

Leveraging a Novel Combination of Spatial and School Data to Explore Associations between Neighborhood Trauma and Social Determinants of Health in Philadelphia Schools

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Abstract

Trauma is a pervasive public health issue that disproportionately affects youth in disadvantaged communities. Schools are increasingly recognized as key settings for addressing trauma and social determinants of health (SDOH), yet tools to identify and prioritize school environments for trauma-informed efforts are limited. This study aimed to (1) develop a Neighborhood Adversity Index (NAI) to operationalize neighborhood trauma for school neighborhoods in Philadelphia and (2) examine associations between neighborhood trauma and school-level SDOH indicators, including health behaviors, school climate, and school meal participation. This study combined geospatial and administrative data from all public schools in Philadelphia (N = 218) from 2023–2025. School neighborhoods were defined using catchment areas; NAI scores were generated through area-weighted aggregation of census tract–level indicators. School-level SDOH outcomes were derived from administrative and survey data and analyzed using linear regression models, with NAI categorized into tertiles (low, medium, high). Neighborhood trauma displayed clear spatial patterning; of 14 SDOH outcomes examined, 7 were significantly associated with trauma levels. Compared to low-trauma areas, schools in high-trauma neighborhoods had lower attendance ($\beta = -11.69$, $p < 0.001$), reduced physical activity ($\beta = -0.048$, $p = 0.006$), less healthy beverage consumption ($\beta = -0.053$, $p = 0.021$), lower perceived safety (β range: -5.36 to -5.72 , $p < 0.05$), and greater economic disadvantage ($\beta = 9.92$, $p < 0.001$). High-trauma neighborhoods were associated with higher school lunch participation ($\beta = 0.062$, $p = 0.034$). These findings highlight NAI as a novel, actionable tool for targeting trauma-informed school interventions.

Introduction

Trauma and School Health

Trauma is a widespread public health issue, with nearly 2/3 of Americans experiencing a traumatic event before age 18.¹ While healing and resilience after trauma are possible, trauma exposure is associated with harmful outcomes related to development, behavior, and long-term health.^{2–12, 13} Trauma is the response to an event that overwhelms one's coping skills and threatens physical or psychological safety. It includes individual (e.g., witnessing violence), interpersonal (e.g., experiencing abuse by a trusted adult), or collective exposures (e.g., experiencing racism), including many of which can both occur and manifest in school settings.^{14–19}

Trauma-informed approaches are individual and systems-level interventions that are designed to realize the impact of trauma, recognize signs of trauma, respond with appropriate care, and resist re-traumatization.^{14,20,21} In school settings, enthusiasm for trauma-informed approaches has grown rapidly (Fig. 1).²² Yet, recent syntheses highlight that empirical evidence for whole school implementations remains limited, fragmentary, and often focused on educational climate and disciplinary practices rather than health programming.^{22,23} Reviews also highlight persistent implementation barriers such as

insufficient leadership support, limited professional development, and challenges sustaining organizational change underscoring the need for rigorous, context attentive implementation science.^{23,24}

Food Insecurity and School Health

Children who are members of health disparity populations, such as children living in low-income households and who identify as Black or Latino/a/x (henceforth Latinx for gender expansiveness²⁵), are more than twice as likely to experience food insecurity than white, middle class counterparts.²⁶ Risk for food insecurity is heavily linked to risk for obesity;²⁷ this relationship is heightened in socially and economically marginalized populations.²⁸ Schools have been relied upon to provide mental²⁹ and physical health services, especially as a result of the COVID-19 pandemic.³⁰ Therefore, the school setting represents a key environment to prioritize given the wealth of resources available for families within marginalized communities, with USM being a particularly salient intervention to improve student health within the school environment.

School meal programs are among the most scalable, place-based health interventions in the United States. Universal free school meals (USM), including adoption of the Community Eligibility Provision (CEP), have been associated with increased participation, reduced stigma and paperwork barriers, improvements in diet quality, and potential reductions in food insecurity.^{31,32} Emerging evidence suggests USM may help lower obesity risk in some populations, though estimates vary by setting and time since adoption.³² School meals are also among the healthiest foods children consume on a typical day, reflecting nutrition standards established by the Healthy, Hunger-Free Kids Act and ongoing USDA updates aligning meal patterns with the Dietary Guidelines for Americans which represents an important context for equity-oriented public health.

Unfortunately, despite evidence showing the impact of USM on improved food insecurity, decreased risk for obesity, and increases to attendance and academic achievement,^{31,32} implementation of USM has been limited because prior USM work has not focused on equity nor sustainability.³³ School-level rates of student uptake remain low, and there is a need for novel efforts to improve USM reach and effectiveness.³⁴ This is especially true in districts that experience high rates of food insecurity, poor nutrition-related outcomes, and obesity.³⁵ This is the case in Philadelphia, Pennsylvania (the setting of the study reporting in this manuscript), where 75% of the student population identifies as Black or Latinx,³⁶ 87% are low income,³⁷ inequities in obesity persist,³⁵ and district-wide uptake of breakfast (~ 40% participation) and lunch (~ 70%) are lower than anticipated given that over 25% of families report facing food insecurity.³⁸ Innovative projects that examine understudied influences on USM uptake - especially in populations that experience nutrition and obesity inequities - are urgently needed.

