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Geographic Variation in Mortality Among Children and Adolescents Diagnosed with Cancer in Tennessee: Does Race Matter?

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Abstract

Cancer is one of the leading causes of death among children in the United States. Previous research has examined geographic variation in cancer incidence and survival, but the geographic variation in mortality among children and adolescents is not as well understood. The purpose of this study was to investigate geographic variation by race in mortality among children and adolescents diagnosed with cancer in Tennessee. Using an innovative combination of spatial and non-spatial analysis techniques with data from the 2004–2011 Tennessee Cancer Registry, pediatric deaths were mapped and the affect of race on the proximity to rural areas and clusters of mortality were explored with multivariate regressions. The findings revealed that African American children and adolescents in Tennessee were more likely than their counterparts of other races to reside in rural areas with close proximity to mortality clusters of children and adolescents with a cancer. Findings have clinical implications for pediatric oncology nurses regarding the delivery of supportive care at end of life for rural African American children and adolescents.

Introduction

In the United States, cancer is one of the leading causes of death among children. It is estimated that more than 15,500 children are newly diagnosed with cancer and almost 2,000 pediatric cancer deaths occur each year (American Cancer Society, 2014; Hamilton et al., 2013; Ward et al., 2014). The most common causes of cancer-related mortality include leukemia, central nervous system cancers, and lymphomas (Hamilton et al., 2013). Despite medical advances in pediatric cancer screening and treatment, racial disparities in cancer exist. In the past decade there has been a 1.3% increase in the cancer rate among African American children, with significantly higher mortality rates than other racial groups (Center for Disease Control and Prevention, 2007; Goggins et al. 2012; Henderson et al., 2011; Pui et al., 2012; Siegal et al., 2014), even though the overall rate of childhood cancers has

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remained stable during this time (CDC, 2007; Siegal et al., 2014). Additionally, mortality among children and adolescents with cancer varies geographically with high rates in the West and South of the United States (CDC, 2007).

Previous research has examined geographic variation in cancer incidence (Li et al., 2008; Openshaw et al., 2003; Steliarova-Foucher et al., 2004; Siegal et al., 2014) and survival (Steliarova-Foucher et al., 2004; Youlden et al., 2011; Valery et al., 2013), but the geographic variation in mortality among children and adolescents is not as well understood. Recent work found that mortality among children and adolescents with cancer was geographically dispersed across the state of Tennessee, and that geographic variation in mortality was relatively consistent over a three-year period (Lindley & Edwards, 2014). In a study conducted in Texas, Lin and Zhan (2014) investigated geographic variation in cervical cancer mortality among girls and women by race and ethnicity. Using 1995 to 2008 Texas Cancer Registry data and 2000 US Census data, these researchers found that a significantly higher cervical cancer mortality rate was present among African Americans in eastern Texas and several urban areas (Houston, Austin-San Antonio, Dallas-Fort Worth). This emerging research suggests that geographic variations in mortality exist among children and adolescents with cancer and that race might be an indicator of geographic variation.

However, there is still a lack of specific knowledge about geographic variation. For example, there is a gap in knowledge of urban and rural differences in mortality among children and adolescents with cancer. In addition, little is known about the geographic clustering of mortality, especially by race. Improving the understanding of urban/rural geographic variation in mortality, along with clustering of mortality, may provide important location information that informs the practice of oncology nurses caring for these children and adolescents at end of life.

The main objective of this study was to investigate geographic variation by race in mortality among children and adolescents diagnosed with cancer in Tennessee. This research addressed four specific questions: (1) How does mortality vary by urban/rural areas; (2) What affect does race have on proximity to rural areas; (3) How does mortality cluster geographically; and (4) What affect does race have on proximity to mortality clusters?

Methods

Study Design and Data Source

The data source for the retrospective, correlational study was the 2004 to 2011 Tennessee Cancer Registry (TCR). The TCR is a state-wide population cancer surveillance system that includes information on all cancer incidents diagnosed in Tennessee. Data were collected and reported by the Tennessee Department of Health in accordance with federal reporting guidelines for cancer registries. Data from 2004 was used as the study's starting point because this is the first year that Tennessee Cancer Registry data was compliant with national registry standards and 2011 data as its end point because it was the most current available. Tennessee Cancer Registry data files contain individual-level demographics, death information, diagnostic information, and geocoded addresses (latitude and longitude). The

study was approved by the Institutional Review Boards of the University of Tennessee, Knoxville, and the Tennessee Department of Health.

