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# The Role of Neighborhoods in the Receipt of Transcranial Doppler Screening Among Children With Sickle Cell Disease

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**Summary:** Although transcranial Doppler (TCD) screening assesses the need for stroke prevention efforts among children with sickle cell disease (SCD), screening rates remain low across many parts of the United States. We sought to identify neighborhoods with low TCD screening rates and neighborhood-level factors related to screening to inform the utility of community-level interventions to improve TCD screening. Children ages 2 to 16 years with SCD (HbSS/HbS/ $\beta$ -thalassemia) living in Wayne County, MI, were identified in Michigan Medicaid (2007 to 2011) through newborn screening records. Children were enrolled for  $\geq 1$  year and could contribute multiple years. We determined receipt of  $\geq 1$  TCD screening and neighborhood (census tract) each year. The proportion of children receiving TCD in the tract was calculated and investigated for spatial patterns across tracts (Moran's I). Median household income, % unemployment, % black residents, and % less than high school education within each tract were ascertained from the American Community Survey. Logistic regression with generalized estimating equations was used to model associations between TCD screening and neighborhood-level factors. Overall, 329 children contributed 532 person-years and screening rates increased from 7% to 36% from 2007 to 2011. Median screening rate in tracts was 0% (interquartile range = 29%) and there was no spatial pattern of TCD screening across tracts (Moran's I Z-score = -0.94,  $P$ -value = 0.35). No associations were found between neighborhood characteristics and receipt of TCD screening in this disadvantaged Michigan county. Additional research is needed to inform interventions to increase TCD screening in this high stroke-risk population.

**Key Words:** sickle cell disease, transcranial Doppler screening, neighborhoods, Medicaid

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Sickle cell disease (SCD) is a chronic condition causing significant morbidity and mortality and is associated with an elevated risk of stroke.<sup>1–3</sup> In the United States, SCD affects predominately minority children, with approximately 1 in 375 African American births diagnosed with SCD.<sup>4</sup> Transcranial Doppler (TCD) screening is used in these children to detect high blood flow velocities in cerebral vessels, which indicate an increased stroke risk and

signal the need to initiate chronic blood transfusions as a key stroke prevention strategy.<sup>5–7</sup> Once transfusions are initiated, stroke incidence is reduced by up to 90% relative to standard medical care as shown in the 1998 Stroke Prevention Trial in Sickle Cell Anemia (STOP) study.<sup>5</sup>

Although chronic blood transfusion has been known to be an effective stroke prevention strategy since the late 90s, TCD screening rates continue to be low, and few individual-level characteristics impacting screening rates have been identified.<sup>8–11</sup> Neighborhood factors have been shown to influence health status among children with chronic conditions; these factors may also influence TCD screening among children with SCD, although this has not yet been explored.<sup>12–14</sup> Neighborhood effects may impact TCD screening through multiple pathways. Residing in a socioeconomically disadvantaged neighborhood has been shown to reduce the likelihood of having a medical home and receiving preventive services, while also increasing the likelihood that residents of those neighborhoods are unable to obtain health care when necessary.<sup>15</sup> Living in a disadvantaged neighborhood leads to higher levels of stress, which is associated with lack of receipt of preventive care.<sup>15</sup> Increased stress is, in turn, connected with depression, anxiety, distress, and feelings of powerlessness, all of which may decrease the likelihood of receipt of TCD screening.<sup>16</sup> Individuals residing in disadvantaged neighborhoods may be less likely to participate in health-related behaviors because of lower levels of social support.<sup>17,18</sup> Conversely, utilization of preventive services has been shown to be positively correlated with the racial and ethnic composition of the neighborhood.<sup>19</sup> For example, neighborhoods with a greater concentration of African Americans may have increased TCD screening rates compared with neighborhoods with a lesser concentration of African Americans because of the sharing of health-related information about SCD, given that it predominantly affects those populations.

Identification of neighborhood factors influencing TCD screening could inform the utility of community-level interventions to improve screening rates among children with SCD. With this in mind, our objective was to investigate the geographic variability in TCD screening rates and the role of neighborhood factors in the receipt of TCD screening among children with SCD. We hypothesized there would be a spatial pattern of TCD screening rates across neighborhoods and that living in a socioeconomically disadvantaged neighborhood would be associated with lack of TCD screening. However, the proportion of African American residents within a neighborhood would be associated with increased TCD screening among children with SCD.

## METHODS

We used data from Michigan Medicaid to examine the role of the neighborhood in the receipt of TCD screening

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among children with SCD residing in Wayne County, MI. A large proportion of the county, which includes the City of Detroit, is African American and is home to the majority of children with SCD in the state. Additional cases of SCD were scattered either individually or in small numbers in census tracts across the state and therefore were excluded from our analysis.