The Intersection of Trauma and Nutrition Equity in School Health

This nexus of trauma and nutrition equity is especially salient for Black and Latino/a/x students, who disproportionately experience adverse and community-level childhood adversities, due to socially-driven structural inequities ground in racism, classism, and power imbalances.³⁹ For example, exposures such as including exposure to neighborhood violence, experiencing identity-based discrimination, family disruption due to harmful immigration policies and incarceration inequities, and household poverty are traumatic stressors that are often high in Black and Latinx and low income communities and are consistently linked to poor health and educational outcomes.³⁹ Youth-engaged trauma research in Philadelphia has highlighted that neighborhood stressors (e.g., witnessing violence, feeling unsafe, experiencing racism) in a socioeconomically and racially diverse city population are perceived by youth as traumatic.¹⁵ Additionally, recent spatial analyses further demonstrate that higher ACE burden co-occurs with other markers of neighborhood disadvantage and environmental risk factors, supporting the relevance of place when designing trauma-informed interventions.⁴⁰

To inform such strategies, practitioners need tools to prioritize schools where neighborhood trauma is highest, and meal uptake is lowest. Prior Philadelphia work developed and tested a composite Neighborhood ACE index; NAI herein) that can be operationalized as a measure of neighborhood trauma at local geographies, such as school catchments, A NAI can be leveraged identify schools in highest trauma neighborhoods, which would serve as priority settings for trauma-informed school meal and nutrition programming, and assess how school neighborhood trauma relates to school-level factors important to trauma, health, and learning.⁴¹ Accordingly, the purpose of the present study was to elucidate associations between neighborhood trauma (as operationalized via the NAI) and social determinants of health (SDOH) at the school level, Using spatial and school-level data from Philadelphia schools (school years 2023–2025) and publicly available geospatial data, the study aims were: 1) To develop an NAI for Philadelphia that reflects current neighborhood context around each school in Philadelphia and explore spatial patterning across the city and 2) To evaluate relationships between NAI and school-level SDOH variables potentially relevant to trauma, health, and learning. We hypothesized that there would be observable spatial patterning in schools' neighborhood trauma across the city, and that high neighborhood trauma would be associated with less favorable school-level SDOH.

Methods

Manuscript reporting is per Strengthening Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies. This study was a secondary analysis of existing spatial and school administrative data. The setting was Philadelphia PA USA during school years 2023–2025. All schools in the school district with complete data were included in the study sample. Variables, including data source and operationalization, are detailed below first for the neighborhood trauma measure, and then for the school-level SDOH measures.

NAI Creation for School Neighborhoods

NAI creation for school neighborhoods included three steps: (1) preparing spatial data and computing a Neighborhood Adversity Index (NAI) for every census tract in Philadelphia; (2) geographically operationalizing each school's neighborhood via spatial data capturing school catchment; and (3) generating an NAI score for each school's neighborhood. Because this study focused on school context and the environment surrounding a school in which a child is exposed to during the school day (not home neighborhood), neighborhood was operationalized as school catchment.

We prepared a spatial dataset containing all variables used in the NAI. Variable inclusion and operationalization followed previously developed and tested methods for NAI construction. We created variables for every Philadelphia census tract using 2024 spatial data when available; if 2024 data were not available for a given source, we used the closest available year consistent with established practice and our prior NAI development. We combined and processed all data in ArcGIS Pro and R. Using this dataset, we computed the NAI for each census tract according to the previously described and validated procedures.⁴² Following, we obtained the school catchment using publicly available school district data. Lastly, we assigned an NAI to each school's neighborhood using ArcGIS's *Tabulate Intersection* tool to compute the area weighted contribution of every tract intersecting the school's catchment. For example, a school catchment comprising 25% of tract A (NAI = 100), 25% of tract B (NAI = 75), and 50% of tract C (NAI = 200) received a school neighborhood NAI of $0.25 \times 100 + 0.25 \times 75 + 0.50 \times 200 = 143.75$. After calculating an NAI for all schools, we categorized school neighborhood NAI into low, medium, and high using data driven tertiles (no a priori thresholds exist for "low/medium/high" trauma exposure; hence, categories were relative to the observed distribution).

Preparing School-level Social Determinants of Health Data

We merged several large student level administrative datasets provided by the School District of Philadelphia (SDP) and aggregated them to the school level (codebook in Appendix A). Assessed outcomes included attendance (percent of students per school with > 90% attendance), healthy fruit intake (percent of students per school self-reporting at least 4 servings of fruit per day), healthy vegetable intake (percent of students per school self-reporting at least 4 servings of vegetables per day), low sugar-sweetened beverage (SSB) intake (percent of students per school self-reporting 1 or fewer servings of SSB per day), healthy physical activity (PA) (percent of students per school self-reporting one hour or more of PA at least 5 days per week), Federal support (percent of students per school receiving any federal support program), moderate student hunger (percent of students per school who went hungry due to not enough food in the home sometimes, most of the time, or always during the last 30 days), high student hunger (percent of students per school who went hungry due not enough food in the home most of the time or always during the last 30 days), violent incident prevalence (number of violent incidents reported per 100 students), non-violent incident prevalence (number of non-violent incidents reported per 100 students), perceived safety in cafeteria, hallway, stairwell, and classrooms (percent of students per school who self-reported feeling safe always or almost always in each of those locales,

respectively), and school lunch uptake (% of students per school participating in school lunches). Variable selection was guided by data availability, content expertise, and prior work, with the aim of capturing school level SDOH plausibly related to trauma exposure. The district provided formal support for data sharing based on prior collaborations with the research team.

Analyses of relationships between NAI and school-level SDOH

We first examined descriptive statistics for the school neighborhood NAI and all school-level SDOH measures. We then estimated separate regression models for each SDOH outcome with NAI as the primary predictor. Our primary specification treated NAI as a categorical variable (high neighborhood trauma, medium neighborhood trauma, and low neighborhood trauma [reference group] per data-driven tertiles), and sensitivity analyses treated NAI as continuous. For continuous outcomes, we assessed normality; when necessary, we address departures via robust standard errors in modelling. For categorical SDOH outcomes, we defined categories based on empirical distributions and domain knowledge. We used linear regression and evaluated model adequacy using standard fit indices and diagnostic checks. Schools' missing data for an outcome were excluded from that analysis. We report model estimates, standard errors, and 95% confidence intervals. Because our objective was to explore whether and how each SDOH was independently associated with neighborhood trauma, rather than to compare effect sizes across SDOH domains, we modeled each SDOH separately without controlling for other covariates and did not adjust *p*-values for multiple comparisons. All analyses were done using R Studio 4.5.0.

In addition to regression analyses, we explored associations between neighborhood trauma and school-level SDOH via mapping with ArcGIS Pro. The maps complement the quantitative analyses by visually displaying areas that have both high neighborhood trauma and school-level SDOH needs. These visualizations are intended to support local hypothesis generation and to demonstrate a spatially grounded approach for sharing findings with community partners, helping to identify sites that may benefit most from trauma-informed school interventions.

