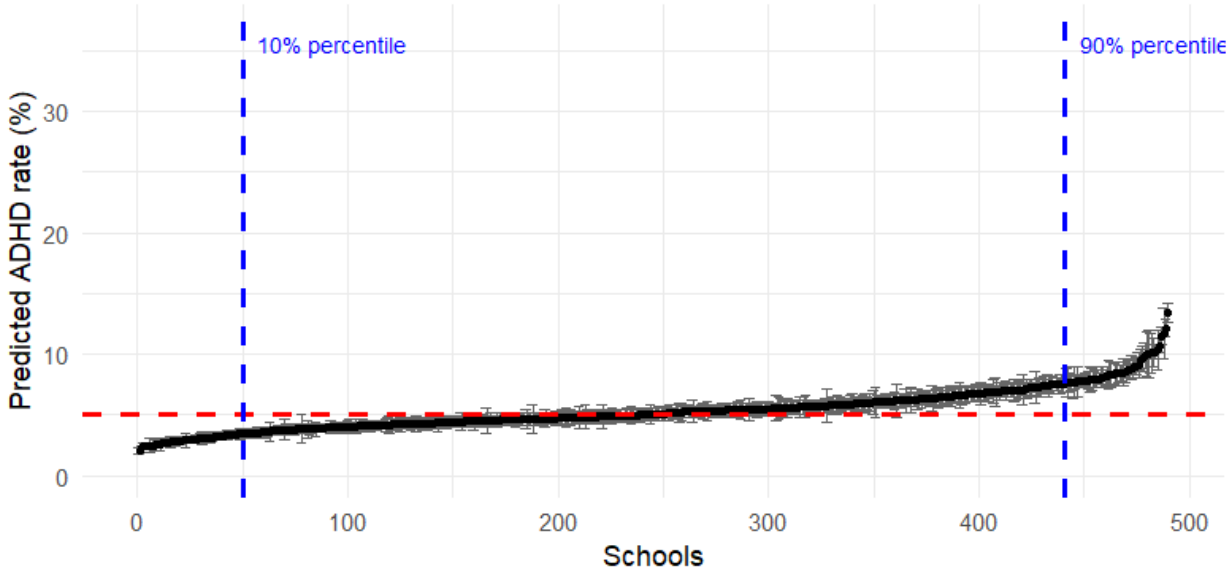


Figure 2. Unadjusted and model-adjusted rates of ADHD diagnosis.

Panel A.



Panel B.



Notes: Unadjusted and model-adjusted rates of ADHD diagnosis for 490 schools during study period with associated 95% confidence intervals, ordered from lowest to highest rate of ADHD diagnosis. (A) Unadjusted rates and (B) Model-adjusted rates. The median rate of ADHD is denoted in red. The median observed ADHD diagnosis rate shows a 4.9 times difference between the 10th and 90th percentiles. The median model-adjusted ADHD diagnosis rate shows a 2.2 times difference between the 10th and 90th percentiles.

Table 1. Sociodemographic of study population.

Characteristic	N / Mean N = 87,383	% / SD
ADHD diagnoses during kindergarten	4,520	5.2
Sex, n (%)		
Female	42,773	49.0
Male	44,610	51.0
Race/ethnicity, n (%).		
Hispanic	9,779	11.2
Non-Hispanic African American	20,021	22.9
Non-Hispanic White	52,240	59.8
Non-Hispanic other race	5,343	6.1
Other individual characteristics, n (%).		
Went to a school-based health center	2,130	2.4
Active in special education program	14,794	16.9
Changed schools during kindergarten	10,051	11.5
Young for grade	18,060	20.7
Individual level meal status, n (%).		
Meal status – free meal	59,699	68.3
Meal status – reduced price	6,707	7.7
Meal status - full-price paid	20,977	24.0
Co-occurring conditions of interest, n (%)		
Oppositional defiant disorder (ODD)	1,713	2.0
Other disruptive behavioral disorders	3,855	4.4
Autism (AUT)	1,635	1.9
Depression (DEP)	297	0.3
Anxiety (ANX)	3,229	3.7
Stress disorders	782	0.9
Specific learning disorder (SLD)	193	0.2
Tic disorder (TIC)	223	0.3
Used prescription stimulants during kindergarten	3,684	4.2
Received at least 1 disciplinary referral during kindergarten, n (%)	6,793	7.8
Region, n (%)		
Country	36,256	41.5
Delta	6,529	7.5
Mountain	4,743	5.4
Northwest	18,373	21.0
Suburban	10,521	12.0
Urban	10,961	12.5
Child opportunity scores, mean (sd)		
Overall	47.14	27.87
Education	47.98	27.85
Health and environment	47.81	28.02
Social and economic	47.14	27.97
School level meal delivery policies, n (%)		
Universal free meal	19,431	22.2
Breakfast after bell	29,851	34.2

Table 2. School characteristics by quintile of schools based on rates of children within the school newly diagnosed with ADHD during kindergarten

