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Rural and Urban Ecologies of Early Childhood Toxic Lead Exposure: The State of Kansas, 2005 to 2012

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ABSTRACT

Introduction. No safe detectable level of lead (Pb) exists in the blood of children. Until recently, U.S. Centers for Disease Control and Prevention (CDC) guidelines designated a blood lead level (BLL) ≥ 5 μg/dL as an elevated BLL (EBLL). For the State of Kansas, early childhood blood lead burdens lack reporting in the literature.

Methods. Secondary analysis was conducted of passively reported EBLL rates ≥ 5 μg/dL among children ages 0 - 5 years at the zip code-level in Kansas during 2005 to 2012. Data weights using corresponding population estimates were applied to produce statewide outcomes.

Results. Statewide estimates of annual testing coverage in Kansas among children ages 0 - 5 years were low (9.7%). Approximately 17,000 children ages 0 - 5 years developed an EBLL ≥ 5 μg/dL each year in Kansas with a 6.9% statewide EBLL rate compared to the national rate of 3.2% for the corresponding years. Significant variations in EBLL rates were found between suburban zip codes compared to urban, urban cluster, or rural at 3.1%, 7.2%, 8.8%, and 10.0%, respectively. Among the worst outcomes in EBLL rates was observed for zip codes in southeast Kansas (13.5%) and rural areas with < 500 persons (15.1%).

Conclusions. Young children in Kansas had twice the risk of developing an EBLL ≥ 5 μg/dL compared to the national rate, while higher rates consistently were seen outside of the suburbs and particularly in more rural and less populated areas. At-risk children and troubled areas of toxic lead exposure in the State of Kansas require increased recognition with improved targeting and interventions.

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INTRODUCTION

Lead (Pb) is a soft, dull gray-colored metal that poses significant systemic and neurotoxic properties that particularly are pronounced among young children.[1] Even at lower levels, exposure to lead during early childhood can result in a variety of negative outcomes to attention, behavior, cognition, decision-making, intellect, memory, and mental health.[2-14] Lead-induced neurotoxicity in children primarily impacts the cerebellum, hippocampus, and prefrontal cerebral cortex.[15] Decreased brain volume and lower structural brain integrity is found in adults with greater lead exposure during childhood.[16-18] Developing infants are the most vulnerable to lead and suffer more exposure in part from their comparatively greater body surface area, higher heart and respiratory rates, ingestion and inhalation of contaminated dust or soil from greater hand-to-mouth activity, pica, floor-level sitting and crawling, and low stature to the ground where lead dust settles.[19]

There has been a significant reduction of the early childhood blood lead burden from an average 16 μg/dL during 1976 to 1980 to a historic low of 2 μg/dL during 2007 to 2010 as a result of public health policies and interventions.[20-24] The CDC previously designated a blood lead level (BLL) ≥ 5 μg/dL as an elevated BLL (EBLL),[20] which recently was revised down to 3.5 μg/dL.[25] However, both the CDC and the American Academy of Pediatrics (AAP) officially recognize that there is no safe level of lead exposure or amount of lead in the blood of children.[26,27] In particular, there is a measurable loss of grade school intelligence quotient (IQ) points even with BLLs beginning at 2 μg/dL during the first two years of life.[4,14] Other negative outcomes associated with early childhood blood lead below the 5 μg/dL EBLL threshold include greater risk of attention-deficit/hyperactivity disorder (ADHD)-like symptoms,[28] childhood anemia and decreasing iron status,[29] and lower math and reading test scores in school.[30] In the U.S., billions of dollars a year in costs are estimated just from lost IQ points alone from early childhood lead exposure and present with significant racial disparities that disproportionately impact Black children as a result of greater amounts of lead exposure.[31]

