

# Social Determinants of Health and Emergency Department Utilization in Alabama Children's Health Insurance Program

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Injuries are the leading cause of death among children and youth in the United States.<sup>1</sup> According to the CDC, for every child injury death, 25 children are hospitalized and another 925 are treated in an emergency department (ED).<sup>2</sup> Pediatric injuries represent a major concern to society and to the public and private health plans covering pediatric patients.

Unlike ambulatory care-sensitive conditions, injuries are less amenable to prevention through clinical interventions<sup>3</sup> and are more likely to be related to patient characteristics and social and environmental factors. The CDC defines social determinants of health (SDOH) as “the conditions in the environments where people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks.”<sup>4</sup> In the United States, race/ethnicity, socioeconomic status (SES), and environmental characteristics have been shown to be risk factors for childhood injury.<sup>5-7</sup> Minority racial/ethnic status and community-level socioeconomic disadvantage have also been linked to higher overall pediatric ED use, perhaps due to lack of access to a usual source of care.<sup>8</sup> However, in the presence of financial, physical, and cultural barriers to seeking care, the SDOH associated with increased risk of pediatric injury may not lead to more ED use.<sup>9</sup> A more nuanced understanding of the factors that confer increased risk of injury and factors that are barriers to seeking health care among children may inform health care and community-level interventions to address and mitigate these risks.

This study adds to the literature by exploring associations between individual- and community-level characteristics and ED visits among publicly insured children in Alabama. In 2012, the CDC released the National Action Plan for Child Injury Prevention, emphasizing the importance of data-driven research as a key component of a national strategy to reduce childhood injury.<sup>10</sup> In some states, health systems have launched interventions targeting pediatric injury prevention at the community level.<sup>11</sup> By focusing on a state with one of the highest rates of childhood injury,<sup>12</sup> this study uses data from ALL Kids, Alabama's Children's Health Insurance Program, to evaluate the relationship between

## ABSTRACT

**OBJECTIVES:** Injuries are the leading cause of death among children and youth in the United States, representing a major concern to society and to the public and private health plans covering pediatric patients. Data from ALL Kids, Alabama's Children's Health Insurance Program, were used to evaluate the relationship between community-level social determinants of health (SDOH) and pediatric emergency department (ED) use and differences in these associations by age and race.

**STUDY DESIGN:** This was a retrospective, pooled cross-sectional analysis.

**METHODS:** We used ALL Kids data to identify ED visits (injury and all-cause) among children who were enrolled at any time from 2015 to 2017. Exploratory factor analysis was used to categorize SDOH from 18 selected Census tract-level variables. Multilevel Poisson regression models were used to evaluate the effects of community and individual factors and their interactions.

**RESULTS:** Census tract-level SDOH were grouped as low socioeconomic status (SES), urbanicity, and immigrant-density factors. Low SES and urbanicity factors were associated with ED visits (injury and all-cause). The low SES and urbanicity factors also moderated the association between race and ED visits (injury and all-cause).

**CONCLUSIONS:** The environment in which children live influences their ED use; however, the impact varies by age, race, and Census tract factors. Further studies should focus on specific community factors to better understand the relationship among SDOH, individual characteristics, and ED utilization.

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## TAKEAWAY POINTS

- ▶ The environments in which children live influence their risk of injury or emergency department (ED) utilization.
- ▶ The impacts of Census tract factors such as low socioeconomic status and rurality on the risk of children's ED visits for injury are different and warrant further investigations on specific community characteristics.
- ▶ The impacts of Census tract factors also vary across demographic characteristics, such as age, gender, and race.

community-level SDOH and pediatric ED use and differences in these associations by age and race.

## METHODS

## Patient and Public Involvement

Neither patients nor the public were involved in the design, conduct, reporting, or dissemination of this research. This work was approved by the University of Alabama at Birmingham Institutional Review Board (record No. IRB-300003138).

## Data and Study Cohort

This study used administrative data from ALL Kids, focused on children enrolled at any time from 2015 to 2017. During this time, ALL Kids coverage was available in 12-month enrollment periods to Alabama children younger than 19 years with family incomes from 146% to 317% of the federal poverty level (FPL).