Sample

There were 315 children and adolescents who met the study eligibility criteria: they had a cancer diagnosis, were registered in the TCR, and died between 2004 and 2011. Children and adolescents were included in the study if they died in Tennessee. Children and adolescents were excluded if they were over 21 years of age or had missing data. A power analysis was conducted and it was determined that a sample of 139 children would be needed based on 15 regressors to provide adequate statistical power. After applying inclusion and exclusion criteria, the final study sample was 192 children and adolescents, which had sufficient power to detect variations in geographic cancer mortality at the 0.05 significance level.

Measures

Dependent variables—Two measures of geographic variation in mortality were developed for this study. The first measure was *proximity to rural areas*, which was defined as whether or not a child's residence was more than 10 miles from an urban area. Urban areas used in the study were the major cities within Tennessee including Memphis, Nashville, Chattanooga, Knoxville, and Bristol. The ten-mile range was assumed to represent the urban limit, which includes the inner city, midtown, and immediate suburbs. Previous studies have used similar proximity metrics to assess a broad range of exposure (Basua et al., 2004; McKenzie et al., 2012; McKenzie et al., 2014; Ghosh et al., 2013 B; Ghosh et al., 2013 A; Oyana et al., 2004). The second measure was *proximity to geographic clusters* with high mortality rates. This was operationalized as whether or not a child's residence was within 10 miles of a high-density area of deaths among children and adolescents diagnosed with cancer. These are referred to as geographically "hot spots" where high values of child and adolescent decedents significantly cluster.

Independent variables—For this study, a categorical *race* variable was created that included Caucasian, African American, and other races (e.g., Asian American, Native American).

Control variables—A set of demographic and health characteristics was created as control variables. *Age* was defined as the age of the child at death. *Gender* was operationalized as male or female. *Insurance status* was a category measurement of public insurance, private insurance, or no insurance. *Metastasis* was whether or not the child's cancer had metastasized upon diagnosis. Whether or not the cancer had advanced to the lymph system upon diagnosis was the measure of *lymph involvement*. Separate variables were created for the child's primary cancer diagnosis, which included central nervous system (CNS), leukemia, soft tissue, endocrine, bones/joints, reproductive, urinary, digestive, lymphoma, and other cancers.

Data Analysis

Spatial data analysis—The primary aim of the study was to examine the relationship between race and geographic variation in mortality among children and adolescents with cancer. To examine how mortality varied by urban/rural areas and how mortality clustered geographically, ArcGIS 10.2.2 (ESRI Inc., Redlands, California) was used to create a series of maps visualizing urban/rural variation and clusters of deaths among children and adolescents, based on census-tract (Oyana et al., 2010). Points on the map were used to illustrate the location of the child's residence. In order to maintain the family's anonymity, addresses were coded within a 1-kilometer perimeter of the residence. For each map, the major urban cities of Tennessee, including Nashville, Memphis, Chattanooga, Knoxville, and Bristol were highlighted. Rural areas were designated as geographic areas 10 miles or more from the major cities. Choropleth mapping techniques were used to display the urban/rural mortality rates and clusters of mortality among children and adolescents diagnosed with cancer. To create the clusters, a spatial analysis technique called hot spot analysis was used. This method geographically evaluates the extent to which values of pediatric deaths are spatially surrounded by similarly high (hot spot) values.

Non-spatial data analysis—Descriptive statistics were obtained on the children and adolescents in the sample, including geographic, demographic, and health characteristics using pooled, cross-sectional data. To evaluate the relationship between race and proximity to rural areas and between race and proximity to geographic clusters with high mortality among children and adolescents diagnosed with cancer, multivariate regressions were conducted. Due to the binary nature of the outcome variables, a logistic regression model was used to estimate the relationships. Individual regression analyses were conducted for each of the dependent variables. The analysis results are presented as adjusted odds ratios (AORs) and 95% confidence intervals (CIs). These analyses are conducted using Stata 11.0 software (Statcorp LP, College Station Texas).

Results

Table 1 displays the characteristics of the children and adolescents with a cancer diagnosis and died in Tennessee from 2004 to 2011. Of the study sample, 78% of the children were Caucasian and the average age was 11 years. Most children and adolescents were male (52%) and less than half had private health insurance (44%). Approximately a quarter of the children and adolescents (24%) had metastasis upon diagnosis and 14% had lymph involvement. The four most common types of cancer were CNS (30%), leukemia (23%), bones and joints (10%), and soft tissue (10%). Sixty-five percent resided in rural areas more than 10 miles from the urban centers of Memphis, Nashville, Knoxville, Chattanooga, and Bristol and 66% of the children resided within 10 miles of a cluster of high pediatric cancer mortality.

The urban/rural pediatric cancer mortality is mapped in Figure 1. Pediatric deaths were geographic dispersed across Tennessee. Of the 315 children and adolescents with cancer, rural areas of the state had the most deaths with 182 children and adolescents. In urban areas, Memphis had 45 cancer deaths, followed by 44 in Nashville, 27 in Knoxville, 12 in

Chattanooga, and 5 in Bristol. Areas of very high mortality were present in the rural and several urban areas of Tennessee.