	Quintile of ADHD diagnoses rate during kindergarten						
	Q1	Q2	Q3	Q4	Q5	Q5/Q1	
Proportion of children newly diagnosed with ADHD (%)	1.7	3.4	4.6	6.1	10.0	5.71	+
Number of schools	98	98	98	98	98	NA	
Number of students	14171	16526	19399	20163	17124	NA	
Child characteristics aggregated to the school level (%)							
Female	49.2	49.3	48.6	49.0	48.3	0.98	
Male	50.9	50.7	51.4	51.0	51.7	1.02	
Hispanic	15.3	9.8	9.9	10.1	7.9	0.51	-
Non-Hispanic African American	12.5	19.6	22.4	28.4	35.5	2.83	+
Non-Hispanic White	64.5	64.7	62.2	56.3	52.0	0.81	-
Non-Hispanic other race	7.6	6.0	5.5	5.2	4.6	0.60	-
Went to a school-based health center	2.3	4.4	2.8	2.2	1.6	0.69	-
Active in special education program	14.9	17.4	17.7	17.1	17.9	1.20	+
Mobile	10.7	11.7	10.7	12.1	13.9	1.31	+
Young for grade	20.6	19.9	20.5	21.5	21.2	1.03	+
Meal status – free meal	65.6	65.5	65.7	73.0	77.0	1.17	+
Meal status – reduced price	8.3	8.2	8.1	7.0	6.5	0.79	-
Co-occurring conditions of interest (%)							
Oppositional defiant disorder (ODD)	1.2	1.3	1.7	2.1	3.2	2.76	+
Other disruptive behavioral disorders	2.4	3.4	4.1	5.2	6.7	2.73	+
Autism (AUT)	1.7	1.9	2.1	1.9	1.6	0.91	
Depression (DEP)	0.3	0.4	0.3	0.3	0.5	1.83	
Anxiety (ANX)	3.5	3.3	3.4	3.8	4.2	1.20	+
Post-traumatic stress disorder (PTSD)	0.8	0.9	0.9	0.9	1.1	1.34	+
Specific learning disorder (SLD)	0.3	0.2	0.2	0.2	0.2	0.73	
Tic disorder (TIC)	0.2	0.2	0.2	0.3	0.2	0.74	
Ever use of stimulants	1.8	3.0	3.8	4.9	7.9	4.52	+
Any disciplinary infraction (%)	5.6	6.5	7.0	7.9	11.0	1.94	+
Student Region (%)							
Country	29.9	35.8	33.4	34.3	48.4	1.62	+
Delta	2.0	5.9	6.1	11.9	13.2	6.47	+
Mountain	14.0	6.1	6.3	6.2	0.1	0.01	-
Northwest	38.7	24.5	20.5	16.9	5.2	0.13	-
Suburban	7.0	16.7	12.5	14.2	10.3	1.47	+
Urban	8.3	11.0	21.3	16.4	22.8	2.74	+
Child opportunity index (1-100)							
Overall COI	50.61	48.70	48.98	43.20	38.67	0.76	-
Education (ED)	49.27	46.25	48.06	46.03	39.76	0.81	-
Health and environment (HE)	52.80	47.66	49.35	43.86	38.42	0.73	-
Social and economic (SE)	50.97	49.78	49.06	42.94	39.34	0.77	-
School characteristics							
Total number of enrolled students	144.60	168.63	197.95	205.74	174.73	1.21	
Universal free meal (%)	16.9	19.2	22.0	30.0	31.5	1.86	+
Breakfast after bell (%)	31.8	31.3	37.9	38.0	30.8	0.97	

+/-: significant at 0.05 level based on the Cochran-Armitage test for trend (or the Jonckheere–Terpstra test for continuous variables).

Table 3. Adjusted odds ratios from mixed-effects logistic regression model for the outcome of ADHD diagnoses during kindergarten.

Factor	Odds ratio (95% CI)	P value
Sex (ref: Male)		
Female	0.39 (0.36 - 0.41)	<0.001
Race/ethnicity (ref: Non-Hispanic White)		
Hispanic	0.41 (0.36 - 0.47)	<0.001
Non-Hispanic African American	0.94 (0.86 - 1.03)	0.20
Non-Hispanic other race	0.67 (0.58 - 0.77)	<0.001
Other individual-level characteristics		
Went to a school-based health center	1.10 (0.89 - 1.35)	0.37
Mobile	1.50 (1.38 - 1.62)	<0.001
Young for grade	1.25 (1.16 - 1.34)	<0.001
Individual level meal status (ref: Full-price paid)		
Meal status – free meal	2.13 (1.94 - 2.34)	<0.001
Meal status – reduced price	1.67 (1.46 - 1.92)	<0.001
Child opportunity levels (ref: Very low)		
Education – low	1.02 (0.91 - 1.15)	0.68
Education – moderate	1.14 (1.00 - 1.29)	0.04
Education – high	1.14 (0.99 - 1.30)	0.07
Education – very high	1.15 (0.98 - 1.36)	0.10
Health and environment – low	0.94 (0.84 - 1.05)	0.26
Health and environment – moderate	0.90 (0.79 - 1.02)	0.11
Health and environment – high	0.90 (0.78 - 1.03)	0.13
Health and environment – very high	0.91 (0.78 - 1.06)	0.22
Social and economic – low	0.87 (0.78 - 0.97)	0.01
Social and economic – moderate	0.86 (0.76 - 0.97)	0.01
Social and economic – high	0.84 (0.74 - 0.96)	0.01
Social and economic – very high	0.78 (0.66 - 0.92)	0.003
School-level meal program		
Universal free meal	0.79 (0.71 - 0.88)	<0.001
Breakfast after bell	0.98 (0.91 - 1.07)	0.70
	Random effect (variance)	
School (Intercept)	0.11	
Student region (Intercept)	0.03	
Provider (Intercept)	0.05	
N	87,383	
N of schools	490	
N of providers	3,579	
N of regions	6	

Note: To facilitate model convergence, continuous COI levels were categorized as “very low”, “low”, “moderate”, “high”, and “very high”. Discrimination performance of this model as measured by area under the receiver operating characteristics curve was 0.722. Intraclass correlation coefficients (ICC) for the random effects terms were: school (ICC=0.032), medical provider (ICC = 0.015), and region (ICC=0.008).