Individual characteristics, including enrollee age, gender, race, and cost-sharing group, were obtained from administrative data. Race and ethnicity are social constructs but are used as a lens through which to study disparities in health care. We used the following self-reported racial categories: American Indian/Alaska Native, Asian, Black or African American, more than 1 race, Native Hawaiian or other Pacific Islander, White, and unknown or not reported. The proportions of respondents in the categories other than Black or African American and White were small, so they were combined into an "other" category. Based on previous literature,<sup>13,14</sup> 18 Census tract-level variables were selected and used for exploratory factor analysis (EFA) to capture community SDOH (eAppendix Table 1 [eAppendix available at [ajmc.com](http://ajmc.com)]). Home addresses at time of enrollment were used to map children to their Census tract. County-level health resource factors, including the number of pediatricians and the number of total hospital beds per 1000 population, were obtained from Area Health Resource Files.<sup>15</sup>

## Outcomes

The primary health outcome measures were counts of ED visits (injury and all-cause) by enrollee and calendar year. The validated<sup>16</sup> New York University (NYU) ED Classification Algorithm, previously used with ALL Kids data,<sup>17</sup> was employed to classify common

primary ED discharge diagnoses as having varying probabilities of falling into 1 of 4 severity categories.<sup>18,19</sup>

## Statistical Analysis

In this pooled cross-sectional analysis, we used EFA on the Census tract-level variables to reduce complexity and potential collinearity in the models and categorize SDOH.<sup>14</sup> Multilevel models were used to explore the association between SDOH and injury ED visits using indi-

vidual-, Census tract-, and county-level factors. Detailed descriptions of the EFA and multilevel modeling are provided in the eAppendix.

Because the causes and patterns of injuries may be different for younger vs older children, we estimated age-stratified models for children younger than 10 years or 10 years and older.<sup>20,21</sup> Other individual covariates included race, gender, and 3 income-based eligibility groups (low-fee, 146%-156% FPL; fee, 157%-208% FPL; and expansion, 209%-317% FPL). Due to small sample size, a fourth no-fee group, composed of Native American children federally exempt from all forms of cost sharing, was combined with the "other" race category of the low-fee group, avoiding issues of multicollinearity.

To explore possible intersectionalities between race and community characteristics, we estimated models containing interaction terms between individual race and SDOH categories. To simplify the interactions between race and SDOH, we categorized each factor into deciles that were included as continuous variables in the model.<sup>22</sup>

All models were estimated using multilevel mixed-effect Poisson regression, with robust standard errors accounting for the interdependency of observations throughout the study period. Results are presented as incidence rate ratios (IRRs). A 2-sided *P* value less than .05 was considered significant. All analyses were performed using Stata 16 (StataCorp).

## RESULTS

## Results From EFA and Summary of Cohort Characteristics

Three SDOH categories were generated by EFA of 18 Census tract-level variables (eAppendix Table 2 and eAppendix Figure): (1) low SES, (2) urbanicity (high degree of urbanization), and (3) immigrant density (high density of recent immigrants). Distributions of individual characteristics across quintiles of SDOH are summarized in eAppendix Table 3.

## Results for Injury ED Visits

Low SES was positively associated with injury-related ED visits (Table 1) only among children 10 years and older (IRR, 1.022; *P* < .01), whereas urbanicity showed negative association in both age groups ( $\geq 10$  years: IRR, 0.987; *P* < .05; < 10 years: IRR, 0.989; *P* < .05). No significant associations were observed between immigrant density and injury ED visits.