Results

The final analytic sample included all *N* = 218 school district schools, attended by *N* = 112,421 total students. Table 1 provides an overview of the sample demographics including race and ethnicity, English language learners, economic disadvantage, and biological sex of students expressed as a mean percentage (SD). Most students in the sample identified as Black (50.06%), were male (51.96%), and were families that were eligible for Federal economic assistance (76.44%). These data largely reflect city demographics as a whole. ⁴³

Table 1
Sample Demographics for Total Sample and by High/Medium/Low Neighborhood Trauma

Total Sample				
Mean SD Mean SD				
Sex				
Female	48.02	2.95	40.71	56.28
Male	51.96	2.94	43.72	59.29
Race				
American Indian or Alaska Native	0.22	0.33	0.00	2.10
Asian	6.74	9.80	0.00	42.83
Black	50.06	31.84	2.44	96.10
More Than One Race	0.11	0.22	0.00	1.36
Native Hawaiian or Pacific Islander	3.38	2.55	0.00	12.66
White	13.42	17.48	0.00	75.24
Ethnicity				
Hispanic	26.05	23.90	2.60	91.06
Other Characteristics				
English Language Learner	17.51	16.49	0.00	70.89
Individual Education Program	20.00	7.88	5.04	48.29
Eligible for Community Eligibility Provision	96.46	12.17	22.21	100.00
Receiving Federal Assistance Program	76.44	14.42	16.74	95.11
Low Neighborhood Trauma				
Sex				
Female	47.43	3.21	40.71	54.01
Male	52.54	3.21	45.99	59.29
Race				
American Indian or Alaska Native	0.19	0.24	0.00	0.74
Asian	7.00	10.52	0.00	42.83
SD=Standard Deviation				

Total Sample				
Mean SD Mean SD				
Sex				
Black	46.70	29.62	2.44	94.44
More Than One Race	3.82	2.84	0.00	11.19
Native Hawaiian or Pacific Islander	0.07	0.16	0.00	0.78
White	16.72	18.66	0.33	74.22
Ethnicity				
Hispanic	25.45	23.54	3.33	83.80
Other Characteristics				
English Language Learner	16.94	15.79	0.00	70.89
Individual Education Program	20.77	8.83	9.63	45.16
Eligible for Community Eligibility Provision	93.86	14.72	22.21	100.00
Receiving Federal Assistance Program	73.13	16.38	16.74	90.87
Medium Neighborhood Trauma				
Sex				
Female	48.30	2.74	41.07	55.79
Male	51.66	2.73	44.21	58.93
Race				
American Indian or Alaska Native	0.31	0.45	0.00	2.10
Asian	9.33	10.90	0.00	37.41
Black	54.59	33.62	2.86	96.10
More Than One Race	3.59	2.70	0.67	12.66
Native Hawaiian or Pacific Islander	0.15	0.29	0.00	1.36
White	14.97	18.81	0.00	61.69
Ethnicity				
Hispanic	17.05	16.56	2.60	57.99
Other Characteristics				
SD=Standard Deviation				

Total Sample				
Mean SD Mean SD				
Sex				
English Language Learner	18.03	18.63	0.43	65.46
Individual Education Program	18.65	6.49	5.04	33.33
Eligible for Community Eligibility Provision	95.52	14.60	22.73	100.00
Receiving Federal Assistance Program	73.11	15.14	17.34	91.86
High Neighborhood Trauma				
Sex				
Female	48.32	2.84	41.72	56.28
Male	51.66	2.83	43.72	58.28
Race				
American Indian or Alaska Native	0.16	0.26	0.00	1.36
Asian	3.89	6.90	0.00	29.02
Black	48.87	32.26	3.05	94.99
More Than One Race	2.72	1.91	0.00	9.09
Native Hawaiian or Pacific Islander	0.12	0.17	0.00	0.66
White	8.56	13.75	0.00	75.24
Ethnicity				
Hispanic	35.65	27.03	2.86	91.06
Other Characteristics				
English Language Learner	17.56	15.14	0.50	62.46
Individual Education Program	20.58	8.12	8.79	48.29
Eligible for Community Eligibility Provision	100.00	0.00	100.00	100.00
Receiving Federal Assistance Program	82.68	8.90	60.84	95.11
SD=Standard Deviation				

A summary of descriptive statistics of school-level SDOH is presented in Table 2. Over half of the sample reported drinking 1 or less sugar-sweetened beverage per day (53.1%), had over 90% attendance (59.9%), and reported feeling safe in the school cafeteria, stairs, classrooms, and hallways (61.6–71.2%). Almost

30% of students reported feeling hunger due to not having enough food in the home sometimes, most of the time, or always, with 17% reporting most of the time or always. Health-promoting fruit and vegetable intake was low with 20.8% reporting consuming more than 4 fruits per day and 18% consuming more than 4 vegetables per day.