For the State of Kansas, there is a paucity of published literature examining historical and ongoing lead hazards in the environment, in addition to burdens of lead exposure among the population. Only two descriptive studies published in the state medical and nursing journals for Kansas in 1993 and 1994, respectively, have assessed the early childhood blood lead burden in the state.[32,33] More recent research by the CDC in 2015 found that workers in Kansas ages 16 years and older have the second highest rate of an EBLL ≥ 10 μg/dL at 77.3 in 100,000 persons, followed by the State of Missouri with 106.7 in 100,000.[34] Two other studies of lead exposure in Kansas published in 1999 and 2016 examined early childhood BLLs and observed positive associations with increasing concentrations of soil contamination or anthropogenic lead emissions resulting from industrial activity.[35,36] Therefore, recent descriptions of the childhood blood lead burden in Kansas were lacking.

In 2016, the Reuters news agency reported that thousands of locales in the U.S. were experiencing early childhood EBLL rates that exceeded those which occurred in Flint, Michigan at the peak of its water crisis between 2014 and 2016.[37] The following year, Reuters published data for the State of Kansas after it was disclosed to the news agency. Therefore, these data were utilized to conduct an investigation of Kansas for the years of 2005 to 2012.

METHODS

Study Sample. Data of blood lead testing provided to Reuters were retrieved in their national reporting,[37] which originally were obtained from various state health departments and the CDC. For the State of Kansas, this included an eight year survey period between 2005 and 2012 of children ages 0 - 5 years. Tests for blood lead were reported passively by providers to the Kansas Department of Health and Environment (KDHE), which discloses the data for the total number of overall tests and the total number of EBLL cases at the zip code-level. The KDHE uses CDC guidelines to identify an EBLL ≥ 5 µg/dL by rounding to the first decimal place and using values 4.5 µg/dL or higher.[20] However, the KDHE suppressed data for zip codes reporting > 0 but < 5 total tests or EBLL cases as a result of privacy concerns. Similar to other states, early childhood blood lead testing primarily involves an initial capillary blood test that typically is followed by a subsequent whole blood venous to confirm an EBLL identified via capillary testing. When multiple blood lead tests exist for an individual case in a given year, the highest blood lead value is identified, while other results are removed to prevent multiple entries in reporting. Lastly, nationwide reporting was retrieved for children ages 1 - 5 years from the 2005 to 2012 National Health and Nutrition Examination Survey (NHANES), which is a nationally-representative cross-sectional survey (www.cdc.gov/nchs/nhanes.htm).[38]

Geographic Designations. Zip codes in Kansas were categorized by their most populous city. Individual zip codes within multiple counties were designated to the county where the largest proportion of their population resided. Zip codes were categorized as either suburban, urban, urban cluster, or rural. As shown in Figure 1, urbanized metropolitan areas and urban clusters were defined using official designations from the 2010 census for the State of Kansas.[39] Urban zip codes included the three major urban cities of Kansas City, Topeka, or Wichita. Suburban designation was reserved for all other remaining zip codes within urbanized areas, in addition to the cities of Lawrence and Manhattan. Urban cluster cities are smaller urbanized capitals throughout the rest of Kansas that serve as the county seats for their respective counties, although not every county in the state has an urban cluster. Rural zip codes were designated as any other remaining zip codes that did not match one of the three aforementioned criteria. Lastly, the KDHE defines six different regions within the state along county lines. Zip codes were assigned to each region corresponding to their designated county.