**TABLE 1.** Association Between All Factors and Injury ED Visits, Shown as Incidence Rate Ratio (SE)

	Children aged ≥ 10 years			Children aged < 10 years		
	No interaction term	Interaction between race and poverty	Interaction between race and urbanicity	No interaction term	Interaction between race and poverty	Interaction between race and urbanicity
N	127,038	127,038	127,038	120,216	120,216	120,216
Race						
White	Ref	Ref	Ref	Ref	Ref	Ref
Black or African American	0.982 (0.0486)	1.101 (0.0716)	0.803** (0.0655)	0.862** (0.0297)	0.865* (0.0544)	0.773** (0.0742)
Other	0.841** (0.0316)	0.906 (0.0567)	0.781** (0.0587)	0.808** (0.0248)	0.762** (0.0495)	0.857* (0.0566)
Gender						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.741** (0.019)	0.741** (0.019)	0.741** (0.019)	0.810** (0.0182)	0.811** (0.0182)	0.811** (0.0183)
Age	1.022** (0.00451)	1.022** (0.00452)	1.022** (0.00451)	0.978** (0.0075)	0.978** (0.0075)	0.978** (0.0075)
Numbers of enrollees in the Census tract <sup>a</sup>	0.999 (0.00041)	0.999 (0.00047)	0.999 (0.00046)	1.000 (0.00038)	1.000 (0.00038)	1.000 (0.00038)
Cost-sharing group						
Low fee/no fee	Ref	Ref	Ref	Ref	Ref	Ref
Fee	0.910* (0.0378)	0.910* (0.0377)	0.910* (0.038)	0.879** (0.0318)	0.879** (0.0319)	0.879** (0.0318)
Expansion	0.833** (0.0319)	0.833** (0.0318)	0.834** (0.032)	0.833** (0.0339)	0.833** (0.034)	0.833** (0.0339)
Low SES factor <sup>b</sup>	1.022** (0.00696)	1.031** (0.00887)	1.020** (0.0071)	1.005 (0.0055)	1.003 (0.00696)	1.005 (0.00533)
Urbanicity factor <sup>b</sup>	0.987* (0.0061)	0.988* (0.00611)	0.975** (0.00749)	0.989* (0.0047)	0.988* (0.00461)	0.988 (0.00633)
Immigrant-density factor <sup>b</sup>	0.988 (0.00776)	0.987 (0.00801)	0.989 (0.00774)	0.997 (0.00501)	0.997 (0.00518)	0.997 (0.00504)
Interaction term						
White and low SES		Ref			Ref	
Black or African American and low SES		0.981 (0.0112)			1.000 (0.0115)	
Other and low SES		0.986 (0.0117)			1.011 (0.0111)	
White and urbanicity			Ref			Ref
Black or African American and urbanicity			1.036** (0.0131)			1.016 (0.0129)
Other and urbanicity			1.016 (0.0129)			0.99 (0.0115)
Number of pediatricians per 1000 population	0.521* (0.156)	0.530* (0.159)	0.497* (0.152)	0.640** (0.0934)	0.640** (0.0936)	0.629** (0.0914)
Number of hospital beds per 1000 population	1.004 (0.00904)	1.004 (0.00883)	1.003 (0.0087)	0.99 (0.0089)	0.99 (0.00894)	0.991 (0.0089)
Year						
2015	Ref	Ref	Ref	Ref	Ref	Ref
2016	0.985 (0.0341)	0.985 (0.0341)	0.985 (0.034)	0.920** (0.0289)	0.920** (0.0288)	0.920** (0.0289)
2017	1.02 (0.0436)	1.02 (0.0436)	1.02 (0.0435)	0.935* (0.0292)	0.935* (0.0292)	0.935* (0.0292)

Ref, reference; SES, socioeconomic status.

\* $P < .05$ ; \*\* $P < .01$ .<sup>a</sup>Weighted by the proportion of time enrolled in a year.<sup>b</sup>In deciles.

Black or African American children younger than 10 years had a lower rate of injury ED visits than White children, but there was no significant difference for children 10 years and older. Girls were less likely to have injury ED visits than boys across both age groups. A 1-year increase in age was positively associated with injury ED visits for children younger than 10 years but negatively associated for children 10 years and older.

In models with interaction terms between low SES and race for injury ED visits, low SES remained significant for children 10 years and older (IRR, 1.031;  $P < .01$ ), whereas the interaction between low SES and Black or African American race was not statistically significant (IRR, 0.981;  $P = .095$ ). This indicated that although the rate of injury ED visits increased with higher deciles of low SES among children 10 years and older, the increase could be smaller for Black