Table 2
Descriptive Statistics of School-level Social Determinants of Health

Variable	Mean (SD)
Moderate Student Hunger: % of students who went hungry due to not enough food in the home sometimes, most of the time, or always during the last 30 days (N = 159 schools)	29.5% (9.2)
High Student Hunger: % of students who went hungry due to not enough food in the home most of the time or always during the last 30 days (N = 159 schools)	17.2% (5.5)
Health-Promoting Fruit Intake: % of students per school who eat 4 + fruits per day (N = 159 schools)	20.8% (4.8)
Health-Promoting Vegetable Intake: % of students per school who ate 4 + vegetables per day (N = 159 schools)	18.0% (4.3)
Low Sugar Sweetened Beverage Intake: % of students per school who drink SSBs 0 or 1 times per day (N = 159 schools)	53.1% (10.4)
Health-Promoting Physical Activity: % of students per school who were active for 60 minutes at least 5 of the last 7 days (N = 159 schools)	43.2% (7.5)
Violent Incident Prevalence: Number of violent incidents per 100 students (2023/2024) (N = 203 schools)	1.3 (1.5)
Non-Violent Incident Prevalence: Number of violent incidents per 100 students (2023/2024) (N = 203 schools)	2.4 (2.3)
Good Attendance: % of students with > 90% attendance (N = 214 schools)	59.9% (16.4)
Perceived Safety in Cafeteria: % of students per school who often or almost always feel safe in the cafeteria (N = 202 schools)	62.3% (10.8)
Perceived Safety in Stairwells: % of students per school who often or almost always feel safe in stairwells (N = 202 schools)	61.6% (11.2)
Perceived Safety in Classroom: % of students per school who often or almost always feel safe in the classroom (N = 202 schools)	71.2% (9.9)
Perceived Safety in Hallways: % of students per school who often or almost always feel safe in hallways (N = 202 schools)	66.4% (11.23)
School Lunch Uptake: % of students per school who are participating in school meals (N = 162 schools)	56.7% (15.32)
<p>SD = Standard Deviation</p> <p>Results documented in Table 3 demonstrate that N = 7 of N = 14 assessed outcomes were significantly associated with NAI. More specifically, a school being in a neighborhood with high neighborhood trauma (as compared to low neighborhood trauma) was associated with worse attendance, less healthy levels of SSB consumption, less healthy levels of PA, greater economic disadvantage, lower levels of perceived safety in school stairwells, school hallways, and school classrooms, and higher school meal uptake. See Table 3 for detailed results. Sensitivity analyses treating NAI as a continuous variable showed similar patterns of association (data not shown).</p>	

Table 3
Regression Analyses between Neighborhood Trauma Levels and Social
Determinants of Health

Variable	β (Standard Error)	P-value
Moderate Student Hunger	0.009 (0.021)	0.689
Low NAI School (ref)	0.029 (0.021)	0.179
Medium NAI School		
High NAI School		
High Student Hunger	0.007 (0.013)	0.571
Low NAI School (ref)	0.019 (0.013)	0.132
Medium NAI School		
High NAI School		
Healthy Fruit Intake	-0.003 (0.010)	0.777
Low NAI School (ref)	-0.001 (0.010)	0.953
Medium NAI School		
High NAI School		
Healthy Vegetable Intake	0.003 (0.010)	0.763
Low NAI School (ref)	0.020 (0.010)	0.062*
Medium NAI School		
High NAI School		
Low Sugar-Sweetened Beverage Intake	0.019 (0.027)	0.477
Low NAI School (ref)	-0.053 (0.023)	0.021*
Medium NAI School		
High NAI School		
Healthy Physical Activity	-0.006 (0.017)	0.710
Low NAI School (ref)	-0.048 (0.017)	0.006*
Medium NAI School		
High NAI School		
Violent Incident Prevalence	-0.134 (0.309)	0.664
Low NAI School (ref)	-0.247 (0.275)	0.370
* = statistically significant at p < 0.05 threshold		

Variable	β (Standard Error)	P-value
Medium NAI School		
High NAI School		
Non-violent Incident Prevalence	-0.285 (0.463)	0.539
Low NAI School (ref)	-0.485 (0.420)	0.250
Medium NAI School		
High NAI School		
Good Attendance	3.273 (2.718)	0.230
Low NAI School (ref)	-11.686 (2.705)	< 0.001
Medium NAI School		
High NAI School		
Federal Support	0.030 (3.321)	0.993
Low NAI School (ref)	9.920 (2.737)	< 0.001
Medium NAI School		
High NAI School		
Perceived Safety in Cafeteria	0.134 (2.189)	0.951
Low NAI School (ref)	-3.274 (2.189)	0.137
Medium NAI School		
High NAI School		
Perceived Safety in Stairwells	-0.412 (2.383)	0.863
Low NAI School (ref)	-5.356 (2.136)	0.013
Medium NAI School		
High NAI School		
Perceived Safety in Classroom	-0.694 (2.013)	0.731
Low NAI School (ref)	-5.724 (2.013)	0.005*
Medium NAI School		
High NAI School		
Perceived Safety in Hallways	-0.285 (2.252)	0.900
Low NAI School (ref)	-5.482 (2.252)	0.016*
* = statistically significant at p < 0.05 threshold		

Variable	β (Standard Error)	P-value
Medium NAI School		
High NAI School		
School Lunch Participation	-0.008	0.787
Low NAI School (ref)	0.062	0.034*
Medium NAI School		
High NAI School		
* = statistically significant at $p < 0.05$ threshold		

Figures 1–4 show visualization through maps of the patterns of neighborhood trauma overlaid with select school-level SDOH variables that were found to be statistically significant. Collectively, each identifies areas in which there may be an opportunity to support improvement in school-level SDOH via trauma-informed intervention.

Figure 1: Sugar sweetened beverage and vegetable intake, by school neighborhood trauma level (elementary/middle and high for each; 4 images)

Figure 2: Health-promoting physical activity, by school neighborhood trauma level (elementary/middle and high; 2 images)

Figure 3: Safety in classroom and hallways, by school neighborhood trauma level (elementary/middle and high for each; 4 images)

Figure 4: School meal participation (%), by school neighborhood trauma level (elementary/middle and high for each; 2 images)

The appendices (B-E) show maps of neighborhood trauma overlaid with remaining school-level SDOH variables that were not statistically significant.

Discussion

This study leveraged a novel integration of spatial and school-level data to examine how neighborhood trauma relates to SDOH within school environments. We observed clear spatial patterning of neighborhood trauma across Philadelphia and found that higher neighborhood trauma was associated with a range of school-level SDOH outcomes, including lower attendance, reduced physical activity, less healthy beverage consumption, and decreased perceptions of safety. Notably, higher trauma exposure was also associated with increased school meal participation. Collectively, these findings highlight the importance of place-based approaches to understanding trauma and underscore the value of schools as critical settings for intervention.