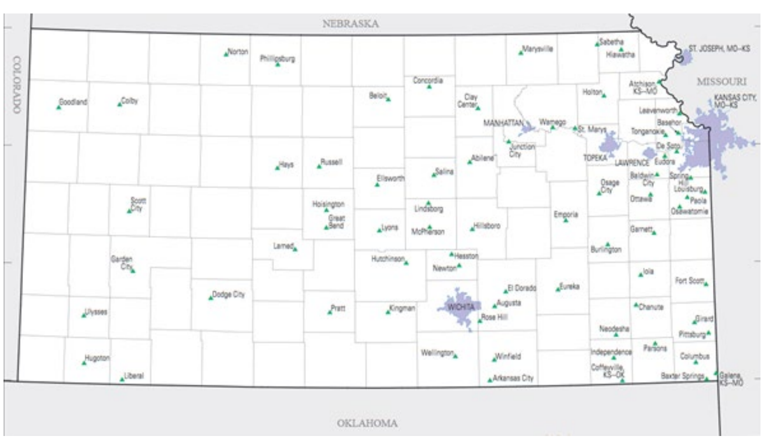

Figure 1. Urbanized metropolitan areas (dark blue) and urban cluster cities (green triangles) in the State of Kansas, 2010 census (US Census Bureau, 2012).

Statistical Design and Analysis. Early childhood EBLL rates were derived by dividing the total number of EBLL-positive cases by the total number of overall tests for each zip code. To produce statewide estimates, EBLL rates were weighted by total population estimates of children 0 - 5 years of age. Population weights were constructed by using five year estimates of the total population (all ages) for each zip code from the American Community Survey (ACS), which involved the survey years of 2015 to 2019 as a result of limited data availability. To construct childhood population weights, total population estimates were multiplied by the percentage of the population accounted for by children ages 0 - 5 years within each county corresponding to the zip code as reported from the 2010 census.[39] As previously mentioned, the KDHE suppressed the reporting of data when a zip code has > 0 but < 5 blood lead tests and/or EBLL cases over privacy concerns. To address this issue, data imputation was performed using a uniform distribution of values {1, 2, 3, 4} that conferred equal probability to each number being retrieved for suppressed data. Suppressed EBLL cases were not imputed for zip codes in which the total number of blood lead tests also had been suppressed, which were treated as unavailable data. Annual blood lead testing coverage was determined from multiplying estimated population totals for children 0 - 5 years of age by the eight survey years and dividing total BLL tests by that figure, while three zip codes were set to 100% as a result of exceeding that value. Simple regression analysis was used to assess linear trends while statistical significance was determined by a p value ≤ 0.05 for all testing.

RESULTS

Descriptive Statistics. As shown in Figure 2, unsuppressed data for blood lead testing rates were available from 662 zip codes (95.4%) and demonstrated a low average rate of testing statewide at 11.8%. Data including imputation for rates of an EBLL ≥ 5 µg/dL were available from 655 zip codes (94.4%) that included 45 suburban, 50 urban, 82 urban cluster, and 478 rural areas. As shown in Table 1, these examined zip codes represented an estimated 247,320 children 0 - 5 years of age (99.7%) residing in the State of Kansas in a given year. Within these zip codes, there was a total of 192,474 individual blood lead tests passively reported to the KDHE over the eight year survey period. Among the included blood lead tests, there were a total of 15,937 EBLL-positive cases at an 8.3% EBLL rate. A total of 635 EBLL-positive cases were imputed for 261 zip codes with suppressed data involving an estimated 22,449 children ages 0 - 5 years. There were seven zip codes with no blood lead testing involving an estimated 135 children ages 0 - 5 years, in addition to 32 zip codes with unavailable data as a result of suppressed data for both blood lead tests and EBLL-positive cases involving an estimated 628 children ages 0 - 5 years.

Weighted Outcomes. Weighted estimates for children ages 0 - 5 years were produced for blood lead outcomes among zip codes. As shown in Table 2, an estimated 16,928 EBLL-positive cases occurred each year in Kansas with an early childhood EBLL rate at 6.9% compared to the national rate at 3.2% produced from the NHANES data for the corresponding years of 2005 to 2012. Therefore, young children in the State of Kansas had more than twice the risk of developing an early childhood EBLL than their peers at the national level.