### Study Population

Our study population included children enrolled in Medicaid 2 to 16 years of age with SCD. All states perform newborn screening (NBS) to facilitate early identification of SCD upon birth. The Michigan Department of Community Health (MDCH) follows a 4-step process to confirm SCD cases, which includes contact with the primary care physician of the child, the Sickle Cell Disease Association of America—Michigan Chapter, and 2 positive hemoglobinopathy laboratory reports. Using birth certificates, Michigan Medicaid data were linked to NBS data to identify children with SCD.<sup>20</sup>

### Inclusion Criteria

We included children with at least 1 year of continuous enrollment in Michigan Medicaid from January 1 to December 31st from 2007 to 2011 and no other forms of health insurance within this time frame. An allowance for a 1-month gap in enrollment each year was made. The addresses for children on January 1 of each year of continuous enrollment were obtained from Medicaid enrollment files. All addresses were geocoded and tied the census tract using geographic identifiers. We included children with hemoglobin (Hb) SS or Hb S/β-thalassemia based on current recommendations for TCD screening from the NHLBI and the sickle cell variants included in the STOP trial.<sup>5,21</sup>

### Exclusion Criteria

To exclude children with a prior stroke or who were under current treatment for high blood velocities as detected by previous TCD, children with receipt of 6 or more chronic blood transfusions (CPT codes of 09883, 36455, 86999, S3906, S9538, 09882, or 36430 on any inpatient or outpatient claim) in a year were excluded.<sup>5,7</sup> Children missing date of birth information were also excluded.

### TCD Screening and Neighborhood Characteristics

Receipt of TCD screening (yes/no) was defined for each child during each year of continuous enrollment as having any claim with a CPT code of 93866, 93888, 93890, 93892, or 93893.<sup>22</sup> Neighborhoods were defined as census tracts, which have been shown to contain generally consistent measures of sociodemographic characteristics of the residents.<sup>23</sup> Neighborhood characteristics from the American Community Survey (ACS) 5-year estimates (2007 to 2011) were linked by census tract to children meeting study eligibility criteria. Neighborhood characteristics considered included the census tract-level percent unemployment, percent African American residents, percent less than high school education, and median household income.<sup>12,14</sup>

### Statistical Analysis

Frequencies and percentages were determined for demographics of children in the study population and for receipt of TCD screening each year. Means and SDs of neighborhood sociodemographic characteristics were calculated across census tracts. The tract-level TCD screening

rate was calculated as the total number of person-years containing TCD screening divided by the total number of person-years of children with SCD eligible for screening within each tract. We investigated tract-level TCD screening rates using Global Moran's I with inverse distance.<sup>24</sup> Moran's I measures spatial correlation and allows evaluation of a spatial pattern across census tracts (ie, census tracts in close proximity have similar TCD screening rates than those further away).<sup>25</sup> Logistic regression with generalized estimating equations (GEE) was used to estimate the association between each neighborhood-level factor and receipt of TCD screening, adjusted for age as a continuous variable. The GEE framework was conducted to account for the correlation within children, as each child could contribute multiple person-years. The model used an exchangeable correlation structure and robust standard errors to assess significance.<sup>26</sup> Independence was assumed for children in the same census-tract, as the small number of person-years within each tract made estimation of within-tract correlation unfeasible.<sup>27</sup> Statistical analyses were performed with SAS 9.2 and ArcGIS 10.1, which was also used for mapping purposes.

The study was approved by the Institutional Review Board of the University of Michigan (#HUM00051878).

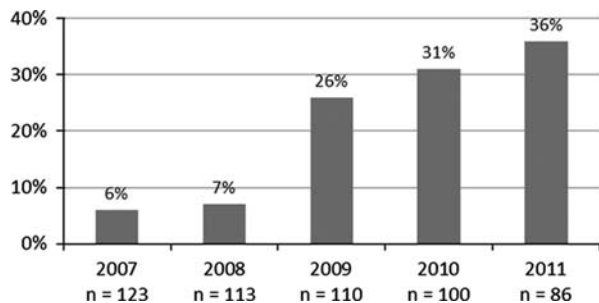
## RESULTS

A total of 989 children with SCD born between 1987 and 2008 were identified in Michigan Medicaid claims from 2007 to 2011. Six percent were excluded for missing birth date or race and 19.5% had no years of continuous enrollment from 2007 to 2011. In total, 329 (33%) met eligibility criteria; 176 of the 329 (54%) children resided in Wayne County during the study period and were included in the analysis. These children collectively contributed 532 person-years. The average age in 2007 was 10.8 years (SD 4), 51% were male and 94% were sickle cell subtype Hb SS (Table 1). The proportion of children receiving TCD screening ranged from 7% to 36%, showing a substantial increase from 2007 to 2011 (Fig. 1). Screening rates differed by age, with 27% of children 2 to 10 years old receiving a TCD and 14% of children 11 to 16 receiving a TCD.