Our findings align with a robust body of literature demonstrating that trauma exposure, particularly when shaped by structural inequities, has wide-ranging effects on children's health, behavior, and academic outcomes.^{3,5,10,44} Childhood trauma is strongly associated with impairments in cognitive functioning, emotional regulation, and school engagement, which may manifest as reduced attendance and participation in health-promoting behaviors.^{1,7,44} At the same time, emerging work emphasizes that trauma does not occur in isolation but is embedded within broader neighborhood contexts characterized by poverty, violence, and resource deprivation.⁴⁰ Our findings extend this literature by demonstrating that neighborhood-level trauma exposure, operationalized through a spatial index, corresponds with measurable differences in school-level SDOH, suggesting that place-based trauma may shape not only individual outcomes but also school environments as a whole.

The observed associations between higher neighborhood trauma and lower physical activity, less healthy dietary behaviors, and reduced perceptions of safety are consistent with theoretical and empirical work linking environmental stressors to health behaviors.⁴⁴ Chronic exposure to stress and unsafe environments may limit opportunities for physical activity and contribute to maladaptive coping behaviors, including unhealthy dietary patterns.⁴⁵ Similarly, perceptions of safety within school spaces are critical for student well-being and engagement; trauma-exposed youth may experience heightened vigilance or fear, which can negatively influence their sense of belonging and safety at school.^{14,23} These findings underscore the need for trauma-informed approaches that address both psychological and environmental dimensions of student well-being.

A particularly noteworthy finding is the positive association between neighborhood trauma and school meal participation. While most SDOH indicators were less favorable in high-trauma settings, school lunch uptake was higher. This pattern is consistent with a growing body of evidence demonstrating that school meal programs serve as essential supports in contexts of economic and social vulnerability.⁴⁶ Universal school meal policies have been shown to increase participation and improve diet quality, food security, and, in some cases, academic outcomes.^{31,47} Additionally, recent research indicates that access to school meals is associated with reductions in household food insecurity, particularly among low-income families.⁴⁷ In high-trauma neighborhoods—where food insecurity and economic hardship are more prevalent—greater reliance on school meals likely reflects both increased need and the role of schools as accessible, stigma-reducing sources of nutrition. These findings suggest that school meal programs may function as protective factors within high-risk environments and highlight the importance of sustaining and expanding equitable access to these services.⁴⁶

From a policy and practice perspective, this study introduces the NAI as a promising tool for targeting interventions. By integrating multiple dimensions of neighborhood trauma into a spatially explicit metric, the NAI enables identification of schools situated in high-risk environments where trauma-informed and health-promoting interventions may be most needed. This approach aligns with calls for more precise, data-driven strategies to address health inequities and to allocate resources efficiently.⁴⁸ Importantly, the use of spatial mapping to visualize co-occurring risks can facilitate communication with community

partners and support collaborative decision-making processes that are grounded in local context. Tools that allow for sharing maps and spatial data with partners and community members, such as ESRI's ArcGIS StoryMap⁴⁹ – are well suited to fostering this collaborative process. Our team has developed a StoryMap to facilitate information sharing and dissemination beyond academic audiences and to facilitate data sharing among practitioners and advocates of place-based health promotion.⁵⁰

At the same time, it is critical to interpret these findings within an equity-focused framework that avoids stigmatization. Differences observed across neighborhoods should not be attributed to inherent characteristics of communities but rather understood as the result of historical and ongoing structural inequities, including racism, disinvestment, and policy decisions that shape access to resources and opportunities. Prior research emphasizes that both trauma and neighborhood disadvantage are socially patterned and reflect broader systems of inequity.⁴⁰ Accordingly, the goal of identifying high-trauma school environments should be to inform resource allocation and support, not to label or pathologize communities.

Limitations

This study has several limitations. First, the cross-sectional design precludes causal inference, and observed associations should be interpreted as exploratory. Second, school-level aggregation may obscure important within-school variation, and future work should incorporate student-level data to better understand mechanisms linking neighborhood trauma to outcomes. Third, the study focused on school neighborhoods rather than students' residential environments; although this aligns with the aim of capturing exposure during the school day, it may not fully reflect total trauma exposure. Finally, variable selection was constrained by data availability, and additional SDOH domains may warrant inclusion in future analyses.

Future research should build on these findings by examining longitudinal relationships between neighborhood trauma and school outcomes, exploring mediating mechanisms, and evaluating the effectiveness of trauma-informed and nutrition-focused interventions in high-NAI settings. Integrating qualitative perspectives from students, families, and community stakeholders will also be essential for ensuring that interventions are contextually appropriate and responsive to local needs.

Conclusion

In conclusion, this study demonstrates that neighborhood trauma is both spatially patterned and meaningfully associated with school-level SDOH. Schools in high-trauma neighborhoods face compounded challenges but may also serve as critical hubs for intervention, particularly through programs such as school meals. By providing a novel, spatially grounded tool for identifying priority settings, this work contributes to efforts to advance trauma-informed, equity-oriented approaches to improving child health and well-being.

Declarations

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The authors have no competing interests to declare

Author Contributions (CRediT):

GMM: conceptualization, data curation, supervision, methodology, writing-original draft, project administration

AGS: data curation, formal analysis, visualization, writing- review & editing

KLS: data curation, formal analysis, visualization, writing- review & editing

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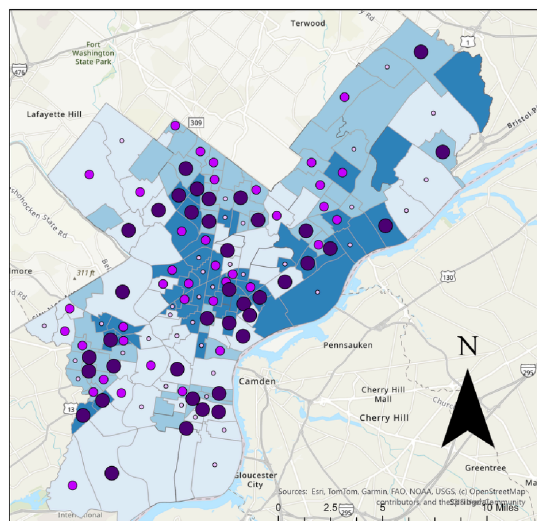
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Figures

Elementary School Catchment Neighborhood Adversity Score
and Healthy Vegetable Consumption