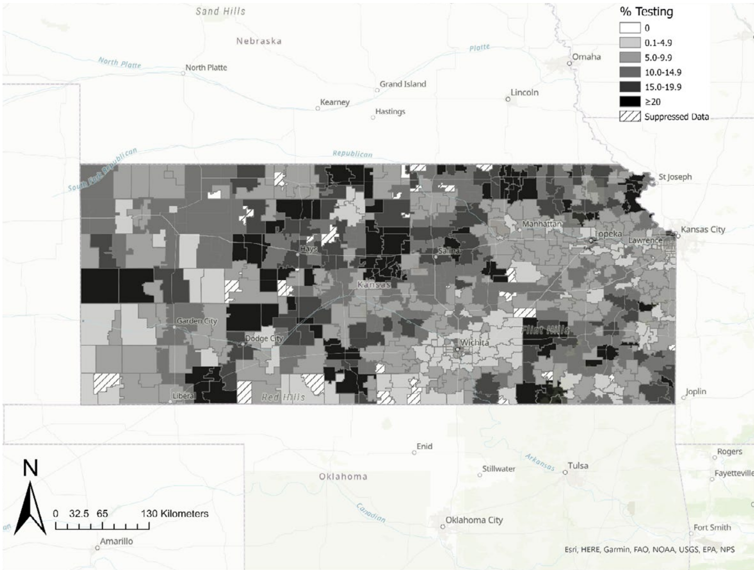

Figure 2. Passive reporting of blood lead levels among children ages 0 - 5 years to the Kansas Department of Health and Environment (KDHE), the State of Kansas, 2005 to 2012.

As shown in Table 2, risk was the lowest for suburban zip codes at an EBLL rate of 3.1%, which is where the lowest number of EBLL-positive cases occurs despite involving the greatest proportion of young children who reside in Kansas. In contrast, much higher rates were seen for urban and urban cluster zip codes at an EBLL rate of 7.2% and 8.8%, respectively. However, the highest rates were seen for rural zip codes at an EBLL rate of 10.0%, which was where the smallest proportion of young children in Kansas reside. Overall, the largest number of EBLL-positive cases occurred in urban cluster cities that stems from both their high EBLL rates and large proportional share of the total pediatric population.

The worst outcomes in EBLL rates observed in Table 2 were for zip codes in counties with a population density < 10 persons per square mile (11.0%), zip codes in counties with a ≥ 40% rural population (11.1%), urban cluster zip codes with a total population < 5,000 persons (12.0%), and rural zip codes that had a total population < 500 persons (15.1%). Regionally, the lowest rates at 4.9% were observed for the Northeast where Johnson County is located, which is predominately suburban and also the most populous county in the state. The highest rates were seen for Southeast Kansas at an EBLL rate of 13.5%, which is more than twice as high compared to the Northeast region.

As shown in Figure 3, there was a small yet significant linear association for Kansas zip codes between increasing early childhood EBLL rates and decreasing log^{10} total population estimates ($R^2 = 0.121$; $\beta = -0.349$; B = -5.03 [S.E. 0.53]; $p < 0.001$). Similar findings were seen in Table 2 in which increasing EBLL rates occurred in a stepwise fashion with categories of decreasing total population estimates among suburban, urban cluster, and rural zip codes. Significant yet weaker linear associations also were observed with log^{10} county-level population densities ($R^2 = 0.069$; $\beta = -0.262$; B = -3.62 [S.E. 0.52]; $p < 0.001$) and county-level rural population percentages ($R^2 = 0.040$; $\beta = 0.200$; B = 0.60 [S.E. 0.01]; $p < 0.001$).

It was hypothesized that rural and urban cluster zip codes located in areas that were more rural and isolated suffered from higher EBLL rates. As shown in Figure 3, the strongest linear associations with increasing EBLL rates were observed among urban cluster cities located in counties with greater percent rural population ($R^2 = 0.207$; $\beta = 0.455$; B = 1.32 [S.E. 0.03]; $p < 0.001$) or counties with decreasing log^{10} population densities ($R^2 = 0.200$; $\beta = -0.448$; B = -4.98 [S.E. 1.11]; $p < 0.001$). However, there was no association among rural zip codes between increasing EBLL rates and increasing rural population ($R^2 = 0.004$; $\beta = 0.061$; B = 0.22 [S.E. 0.02]; $p = 0.182$) and only a very weak significant association with log^{10} population densities ($R^2 = 0.018$; $\beta = -0.133$; B = -2.83 [S.E. 0.97]; $p = 0.004$)