## TRENDS FROM THE FIELD

**TABLE 2.** Association Between All Factors and All-Cause ED Visits, Shown as Incidence Rate Ratio (SE)

	Children aged ≥ 10 years			Children aged < 10 years		
	No interaction term	Interaction between race and poverty	Interaction between race and urbanicity	No interaction term	Interaction between race and poverty	Interaction between race and urbanicity
N	127,038	127,038	127,038	120,216	120,216	120,216
Race						
White	Ref	Ref	Ref	Ref	Ref	Ref
Black or African American	1.052 (0.0364)	1.116 (0.0628)	0.876 (0.0591)	1.284** (0.0399)	1.352** (0.08)	1.154* (0.0675)
Other	0.842** (0.0228)	0.849** (0.0486)	0.877** (0.0441)	0.921** (0.0278)	0.855** (0.0277)	0.852** (0.0348)
Gender						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	1.141** (0.0205)	1.141** (0.0205)	1.141** (0.0206)	0.879** (0.0134)	0.879** (0.0134)	0.879** (0.0134)
Age	1.072** (0.00386)	1.072** (0.00386)	1.072** (0.00387)	0.887** (0.00473)	0.887** (0.00473)	0.887** (0.00472)
Numbers of enrollees in the Census tract <sup>a</sup>	1 (0.000330)	1 (0.000329)	1 (0.000322)	1 (0.000355)	1 (0.000356)	1 (0.000354)
Cost-sharing group						
Low fee/no fee	Ref	Ref	Ref	Ref	Ref	Ref
Fee	0.927** (0.0218)	0.927** (0.0217)	0.928** (0.0219)	0.901** (0.0184)	0.901** (0.0186)	0.901** (0.0184)
Expansion	0.833** (0.0241)	0.833** (0.0241)	0.834** (0.0242)	0.791** (0.0203)	0.790** (0.0204)	0.791** (0.0203)
Low SES factor <sup>b</sup>	1.039** (0.00565)	1.042** (0.00666)	1.037** (0.00567)	1.033** (0.00428)	1.031** (0.00525)	1.031** (0.0042)
Urbanicity factor <sup>b</sup>	0.992 (0.00476)	0.992 (0.00479)	0.986* (0.0068)	0.991 (0.0048)	0.991 (0.00482)	0.984** (0.00495)
Immigrant-density factor <sup>b</sup>	0.992 (0.00548)	0.992 (0.00554)	0.993 (0.00544)	0.995 (0.0041)	0.994 (0.00398)	0.995 (0.00401)
Interaction term						
White and low SES		Ref			Ref	
Black or African American and low SES		0.99 (0.00923)			0.993 (0.00879)	
Other and low SES		0.998 (0.00956)			1.013 (0.00731)	
White and urbanicity			Ref			Ref
Black or African American and urbanicity			1.030** (0.0113)			1.018* (0.00741)
Other and urbanicity			0.994 (0.00994)			1.015* (0.00776)
Number of pediatricians per 1000 population	0.567* (0.145)	0.572* (0.147)	0.535* (0.142)	0.490** (0.0926)	0.492** (0.0923)	0.477** (0.089)
Number of hospital beds per 1000 population	1.005 (0.00928)	1.005 (0.00923)	1.005 (0.00889)	1.009 (0.00966)	1.009 (0.00966)	1.009 (0.00942)
Year						
2015	Ref	Ref	Ref	Ref	Ref	Ref
2016	1.023 (0.0262)	1.023 (0.0263)	1.023 (0.0262)	1.031* (0.0154)	1.031* (0.0154)	1.031* (0.0155)
2017	1.070* (0.0321)	1.070* (0.0321)	1.070* (0.0321)	1.073** (0.0259)	1.073** (0.0259)	1.073** (0.0259)

Ref, reference; SES, socioeconomic status.

\* $P < .05$ ; \*\* $P < .01$ .

<sup>a</sup>Weighted by the proportion of time enrolled in a year.

<sup>b</sup>In deciles.

or African American than White children, implying a widening gap between the races at higher deciles of low SES.

In the interaction models, urbanicity remained significant and negative for both age groups, but the interaction of Black or African American race and urbanicity was positive and significant only for children 10 years and older (IRR, 1.036;  $P < .01$ ). Although Black or African American race and urbanicity were both associated with lower

rates of injury ED visits, the interaction term suggested that Black or African American children 10 years and older who live in more urban areas face increased risk of injury relative to White children.

### Results for All-Cause ED Visits

Low SES was positively associated with all-cause ED visits for both age groups (Table 2). No significant associations between urbanicity

or immigrant density and all-cause ED visits were observed in any model specifications.