The analysis estimating the association between race and proximity to rural areas is shown in Table 2. The odds of residing in rural areas, more than 10 miles from the five major cities, was almost five times higher for African American children and adolescents (odds ratio: 4.66 [95% confidence interval: 1.62–13.38]) compared to Caucasian children and adolescents. No other demographic or health characteristics were related to proximity to rural areas.

The clusters of mortality among children and adolescents are visualized in Figure 2. In total, there were 41 clusters of mortality among children and adolescents with cancer over the 8-year time period. A majority of clusters (n=30, 73.2%) were located in rural areas. There were 11 clusters (26.8%) within urban areas including 4 in Memphis, 3 in Nashville, 2 in Knoxville, 2 in Chattanooga, and 0 in Bristol.

The results of the analysis between race and proximity to geographic clusters of mortality are presented in Table 3. The odds of residing near a mortality cluster were three times higher for African American children and adolescents (odds ratio: 2.92 [95% confidence interval: 1.13–7.54]) than their Caucasian counterparts (Table 3). No other demographic or health conditions were related to residing within 10 miles of a cluster.

Discussion

The goal of this study was to examine the relationship between race and geographic variation in mortality among children and adolescents with cancer in Tennessee during an eight-year period. Using an innovative combination of spatial and non-spatial analysis techniques, pediatric deaths in Tennessee were mapped and the affect of race on the proximity to rural areas and clusters of mortality were explored, while controlling for demographic and health characteristics of children and adolescents.

In this analysis, it was discovered that African American children and adolescents in Tennessee were more likely than their counterparts of other races to reside in rural areas with close proximity to mortality clusters of children and adolescents with a cancer. More specifically, African American children and adolescents tended to reside more than 10 miles from an urban center, and yet they also tended to be within 10 miles of a cluster of deaths. A possible explanation for the clustering of African American children and adolescents who died with cancer in rural areas may be attributable to a lack of health care resources in the area. In many rural areas of Tennessee, communities are designated as Health Professional Shortage Areas (HPSA) and Medical Underserved Areas and Populations (MUAP) (USDA, 2014; US Department of Health & Human Services, 2014). HPSA and MUAP areas would lack access to clinicians such as primary care physicians that might be critical for detecting and screening childhood and adolescent cancers (State of Tennessee, Department of Health, 2014). As a result, rural Tennessee children might be at risk for suboptimal supportive care (e.g., hospice care, palliative care) for controlling pain, managing central lines, and treating infections, which might impact the number deaths. Although the analysis did not allow an

examination of issues of disparities in health care delivery, further geographic research might investigate the potential link between HPSAs and MUAP and clusters of African American children and adolescents who die with a cancer diagnosis in rural areas.

To investigate whether African American children and adolescents with cancer resided near clusters of mortality regardless of area, a supplemental analysis of the geographic clusters of mortality in the five major urban areas was conducted. It was discovered that, although few African American children and adolescents resided in urban centers, when they did reside in urban areas, they were still near clusters of mortality. These findings are consistent with other researchers who report that cancer continues to be a concern among African American children and adolescents regardless of location (Siegal et al., 2014).

Although this is one of the few studies examining the geography of mortality among children and adolescents with cancer, there are a number of limitations. This study was conducted in Tennessee, which limits its generalizability. In addition, there were variations in sizes and shapes of different urban areas in Tennessee that may not be captured by these proximity metrics. Identified cluster can serve as a basis for designing more in-depth studies. Finally, a wider perspective might be obtained by exploring a longer time period.

Despite the limitations, the findings from this study have clinical implications for pediatric oncology nurses. The findings from this study suggest that rural African American children and adolescents may be at increased risk for suboptimal health care services (i.e., supportive care). For those children and adolescents who reside in rural areas, supportive care is often unavailable (Lindley & Edwards, 2014; Madigan et al., 2009). However, when rural supportive care is available, providers often have a service area that extends over several counties and can take staff 2 to 3 hours to traverse. Geographic information that identifies the clusters of children and adolescents with cancer at end of life may enable supportive care providers to target their efforts, especially to rural children and adolescents (Lindley, 2014). Supportive care providers who know where rural children and adolescents are generally located might align their staff and resources to better meet these needs of rural African American children and adolescents and ultimately, improve the end-of-life care for children and adolescents with cancer.

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Biography

Author Biography: Lisa C. Lindley, PhD, RN is a nurse researcher at the University of Tennessee, Knoxville. Tonny J. Oyana, PhD is a geographer at the College of Medicine at the University of Tennessee Health Science Center.