Children in the study population resided in 141 census tracts in Wayne County. Mean percentage of African American residents in the census tract was 80% (SD 28%), percentage of residents with less than a high school education was 27% (SD 18%), percentage unemployed was 27% (SD = 10%), and the mean household income was \$31,040 (SD \$12,091). Number of person-years within each census tract ranged from 1 to 14, with a median of 3

**TABLE 1.** Baseline Demographics of Children With Sickle Cell Disease in Michigan Medicaid Continuously Enrolled for At Least 1 Year From 2007 to 2011 and Residing in Wayne County, MI (2007, n = 123)

	N (%) or Mean (SD)
Age on January 1, 2007 (y)	10.8 (4.0)
Sex	
Male	63 (51)
Female	60 (49)
Sickle cell subtype	
HbSS	116 (94)
HbS/β-thalassemia	7 (6)



**FIGURE 1.** Transcranial Doppler screening rates among children with sickle cell disease continuously enrolled in Michigan Medicaid for at least one year from 2007 to 2011 and residing in Wayne County.

(Interquartile Range [IQR], 2 to 5). The proportion of children receiving TCD screening within census tracts ranged from 0% to 100%, with a median of 0% (IQR, 29%) and a mean of 19% (SD 29%) (Fig. 2). Overall, 60% of neighborhoods ( $n = 85$ ) had screening rates of 0%, and 71% ( $n = 114$ ) had screening rates  $< 50\%$ . Investigation of spatial correlation failed to provide any evidence of a spatial pattern of TCD screening across the census tracts (Moran's I Z-score  $-0.94$ ,  $P$ -value 0.35). No associations were found between the neighborhood characteristics and receipt of TCD screening among children with SCD (Table 2).

## DISCUSSION

TCD screening rates in Michigan were low among children in Wayne County, MI, and across census tracts in Wayne County, showed no spatial pattern and were not found to be associated with neighborhood sociodemographic characteristics. However, overall rates of screening did increase during the study period in Wayne County, increasing from 7% to 36% from 2007 to 2011. The lack of variability in screening rates across neighborhoods may indicate that in Wayne County, interventions targeting the entire population of children with SCD as opposed to particular neighborhoods are necessary to increase TCD screening rates in this high-risk population, particularly given the high level of disadvantage across neighborhoods.

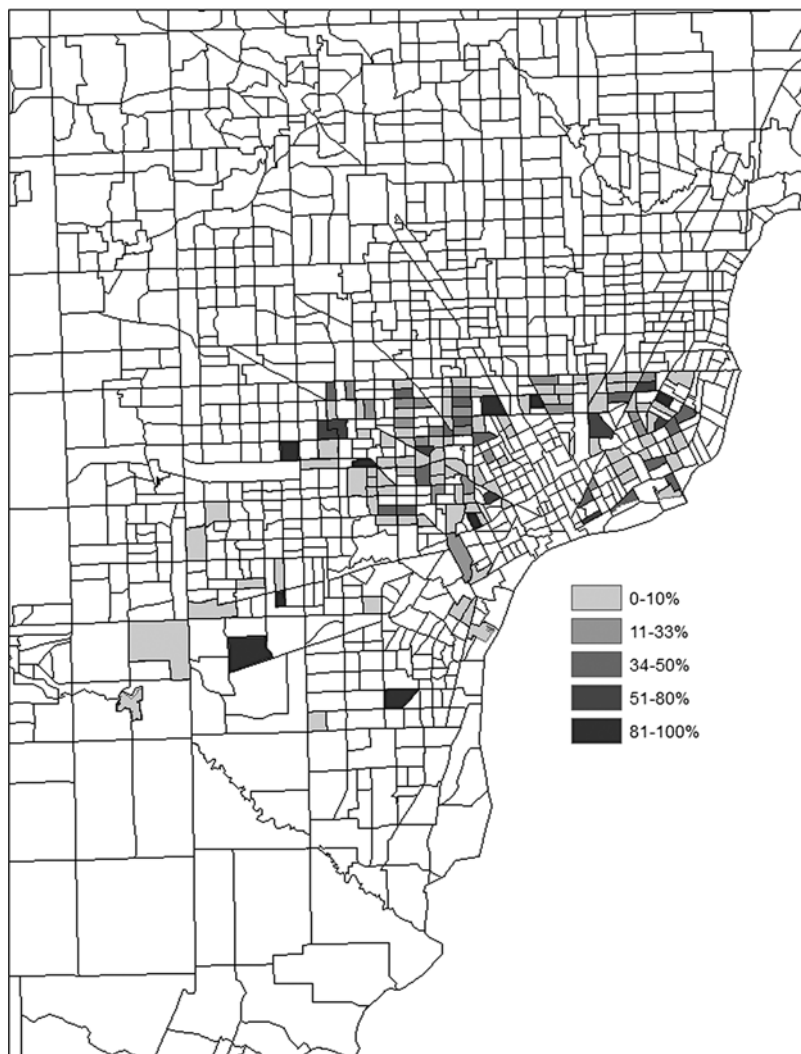
The lack of association between neighborhood characteristics and TCD screening in our study population may be partially due to the low TCD screening rates and high levels of neighborhood disadvantage in Wayne County. TCD screening rates were low across all census tracts, with a median of 0%. In addition, the socioeconomic characteristics of the neighborhoods where children with SCD resided were indicative of a high level of disadvantage. Using American Community Survey 2007 to 2011 estimates, the mean rate of unemployment across our census tracts in Wayne County was 27% versus 8.7% in the United States, median household income was \$31,040 versus \$52,762 in the United States, and the mean percentage less than high school education was 27% in our census tracts versus 8.5% in the United States.<sup>28</sup> These neighborhoods are also more disadvantaged than Wayne County as a whole, an area reflective of other urban populations with a large percentage of African Americans, reporting nearly 10% higher unemployment (Wayne County: 17.4%),