Compared with White children, Black or African American children had a higher rate of all-cause ED visits in the group younger than 10 years, whereas children who were neither White nor Black or African American had a lower rate of ED visits in both age groups. Girls 10 years and older were more likely to have all-cause ED visits than younger girls. Age was negatively associated with all-cause ED visits in the group younger than 10 years but positively associated in the group 10 years and older.

In models with interaction terms, the interaction between Black or African American race and urbanicity was significant for both age groups. Again, higher levels of urbanicity had stronger associations with all-cause ED visits for Black or African American children than for White children.

## DISCUSSION

In this multilevel analysis using Alabama ALL Kids data and Census tract-level measures of SDOH, we observed statistically significant associations between low SES and urbanicity and ED visits (injury and all-cause). We found that low SES was associated with greater risk of ED visits among older children, whereas low urbanicity (rurality) was associated with greater risk of ED visits for all children in multivariate models.

This study found that the rate of injury-related ED visits among Black or African American children and children who are neither White nor Black or African American is lower compared with that among White children, which is counter to findings of other studies.<sup>23,24</sup> ED use by racial and ethnic minority children is often ascribed to their having limited access to primary care, but ALL Kids enrollees have access to the entire Blue Cross and Blue Shield of Alabama provider network, which is the largest private health insurance provider in Alabama. Despite the better accessibility of the provider network, the financial, physical, and cultural barriers to seek care still exist. However, improved access to primary care has been shown to improve efficient use of ED services for ALL Kids.<sup>25</sup> Besides, in models with interactions, the results showed a trend whereby Black or African American children 10 years and older living in high-poverty communities are at decreased risk of injury-related ED visits compared with White children living in high-poverty communities. There are concerns that non-White children in low-SES communities may be less likely to seek ED services even when there is a need,<sup>26</sup> and it may be conjectured that that underutilization may contribute to the relatively low rate of injury-related ED visits among Black or African American children in this study. The findings of this study suggest the need for further investigation into the underlying causes of observed differences in ED utilization by race and SDOH.

The negative associations observed between urbanicity and ED visits support findings of previous studies that children in rural areas have more unmet medical needs and ED dependence.<sup>27,28</sup>

However, increased urbanicity was associated with differential increases in ED visits for Black or African American children relative to White children. This is congruent with the findings of Li et al,<sup>29</sup> who found that predominantly African American communities had higher ED utilization rates when the ED was located within 0.5 miles of a patient's residence. For injury ED visits, this study's findings are consistent with well-documented exposure to community-level violence among urban African American youth.<sup>30</sup>

Compared with injury ED visits, the reasons for all-cause ED visits are more heterogeneous. Previous studies showed that the accessibility of routine care may have different impacts on ED use for different reasons.<sup>38</sup> This may explain the discrepancy in our findings between injury ED visits and all-cause ED visits. Further studies focusing on disease-specific ED use could help illustrate the association between SDOH and ED use.

## Limitations

This study had limitations. First, the NYU ED algorithm does not specifically assess severity. From the administrative data, we cannot determine whether differences in ED utilization among groups are the result of differences in injury incidence or severity, differences in thresholds for seeking ED services, or differences in diagnosis by physicians. Further study should analyze ED utilization by stratifying the injury type and severity. Second, the use of EFA prevented the examination of associations between injury ED visits and specific community factors. Third, results may be sensitive to what community-level variables were originally available in the data set for potential inclusion through EFA, and the EFA method does not allow researchers to choose variables to include in each factor. Fourth, the age-stratified analysis is limited to 2 broad age groups, whereas the causes of injury and the main reasons for ED visits may vary by finer age categories; hence, future studies with larger sample sizes should do more granular analysis by age. Fifth, we did not control for baseline health status measures in the models. To include controls for the presence of chronic health conditions would require the use of a fixed period of prior coverage, which would further restrict our already limited sample. Finally, this study focused on ALL Kids enrollees of Alabama. Caution must be used when extrapolating results to other states.