As shown in Table 3, population estimates and total EBLL cases for zip codes in different categories for EBLL rates were examined. Based upon these categories, a visual illustration of varying EBLL rates among zip codes across the state is displayed in Figure 4. This revealed that more than 1 in 5 young children in Kansas (21.7%) lived in zip codes with an EBLL rate at least three times higher than the national average of 3.2% at the time, which accounted for nearly half of all EBLL cases (44.7%) across the state.

Lastly, as shown in Table 4, estimates for statewide blood lead testing coverage among children ages 0 - 5 years residing in the State of Kansas were low at 9.7% with the lowest testing in zip codes that were suburban (5.6%) compared to zip codes that were urban (11.5%) or urban clusters (12.3%) that had the greatest testing coverage. Furthermore, rural areas had lower testing rates (9.7%) despite having the highest rates of developing an early childhood EBLL.

DISCUSSION

Although our findings were somewhat dated, the current study involved the first descriptive examination of the early childhood lead burden for Kansas in nearly three decades. Compared to the national rate produced from NHANES data, young children in Kansas experienced twice the risk of developing an EBLL. This current study examined the early childhood lead burden in more detail and found that consistently higher rates of elevated blood lead were seen outside of the suburbs and particularly in areas that were more isolated or rural. Higher EBLL rates were correlated with lower population sizes and densities along with greater rural populations. Recently, another study of the national blood lead burden among young children found numerous zip codes in Kansas had the worst risks of developing an EBLL,[40] which were primarily located in rural areas of the state. This strongly suggested far greater early childhood lead exposure was occurring in rural Kansas.

In contrast to other states, higher EBLL rates were found in less urbanized and more rural areas in Kansas. Rural areas typically experience lower EBLL rates than urban cities,[41-44] although similar EBLL rates were found between rural and urban newborns in Iowa.[45] This may be unique to Kansas in part from a greater rural population, major urban cities that are comparatively smaller than others, much older and substandard housing, rural healthcare disparities related to access and affordability, and higher rates of soil contamination and industrial emissions as found in previous studies.[35,36] There also may be a lack of

Table 1. Blood lead testing and population characteristics in the State of Kansas, 2005 to 2012.

Setting		Variable	Summary Statistics			
			Sum	Mean ± S.E.	S.D.	Min-Max
Zip code	%	BLL testing coverage	–	11.8 ± 0.4	11.00	0 to 100
Zip code	%	EBLL-positive tests (≥ 5 μg/dL)	–	11.4 ± 0.4	10.2	0 to 66.7
County	%	Rural population	–	56.8 ± 1.3	34.0	4 to 100
Zip code	N =	BLL tests	192,396	294 ± 27	689	5 to 7,046
Zip code	N =	EBLL-positive tests (≥ 5 μg/dL)	15,937	24 ± 2	60	0 to 632
County	N =	Population density (persons/sq. mile)	–	137 ± 11	289	2 to 1,150
Zip code	N =	Population estimates (all ages)	2,898,982	4,426 ± 325	8,307	29 to 80,489
Zip code	N =	Population estimates (ages 0 - 5 years)	247,320	378 ± 29	741	1 to 6,954

Table 2. Weighted outcomes of elevated blood lead in the State of Kansas, 2005 to 2012.