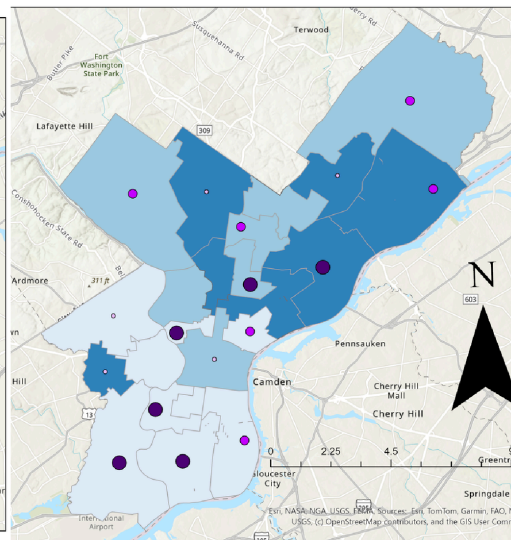
Healthy Vegetable Consumption Neighborhood Adversity Score
healthy_veg

- 0.079710 - 0.157143
- 0.157144 - 0.193370
- 0.193371 - 0.333333

NAI

- Low: 32.01 - 332.38
- Medium: 332.39 - 360.42
- High: 360.43 - 398.61

High School Catchment Neighborhood Adversity Score
and Healthy Vegetable Consumption



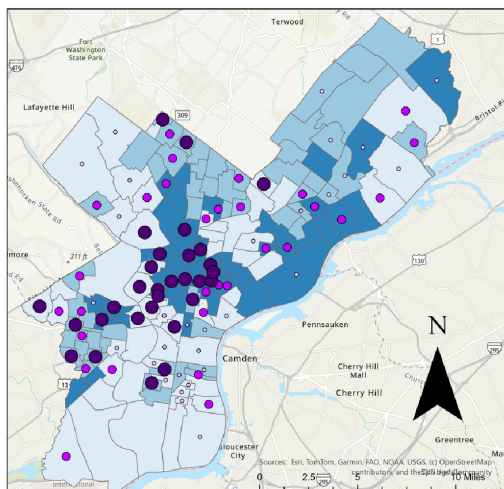
Healthy Veggie Consumption Neighborhood Adversity Score
healthy_veg

- 10.03% - 15%
- 15.01% - 21.1%
- 21.1% - 26.53%

NAI

- Low: 128.995237 - 253.564541
- Medium: 253.564542 - 309.562310
- High: 309.562311 - 381.524086

Elementary School Catchment Neighborhood Adversity Score
and Low Sugary Beverage Consumption



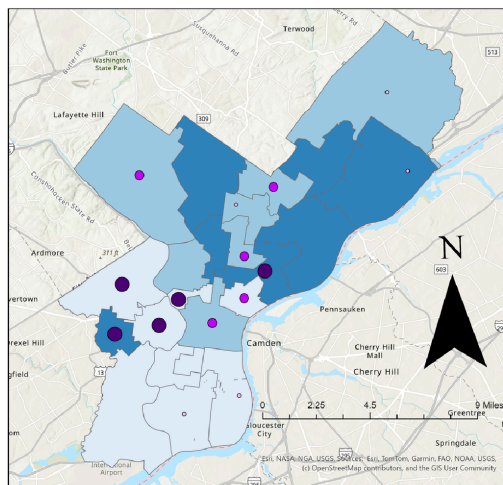
Low Sugary Beverage Consumption Neighborhood Adversity Score
low_sugary_beverages

- High: 28.33% - 45.87%
- Medium: 45.88% - 55.66%
- Low: 55.67% - 86.18%

NAI

- Low: 32.01 - 332.38
- Medium: 332.39 - 360.42
- High: 360.43 - 398.61

High School Catchment Neighborhood Adversity Score
and Low Sugary Beverage Consumption



HS Low Sugary Beverage Consumption HS Neighborhood Adversity Score
low_sugary_beverages

- 44.252874 - 51.428571
- 51.428572 - 57.575758
- 57.575759 - 65.656566

NAI

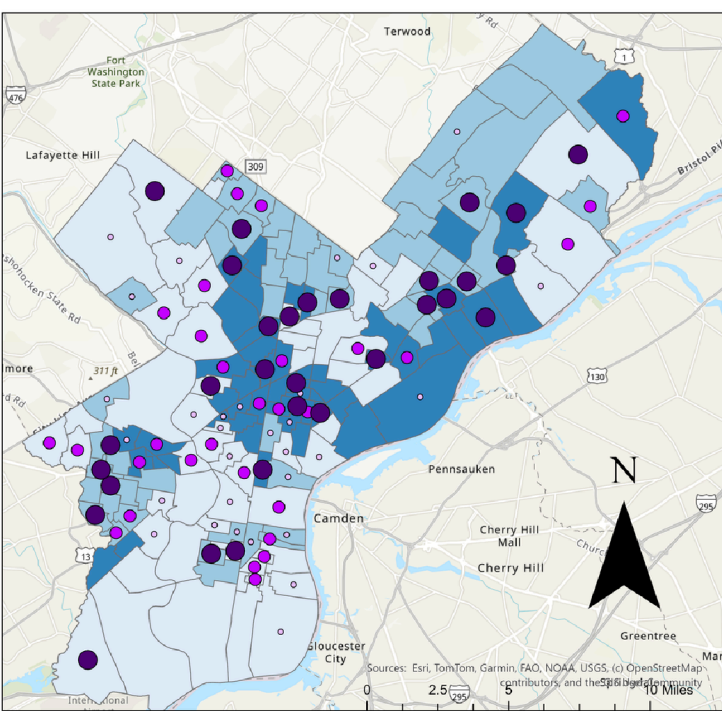
- Low: 128.995237 - 253.564541
- Medium: 253.564542 - 309.562310
- High: 309.562311 - 381.524086

Figure 1. Sugar sweetened beverage and vegetable intake, by school neighborhood trauma level

Figure 1

Sugar sweetened beverage and vegetable intake, by school neighborhood trauma level
(elementary/middle and high for each; 4 images)

Elementary School Catchment Neighborhood Adversity Score
and Healthy Physical Activity