## CONCLUSIONS

This study provides new evidence of the associations between SDOH and ED utilization among ALL Kids enrollees in Alabama. These findings suggest that the environments in which the children live influence their ED use, although the nature of the influence varies across different demographic groups and Census tract factors. Further studies should focus on specific community factors to better understand the relationship among area-level factors, individual factors, and the risk of childhood injury. ■

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## **eAppendix. Details for exploratory factor analysis and multilevel modeling**

### **Exploratory factor analysis**

Exploratory factor analysis (EFA) is a statistical method for collapsing multiple, related variables into summary scores or indices. All 18 census tract-level variables were used for EFA. For this project, a PROMAX rotation strategy was applied to the factor matrix, as this statistical method allows for correlated variables to be handled in what is often considered to be the simplest and most readily interpretable manner (Park, 2002). An a priori factor loading of 0.3 was used to determine whether a covariate loaded on an extracted factor, as it minimizes the overlapping variance with other items in that factor (Costello, 2005; Howard, 2016). Variables with higher loading have greater impacts on the resulting factor. Sensitivity analyses using alternative loading cutoffs and rotations were performed and the resulting 3 factors remained stable.

### **Multilevel modeling**

To construct multilevel models, the most appropriate level(s) to include in the models were explored by estimating null multilevel models (with no covariates) with different levels of clustering. Models were compared by examining the mean outcomes by level and the Akaike information criteria, which is an estimator of the model's goodness of fit to the underlying data (Akaike, 1973). Data were clustered at the individual-level to account for correlation across multiple years of enrollment and at the county-level to account for underlying culture, policy, and health care options. We allowed intercepts to vary by individual and county. Separate models were estimated for injury ED visits and all-cause ED visits.

For  $i^{th}$  individual in  $j^{th}$  county in  $k^{th}$  year:

$$E(Y_{ijk}) = E_{ijk}\mu_{ijk},$$

where  $Y$  denotes the number of ED visits, either of any reason or of injury,  $E$  denotes the person-year,  $\mu$  denotes the incidence rate. The incidence rate was modeled by the random intercept multilevel Poisson model:

$$\ln(\mu_{ijk}) = \beta_{0ij} + \beta_{1ij}SES_{ijk} + \beta_{2ij}Cov_{ijk} + \tau_k + \varepsilon_{ijk} \quad \text{Level}$$

1 model

where  $SES$  denotes the census tract SES factors generated from EFA,  $Cov$  denotes other covariables,  $\tau$  denotes the year fixed effect. Where:

$$\beta_{0ij} = \gamma_{000} + \varphi_{00j} + \theta_{0ij}$$

$$\beta_{1ij} = \gamma_{100} + \varphi_{10j} + \theta_{1ij}$$

$$\beta_{2ij} = \gamma_{200} + \varphi_{20j} + \theta_{2ij}$$

where  $\gamma$  denotes the pooled mean,  $\varphi$  and  $\theta$  denote county- and individual -level intercepts, respectively, indicating the variance of dependent variables across county (level 3) and among individuals within-county (level 2), respectively.

In the model we used the weighted number of total enrollees in the census tract to account for the duration of enrollment for enrollees. For individual  $i$  in a census tract  $C$ , who has  $P$  percent of a year being enrolled in ALL Kids, i.e., the proportion of time enrolled in a year, if in this year there are  $N$  enrollees in a census tract, the weighted number of total enrollees ( $N_w$ ) for this tract  $C$  in this year is

$$N_w = \sum_{i=1}^N 1 \times P_i$$

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**eAppendix Table 1. Census tract-level social determinants of health**

	Source of data	Use in the analysis
Percentage of people who are not non-Hispanic White	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of single parent households with children <18	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of people with cash public assistance or Food Stamps/SNAP	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of people below Federal Poverty Level	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of people >16 who are unemployed	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of people >25 who have no high school diploma	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of people in the total population who are uninsured	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of households with no vehicle available	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Population density	American Community Survey from US Census Bureau*	Population/area of census tract
Percentage of single parent households with children <18	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of people ≤17	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Percentage of tract population that are >1 mile from supermarket	Centers for Disease Control and Prevention**	Direct use from National Environmental Public Health Tracking Network
Percentage of population living ≤0.5 mile of a park, 2015 data	Centers for Disease Control and Prevention**	Direct use from National Environmental Public Health Tracking Network
Average percent of developed imperviousness	Centers for Disease Control and Prevention**	Direct use from National Environmental Public Health Tracking Network
Flag of urban tract, 2010 data	American Community Survey from US Census Bureau*	Direct use of 2010 data
Number of people who were born outside US	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Number of limited English speaking households	American Community Survey from US Census Bureau*	Direct use of 2016 5-year estimation
Environment respiratory hazard index	National Air Toxics Assessment from US Environmental Protection Agency***	Direct use of 2014 national respiratory hazard index

\* US Census Bureau. <https://www.census.gov/>.