\$10,000 lower median household income (Wayne County: \$41,886), and 16% less residents with less than a high school education (Wayne County: 11.5%). These statistics show the census tracts where children with SCD reside in Wayne County are at a severe socioeconomic disadvantage compared with the rest of the United States.

Strengths of this study include identification of the study population using NBS records with a confirmatory result from MDCH. This allowed us to identify children with SCD using the recognized gold standard, blood testing, along with the criterion of continuous enrollment to ensure full capture of all health care claims. However, there are also limitations to this study. Addresses of children were assessed on January 1 of each year of continuous enrollment. Children may have moved in or out of Wayne County within the year, and been inappropriately included, excluded, or attributed to the incorrect neighborhood based on their address. Identification of neighborhoods using census tracts is a crude measure of neighborhood and may not be reflective of the true boundaries that define the residence of children with SCD. The ACS estimates used may introduce bias as 5-year estimates were used. These estimates refer to the sociodemographic characteristics over the entire study period and may not be reflective of the tract-level characteristics each year. The neighborhood variables in this analysis may not have accurately captured the sociocultural and economic variability of the neighborhoods. Additional neighborhood variables may influence TCD screening, such as availability of medical resources, neighborhood safety, and reliability of public transportation, which were not considered. In addition, receipt of TCD screening was determined using Medicaid administrative claims, which may be incomplete and/or inaccurate. However, a recent study assessing the accuracy of administrative claims demonstrated high sensitivity of claims to identify TCD screening when compared with documentation in the medical record.<sup>29</sup> This suggests that using administrative claims to capture TCD screening is an appropriate strategy to capture this type of healthcare utilization.

As the purpose of TCD screening is to identify children at a high risk of stroke and initiate stroke-prevention strategies, identifying rates of stroke within the population as TCD screening increases may also be informative; however, we did not assess the incidence of stroke during this time period, as administrative claims have been shown to be unreliable for capturing stroke in this population.<sup>30</sup> In addition, as this study utilized administrative claims, the clinician perspective regarding opportunities and current policies for TCD screening was not available. Therefore, we were unable to explore explanations for the lack of a TCD screen, such as if the TCD was ordered but not performed, or an appointment was missed. Only children enrolled in Michigan Medicaid were included; however, 70% of children born in Michigan with SCD have a Medicaid ID suggesting these cases are generally representative of the population of children with SCD in Michigan. Further, the sample size was low for this study; adequate power to detect spatial correlation with this data may not have been present.

In conclusion, our results did not show an association between neighborhoods and receipt of TCD screening among children with SCD in Wayne County enrolled in Michigan Medicaid, indicating that additional barriers to screening may exist among patients and providers, and



**FIGURE 2.** Tract-level transcranial Doppler screening rates in Wayne County, MI, from 2007 to 2011.

further investigation of correlates of TCD screening is necessary. Strategies are clearly needed to improve the translation of the clinical trial evidence supporting TCD screening to the population in this geographic area to reduce the incidence of stroke.

**TABLE 2.** Neighborhood Level Factor Associations With Receipt of Transcranial Doppler Screening Among Children With Sickle Cell Disease in Michigan Medicaid Residing in Wayne County, 2007 to 2011\*

	Odds Ratio; 75th vs. 25th Percentile	Confidence Interval
% unemployment	0.98	0.67, 1.43
% African American residents	0.97	0.82, 1.15
% less than high school education	1.27	0.86, 1.86
Median household income	0.97	0.70, 1.33

\*Adjusted for age.

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