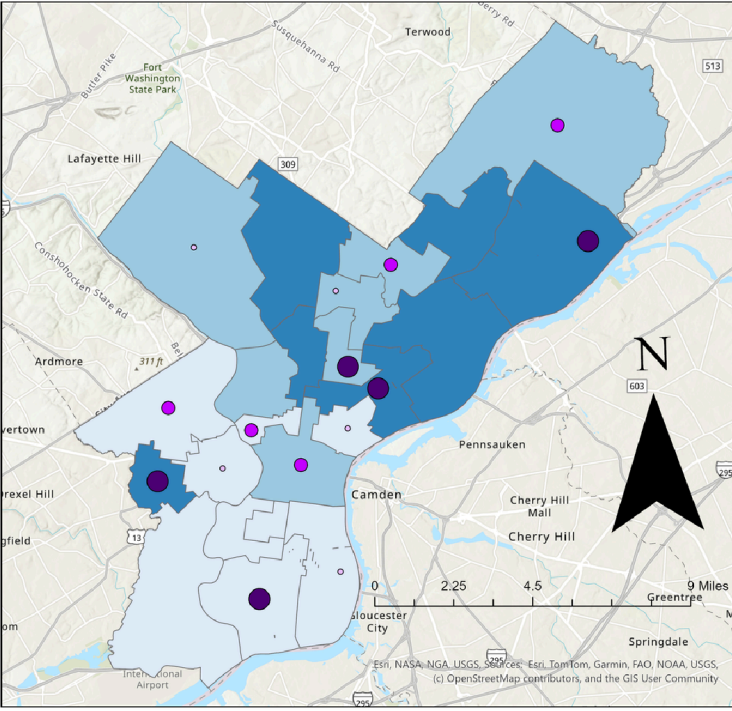
Healthy Physical Activity
healthy_physical_activity

- High: 29.21% - 41.27%
- Medium: 41.28% - 48.45%
- Low: 48.46% - 66.28%

Neighborhood Adversity Score
NAI

- Low: 32.01 - 332.38
- Medium: 332.39 - 360.42
- High: 360.43 - 398.61

High School Catchment Neighborhood Adversity Score
and Healthy Physical Activity



HS Healthy Physical Activity
healthy_pa_pct

- 34.770115 - 36.921529
- 36.921530 - 39.259259
- 39.259260 - 44.907407

HS Neighborhood Adversity Score
NAI

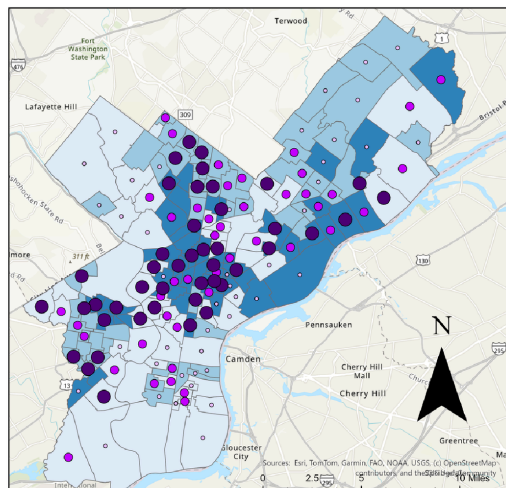
- Low: 128.995237 - 253.564541
- Medium: 253.564542 - 309.562310
- High: 309.562311 - 381.524086

Figure 2. Health-promoting physical activity, by school neighborhood trauma level

Figure 2

Health-promoting physical activity, by school neighborhood trauma level (elementary/middle and high; 2 images)

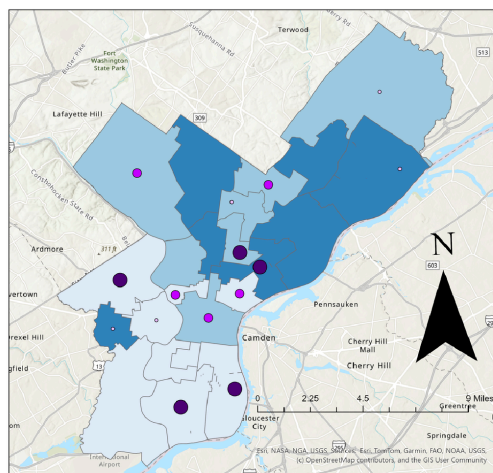
Elementary School Catchment Neighborhood Adversity Score
and Feeling Safe in Classrooms



Feeling Safe in Classrooms
safe_class
● High: 45.53% - 66.13%
● Medium: 66.14% - 76.92%
○ Low: 76.93% - 97.62%

Neighborhood Adversity Score
NAI
■ Low: 32.01 - 332.38
■ Medium: 332.39 - 360.42
■ High: 360.43 - 398.61

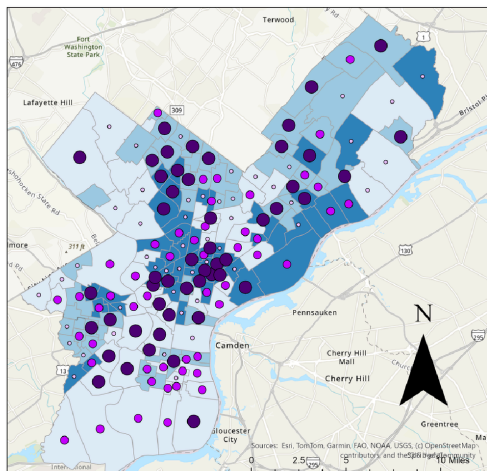
High School Catchment Neighborhood Adversity Score
and Feeling Safe in Classrooms



HS Feelings of Safety in the Classroom
safe_class
● High: 58.011050 - 65.740741
● Medium: 65.740742 - 68.907563
○ Low: 68.907564 - 73.125000

HS Neighborhood Adversity Score
NAI
■ Low: 128.995237 - 253.564541
■ Medium: 253.564542 - 309.562310
■ High: 309.562311 - 381.524086