\*\* <https://ephtracking.cdc.gov/showRiskLandingSolution.action>.

\*\*\* <https://www.epa.gov/national-air-toxics-assessment/2014-nata-assessment-results>

**eAppendix Table 2: Census tract-level factors and underlying variables, based on EFA**

Factor 1: Poverty	Factor 2: Urbanicity	Factory 3: Immigrant-density
Percentage of people who are not non-Hispanic White	Population Density	Number of people who were born outside US
Percentage of single parent households with children <18	Percentage of people >25 who have no high school diploma*	Number of limited English speaking households
Percentage of people with cash public assistance or Food Stamps/SNAP	Percentage of tract population that are >1 mile from supermarket*	Percentage of population that is $\geq 65^*$
Percentage of persons below Federal Poverty Level	Percent of population living $\leq 0.5$ mile of a park, 2015 data	
Percentage of people >16 who are unemployed	Average percent of developed imperviousness	
Percentage of people >25 years who have no high school diploma	Flag of urban tract, 2010 data	
Percentage of people in the total population who are uninsured		
Percentage of households with no vehicle available		

\*These factor loadings were negative, meaning an inverse relationship. Higher absolute values result in a reduction of the factor score

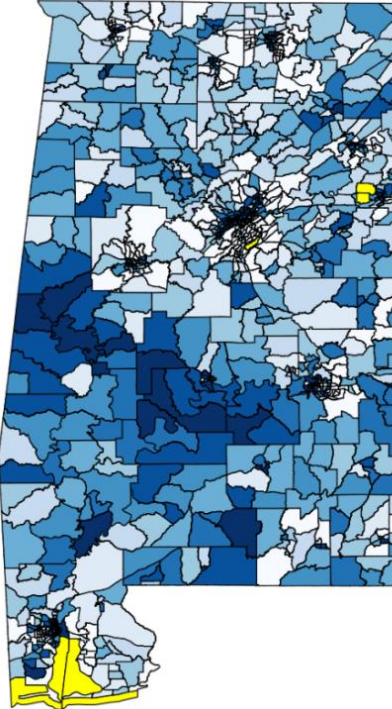
**eAppendix Table 3: Distribution of individual characteristics across quintiles of census tract-level factors**

	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile	p-value
<b>Poverty Factor</b>						
N	60781	63412	55226	42243	25592	
Age, mean (SD)	9.5 (5.4)	9.7 (5.5)	9.8 (5.5)	9.8 (5.5)	10.2 (5.5)	<0.001
Race, N(%)						<0.001
White	36776 (62.0%)	41264 (66.7%)	35673 (66.2%)	19598 (47.7%)	5288 (21.3%)	
Black or African-American	9306 (15.7%)	9364 (15.1%)	8674 (16.1%)	13910 (33.8%)	15217 (61.2%)	
Other	13238 (22.3%)	11270 (18.2%)	9526 (17.7%)	7609 (18.5%)	4343 (17.5%)	
Female, N(%)	30224 (49.7%)	30881 (48.7%)	27098 (49.1%)	20600 (48.8%)	12623 (49.3%)	0.003
Cost-sharing group, N(%)						<0.001
Low fee/No fee	8083 (13.3%)	9255 (14.6%)	8741 (15.8%)	6992 (16.6%)	4717 (18.4%)	
Fee	28147 (46.3%)	31161 (49.1%)	27731 (50.2%)	21807 (51.6%)	14111 (55.1%)	
Expansion	24551 (40.4%)	22996 (36.3%)	18754 (34.0%)	13444 (31.8%)	6764 (26.4%)	
Proportion of time enrolled in a year, median (IQR)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.8 (0.4, 1.0)	0.8 (0.4, 1.0)	<0.001
<b>Urbanicity factor</b>						
N	34417	63655	64067	49358	35757	
Age, mean (SD)	10.0 (5.5)	9.8 (5.5)	9.7 (5.4)	9.7 (5.5)	9.6 (5.5)	<0.001
Race, N(%)						<0.001
White	23986 (71.3%)	45513 (73.2%)	38219 (61.1%)	20507 (42.7%)	10374 (29.9%)	
Black or African-American	4728 (14.1%)	5625 (9.0%)	11801 (18.9%)	17526 (36.5%)	16791 (48.4%)	
Other	4910 (14.6%)	11022 (17.7%)	12513 (20.0%)	9999 (20.8%)	7542 (21.7%)	
Female, N(%)	16670 (48.4%)	31143 (48.9%)	31465 (49.1%)	24428 (49.5%)	17720 (49.6%)	0.012
Cost-sharing group, N(%)						<0.001
Low fee/No fee	5431 (15.8%)	9440 (14.8%)	9388 (14.7%)	7426 (15.0%)	6103 (17.1%)	
Fee	16988 (49.4%)	31494 (49.5%)	31165 (48.6%)	25117 (50.9%)	18193 (50.9%)	