Setting	Studied Sample Zip Codes N	Population Estimate Ages 0 - 5 Years N	Blood Lead ≥ 5 μg/dL Annual Incidence	
			Rate	N
Nationwide (NHANES)				
Total	–	6,673,044	3.2%	214,551
Statewide				
Total	655	247,320	6.9%	16,928
≥ 10,000 persons	94	176,377	6.0%	10,583
1,000 to 9,999 persons	246	60,442	8.2%	4,956
< 1,000 persons	315	10,501	13.0%	1,365
Suburban				
Total	45	74,265	3.1%	2,311
≥ 30,000 persons	5	20,863	2.4%	505
15,000 to 29,999 persons	18	32,972	3.1%	1,021
< 15,000 persons	22	20,430	3.8%	785
Urban				
Total	50	65,001	7.2%	4,693
Topeka, KS	17	13,766	6.5%	894
Kansas City, KS	9	16,156	7.1%	1,142
Wichita, KS	24	35,079	7.6%	2,657
Urban cluster				
Total	82	72,072	8.8%	6,315
≥ 15,000 persons	17	39,176	7.8%	3,035
5,000 to 14,999 persons	37	25,557	9.4%	2,398
< 5,000 persons	28	7,339	12.0%	882
Rural				
Total	478	35,982	10.0%	3,608
≥ 1,500 persons	111	20,498	8.3%	1,697
500 to 1,499 persons	170	11,430	11.4%	1,298
< 500 persons	197	4,054	15.1%	613
County rural population				
< 20%	138	164,455	5.1%	8,387
20 to 39%	94	32,144	8.8%	2,829
≥ 40%	423	50,721	11.1%	5,630

Table 2. Weighted outcomes of elevated blood lead in the State of Kansas, 2005 to 2012. *continued.*

Setting	Studied Sample Zip Codes N	Population Estimate Ages 0 - 5 Years N	Blood Lead ≥ 5 µg/dL Annual Incidence	
			Rate	N
County population density				
≥ 1,000 persons/sq. mile	42	68,208	3.6%	2,445
100 to 999 persons/sq. mile	86	83,520	6.3%	5,219
10 to 99 persons/sq. mile	308	80,398	9.5%	7,596
< 10 persons/sq. mile	219	15,194	11.0%	1,668
Region				
Northeast	175	112,731	4.9%	5,497
North Central	106	23,110	7.0%	1,606
Southwest	71	17,979	7.5%	1,340
South Central	106	66,499	7.7%	5,124
Northwest	93	9,158	10.3%	945
Southeast	104	17,843	13.5%	2,416

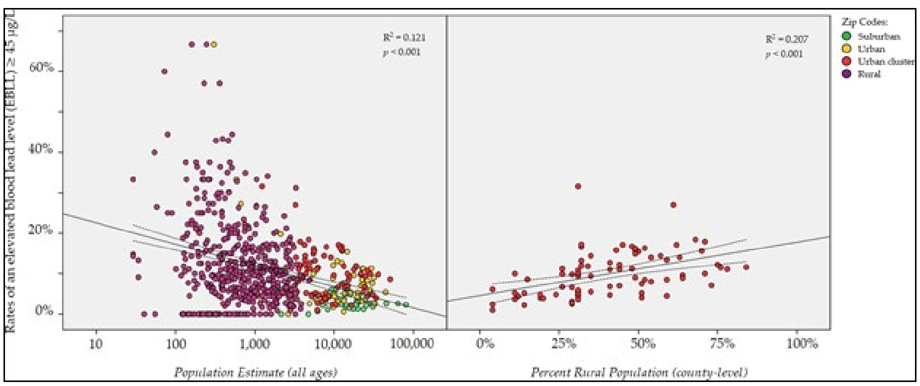

Figure 3. Scatterplots of zip codes with linear trends and 95% confidence intervals for elevated blood lead level (EBLL) rates ≥ 5 µg/dL among children ages 0 - 5 years in the State of Kansas, 2005 to 2012.

Table 3. Weighted outcomes of blood lead testing coverage in the State of Kansas, 2005 to 2012.