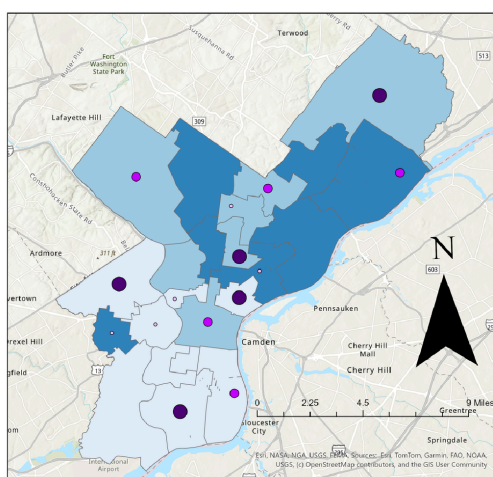
Elementary School Catchment Neighborhood Adversity Score
and Feeling Safe in Hallways



Feeling Safe in Hallways
safe_hallway
● High: 43.342037 - 61.631420
● Medium: 61.631421 - 73.652695
○ Low: 73.652696 - 93.258427

Neighborhood Adversity Score
NAI
■ Low: 32.01 - 332.38
■ Medium: 332.39 - 360.42
■ High: 360.43 - 398.61

High School Catchment Neighborhood Adversity Score
and Feeling Safe in Hallways



HS Feeling Safe in the Hallways
safe_hallway
● High: 53.072626 - 57.494145
● Medium: 57.494146 - 61.764706
○ Low: 61.764707 - 68.152866

HS Neighborhood Adversity Score
NAI
■ Low: 128.995237 - 253.564541
■ Medium: 253.564542 - 309.562310
■ High: 309.562311 - 381.524086

Figure 3. Safety in classroom and hallways, by school neighborhood trauma level

Figure 3

Safety in classroom and hallways, by school neighborhood trauma level (elementary/middle and high for each; 4 images)

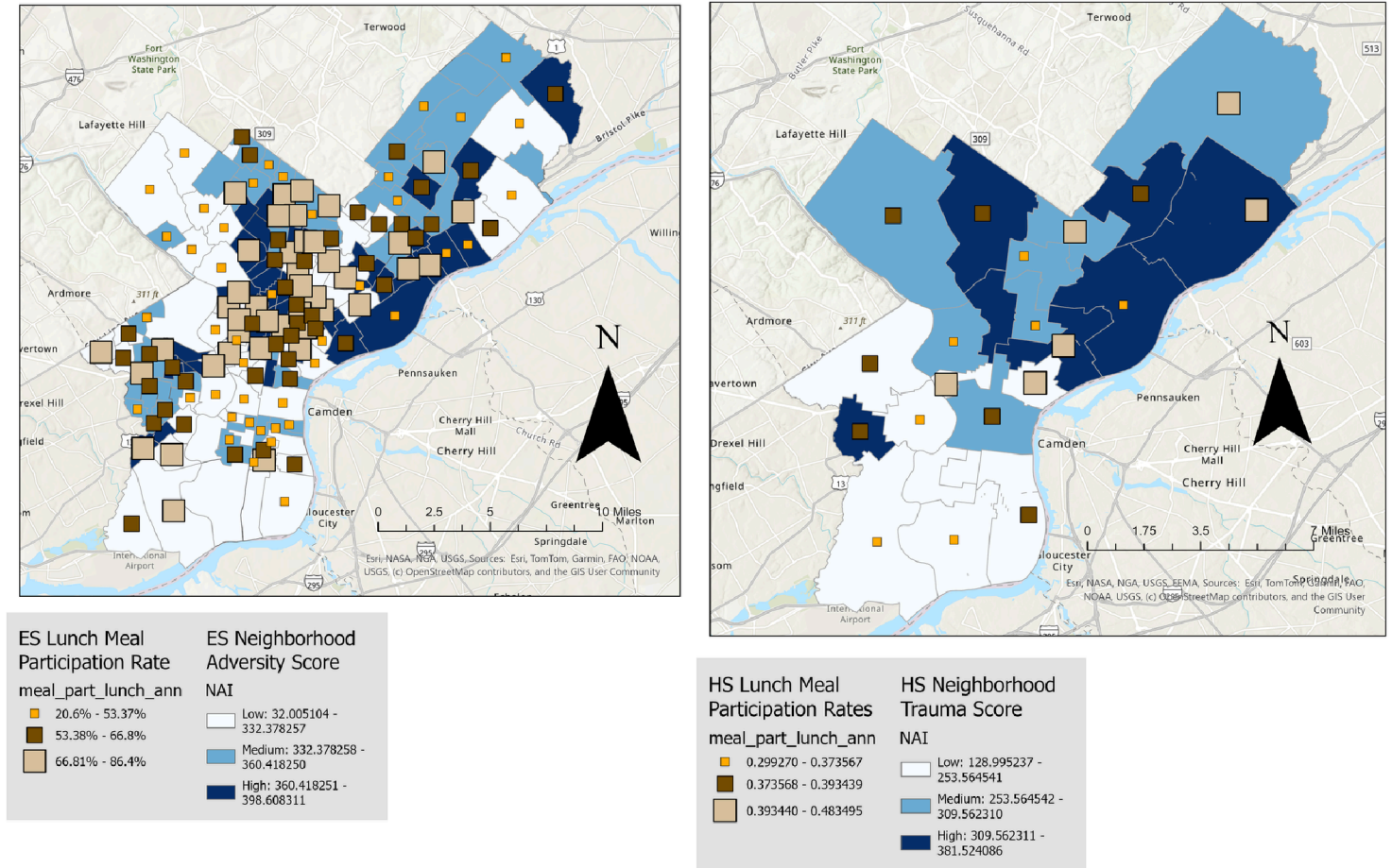


Figure 4. School meal participation (%), by school neighborhood trauma level

Figure 4

School meal participation (%), by school neighborhood trauma level (elementary/middle and high for each; 2 images)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AppendixACodebook.xlsx](#)
- [AppendixBAttendance.pdf](#)
- [AppendixCCafeteriaSafety.pdf](#)
- [AppendixDFederalSupport.pdf](#)
- [AppendixEFruitConsumption.pdf](#)