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Figure 1.
Map of Urban/Rural Mortality Among Children and Adolescents Diagnosed with Cancer in Tennessee, 2004 to 2011.

Figure 2.
Map of Mortality Clusters Among Children and Adolescents Diagnosed with Cancer in Tennessee, 2004 to 2011.

Table 1

Characteristics of Study Sample (N=192)

Variables	No.	Percentage/Mean	Standard Deviation	95% CI
Race				
Caucasian (%)	150	78.13	—	72 to 83
African American (%)	36	18.75	—	14 to 25
Other (%)	6	3.13	—	1 to 7
Age	192	11.07	7.09	
Gender				
Male (%)	100	52.08	—	45 to 59
Female (%)	92	47.92	—	41 to 55
Insurance Status				
Public insurance (%)	100	52.08	—	46 to 59
Private insurance (%)	85	44.27	—	37 to 51
No insurance (%)	7	3.65	—	2 to 8
Metastasis (%)	47	24.48	—	19 to 31
Lymph Involvement (%)	28	14.58	—	10 to 20
Cancer Type				
CNS (%)	58	30.21	—	24 to 37
Leukemia (%)	44	22.92	—	18 to 30
Soft Tissue (%)	19	9.90	—	6 to 15
Endocrine (%)	9	4.69	—	2 to 9
Bones & Joints (%)	20	10.42	—	7 to 16
Reproductive (%)	9	4.69	—	2 to 9
Urinary (%)	9	4.69	—	2 to 9
Digestive (%)	7	3.65	—	2 to 8
Lymphoma (%)	10	5.21	—	3 to 9
Other Cancer (%)	16	8.34	—	5 to 13
Proximity to Rural Areas (%)	124	64.58	—	58 to 71
Proximity to Geographic Clusters (%)	128	66.67	—	60 to 73

Note: CNS, central nervous system

Table 2

Results of Regression Analysis for Proximity to Rural Areas (N=192)

Variables	AOR	(SE)	95% CI
Independent Variables			
Race			
Caucasian	ref		
African American	4.66	** 2.51	1.6242–13.3848
Other	1.59	1.52	0.2452–10.3516
Control Variables			
Age	1.01	0.03	0.9637–1.0651
Female	1.61	0.55	0.8246–3.1606
Insurance Status			
Public insurance	ref		
Private insurance	1.12	0.39	0.5680–2.2061
No insurance	0.63	0.54	0.1198–3.3637
Metastasis	0.73	0.36	0.2757–1.9247
Lymph Involvement	1.58	1.04	0.4350–5.7278
Cancer Type			
CNS	ref		
Leukemia	1.47	0.65	0.6153–3.4921
Soft Tissue	1.91	1.26	0.5192–6.9910
Endocrine	2.33	2.40	0.3088–17.5774
Bones & Joints	1.56	0.92	0.4851–4.9882
Reproductive	omitted		
Urinary	1.87	1.77	0.2907–12.0027
Digestive	0.39	0.37	0.0604–2.5197
Lymphoma	0.81	0.60	0.1901–3.4632
Other Cancer	0.82	0.72	0.1475–4.5369

*
 $p < 0.05$,**
 $p < 0.01$,***
 $p < 0.001$

Note: AOR, adjusted odds ratio; CNS, central nervous system; SE, Standard error

Table 3

Results of Regression Analysis for Proximity to Mortality Clusters (N=192)

Variables	AOR	(SE)	95% CI
Independent Variables			
Race			
Caucasian	ref		
African American	2.92	** 1.41	1.1304–7.5419
Other	omitted		
Control Variables			
Age	0.98	0.03	0.9313–1.0312
Female	0.73	0.25	0.3731–1.4236
Insurance Status			
Public insurance	ref		
Private insurance	1.26	0.44	0.6392–2.4893
No insurance	1.51	1.39	0.2449–9.2539
Metastasis	0.45	0.24	0.1648–1.2547
Lymph Involvement	2.52	1.91	0.5710–11.1360
Cancer Type			
CNS	ref		
Leukemia	0.92	0.41	0.3856–2.2026
Soft Tissue	2.24	1.54	0.5787–8.6560
Endocrine	1.65	1.84	0.1856–14.6846
Bones & Joints	1.09	0.65	0.3395–3.4803
Reproductive	2.03	1.91	0.3201–12.8601
Urinary	1.51	1.51	0.2104–10.7946
Digestive	1.14	1.19	0.1466–8.8133
Lymphoma	1.57	1.25	0.3298–7.4731
Other Cancer	3.24	3.81	0.3247–32.3617

*
 $p < 0.05$,**
 $p < 0.01$,***
 $p < 0.001$

Note: AOR, adjusted odds ratio; CNS, central nervous system; SE, Standard error