Setting	Studied Sample Zip Codes	Population Estimate Ages 0 - 5 Years		Blood Lead ≥ 5 µg/dL Annual Incidence	
	N	N	Percent	N	Percent
Statewide					
Total	655	247,320	–	16,928	–
0%	50	2,482	1.0%	0	0%
>0 to 5%	130	106,426	43.0%	3,147	18.6%
5 to 10%	178	84,896	34.3%	6,209	36.7%
10 to 15%	121	35,600	14.4%	4,143	24.5%
15 to 20%	74	13,769	5.6%	2,275	13.4%
20% or higher	102	4,147	1.7%	1,154	6.8%

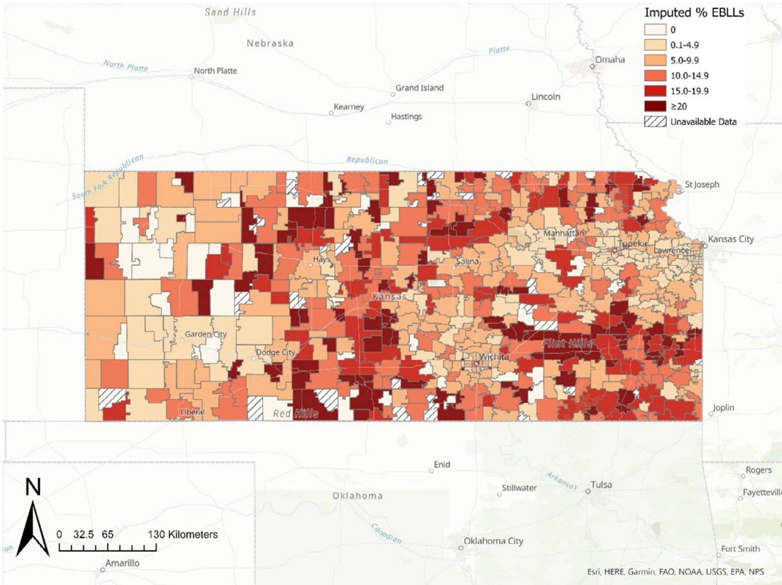

Figure 4. Zip code-level rates of an elevated blood lead level (EBLL) ≥ 5 µg/dL among children ages 0 - 5 years in the State of Kansas, 2005 to 2012.

Table 4. Weighted outcomes of blood lead testing coverage in the State of Kansas, 2005 to 2012.

Setting	Studied Sample Zip Codes N	Population Estimate Ages 0 - 5 Years N	Blood Lead ≥ 5 µg/dL Annual Incidence	
			Rate	N
Statewide				
Total	694	248,083	9.7%	192,474
Suburban	46	74,529	5.6%	33,475
Urban	52	65,067	11.5%	60,008
Urban cluster	82	72,072	12.3%	70,635
Rural	514	36,415	9.7%	28,356

awareness among the public and healthcare providers in rural areas with significant problems related to lead exposure and contamination. Underfunded public health institutions, hospital closures, and a low number of pediatricians and other clinicians in rural areas likely further compound these issues. Lastly, rural children with EBLLs ≥ 10 µg/dL were less likely to have a follow-up blood test,[46] while rural residents have been shown to be less knowledgeable about the prevention of lead exposure.[47]

However, while our findings for rural areas were unique, the findings for urban compared to suburban areas of the state were in agreement with those from other states. Higher early childhood lead burdens in urban areas are well-known and documented in states across the country, which were characterized by significant socio-economic and particularly racial/ethnic disparities that disproportionately impact Black children who are predominately African-American.[31,48] Sources of lead exposure in urban areas included industrial lead emissions,[49,50] soil contamination by industry and automobile traffic that can occur from both historical and ongoing sources of emissions,[51] and older housing containing higher rates of leaded paint and dust. Higher rates of industrial emissions, soil contamination, and household lead hazards still requiring cost-prohibitive remediation disproportionately impacted marginalized Black communities.[49-53] In contrast, suburban areas that typically are more affluent and predominately White were found to have much lower lead burdens compared to other areas outside of the suburbs.[43,44]