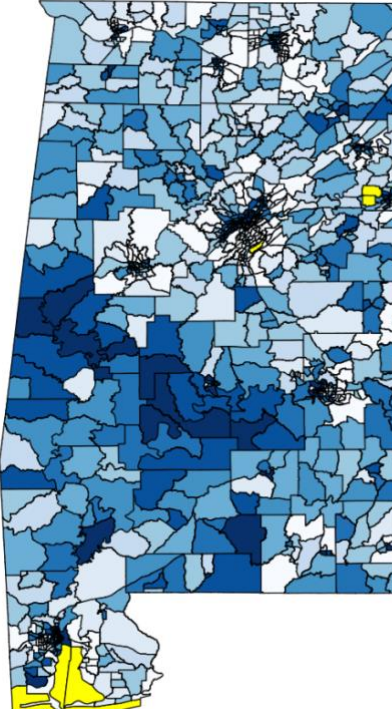
Expansion	11998 (34.9%)	22721 (35.7%)	23514 (36.7%)	16815 (34.1%)	11461 (32.1%)	
Proportion of time enrolled in a year, median (IQR)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.8 (0.4, 1.0)	<0.001
<b>Immigrant-density factor</b>						
N	33764	48200	54389	57167	53734	
Age, mean (SD)	10.1 (5.5)	9.9 (5.5)	9.7 (5.5)	9.6 (5.4)	9.6 (5.5)	<0.001
Race, N(%)						<0.001
White	19564 (59.3%)	30068 (63.9%)	32416 (61.0%)	31532 (56.6%)	25019 (47.9%)	
Black or African-American	8676 (26.3%)	9980 (21.2%)	11293 (21.3%)	12614 (22.7%)	13908 (26.7%)	
Other	4763 (14.4%)	7041 (15.0%)	9393 (17.7%)	11534 (20.7%)	13255 (25.4%)	
Female, N(%)	16498 (48.9%)	23454 (48.7%)	26838 (49.3%)	28252 (49.4%)	26384 (49.1%)	0.087
Cost-sharing group, N(%)						<0.001
Low fee/No fee	5727 (17.0%)	7314 (15.2%)	7944 (14.6%)	8477 (14.8%)	8326 (15.5%)	
Fee	17068 (50.6%)	23593 (48.9%)	26875 (49.4%)	28450 (49.8%)	26971 (50.2%)	
Expansion	10969 (32.5%)	17293 (35.9%)	19570 (36.0%)	20240 (35.4%)	18437 (34.3%)	
Proportion of time enrolled in a year, median (IQR)	0.9 (0.4, 1.0)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.9 (0.5, 1.0)	0.8 (0.4, 1.0)	<0.001

**eAppendix Figure.** Geographical distribution of poverty, urbanicity, and immigrant-density factors (in deciles) of the year 2016 (deeper blue indicates higher value of factor / yellow indicates missing data)

A: Poverty factor



B: Urbanicity factor



C: Immigrant-density factor