By region, the highest EBLL rates were found in Southeast Kansas, which is part of the Midwestern "lead belt" primarily located in Southwest Missouri and also includes Northeast Oklahoma. This region of Kansas has long been impacted by historical and ongoing issues of lead pollution largely resulting from mining and smelting operations centered around the urban cluster city of Galena, Kansas. Previously, two studies on industrial emissions in Kansas found a positive association between higher rates of lead exposure and greater amounts of lead in the blood of children,[35,36] in which a disproportionate share of these industries were located in Southeast Kansas. Workers in Kansas also suffered from the second highest rates of EBLLs ≥ 10 µg/dL in the U.S.,[34] which likely stemmed from greater employment in lead-related industries and can result in take-home contamination that results in childhood lead exposure.[54] Furthermore, many rural areas in Kansas have higher rates of older housing stock and substandard housing.[55] Lastly, the lack of investigations highlighted the need for further study.

Very low testing rates were observed for early childhood blood lead in Kansas, with lower testing rates in suburban and rural zip codes compared to zip codes that are urban or an urban cluster city. These findings revealed a gap between low testing rates and high EBLL rates among young children residing in rural areas of Kansas, which demonstrated the need for increased testing of rural households. Provider education and particularly the availability of point-of-care testing in Pennsylvania were found to increase blood lead testing rates at 1- to 2-year childhood well visits.[56] Such findings also were observed in New Hampshire after the implementation of provider education and point-of-care testing that served as a model for other rural areas.[57] In Ohio, blood lead testing at 1- and 2-year well visits greatly increased after the development of clinical decision-making support tools within the electronic health record.[58] Similar approaches in Kansas could increase early childhood blood lead testing in at-risk areas with low testing rates such as rural communities. Lastly, our findings strongly suggested that federally mandated blood lead testing among children ages 1 - 5 years who are enrolled in Medicaid, the State Children's Health Insurance Program (SCHIP), or other insurance programs that receive title XIX or XXI funding was not occurring frequently as has been seen with other states such as Minnesota and Wisconsin.[59,60]

Some limitations of the current study included a lack of reporting for early childhood EBLLs in zip codes with suppressed data, which led to the use of data imputation for assessing lead burdens in these areas. However, areas with suppressed data accounted for less than 10% of the total pediatric population in Kansas and predominately involved rural zip codes with a very small population. Therefore, this limitation largely involved rural areas that had the highest EBLL rates, while data imputation decreased EBLL rates when utilized and may have led to conservative EBLL estimates. Other limitations included low rates of blood lead testing, low ascertainment rates of EBLLs ≥ 5 µg/dL in Kansas,[61] and reliance on passive reporting to state public health authorities. Furthermore, zip code population estimates of children ages 0 - 5 years were limited by the use of county-level data for the total percent of the population represented by this age group as opposed to actual population counts, while population estimates from 2015 to 2019 were used as a result of limited availability of data regarding population counts for Kansas zip codes. However, the large sample size across several reporting years that was utilized in the present study increased our confidence in the robustness of these findings. Prospective studies still need to elucidate the impacts upon racial/ethnic groups overall and within differing settings. In particular, the conditions of Native children residing in largely rural tribal lands remain unknown.

CONCLUSIONS

Young children in Kansas have much higher EBLL rates than their peers at the national level. The risk of childhood lead exposure in Kansas increased when their residential setting was more rural and less populated, which was contrary to findings from other states in the nation. Wider recognition of at-risk children and troubled areas with regards to childhood lead exposure is needed among the populace, healthcare providers, and public health to address the disparately higher EBLL rates among children in Kansas. Furthermore, better prioritization and improved targeting is needed to identify early childhood lead exposure so that the proper preventative and mitigative interventions may take place. Low testing rates in Kansas could be improved through the promotion of both public and provider education along with greater availability of point-of-care testing. This may identify more EBLL cases among at-risk children while giving a clearer picture of troubled areas in the State of Kansas.

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