Slipped Capital Femoral Epiphysis, Food Deserts, Poverty, and Urban/Rural Residence: Is There a Link?

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Background: Childhood obesity is increased in food deserts, a community with little to no access to healthy food. As obesity is associated with slipped capital femoral epiphysis (SCFE), it was the purpose of this study to analyze the prevalence of SCFE patients by food desert location and its interaction with rural/urban location.

Methods: A retrospective review of all consecutive patients with idiopathic SCFE treated at our institution over 11 years was performed. From the patient's address, the US Census Bureau tract in which the patient resided was determined. Using the census tract code, it was ascertained if the patient lived in a food desert and urban or rural location. Standard statistical analyses were performed; a $P < 0.05$ was considered statistically significant.

Results: There were 177 SCFE patients: 79 girls, 98 boys, 106, White, and 69 nonWhite. The average age at diagnosis was 12.1 ± 1.7 years, the average symptom duration 4.1 ± 5.1 months, and the average weight percentile 94 ± 10. Of these 177 patients, 26.5% lived in a food desert, which was higher than the expected 17.5% ($P = 0.023$). Those living in a food desert were more commonly nonWhite (60% vs. 32%, $P = 0.0014$). There were 25% from rural areas and 75% from urban areas. No rural SCFE patients lived in food deserts whereas 34% of urban patients lived in food deserts. The average poverty rate of the SCFE patient census tracts was 19%, no greater than the expected 15% ($P = 0.32$). SCFE patients living in rural census tracts had a lower poverty rate ($P < 10^{-6}$).

Conclusions: There is a correlation with the prevalence of SCFE patients by residence in a "food desert", but not with rural/urban locale or poverty status in Indiana. Further research will be needed to see if these findings apply to other states within the United States and other parts of the world.

Level of Evidence: III.

Key Words: slipped capital femoral epiphysis, food desert, poverty, rural/urban, food access, demographics

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There is a strong association between childhood obesity and slipped capital femoral epiphysis (SCFE).[1,2] An elevated body mass index (BMI) increases the risk and reduces the age of SCFE onset.[1,2] Childhood obesity is increased in specific communities with little to no access to healthy foods such as fruits and vegetables.[3] Such an area is called a food desert.

Food deserts are defined by the United States Department of Agriculture as US Census tracts that are both low-income and low-access to healthy foods. The US Census Bureau tract [https://www.census.gov/programs-surveys/geography/about/glossary.html#par_textimage_13] is a small, relatively permanent statistical subdivision of a county or equivalent entity and ranges from 1200 to 8000 inhabitants covering a contiguous area. The size of census tracts varies widely depending on the density of the settlement. Low-income tracts are those with a poverty rate $\geq 20\%$, or a median family income that is $\leq 80\%$ of the metropolitan area's median family income (for tracts in metropolitan areas) or the statewide median family income (for tracts in nonmetropolitan areas). Low access is characterized by at least 500 people and/or 33% of the tract population residing more than 1 mile from a supermarket or large grocery in urban areas and more than 10 miles in rural areas.[4] Both low-income and low-food access conditions must be met for a census tract to be a food desert. An urban tract is an area encompassing at least 2500 people, at least 1500 of which reside outside institutional group quarters [https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2010-urban-rural.html] with all other tracts being rural.

Indiana is a heavily agricultural state in the "breadbasket" of the United States but simultaneously has a large urban population. The percentage of Indiana residents living in the urban and rural areas is 72.4% and 27.6%, respectively, (https://data.census.gov/cedsci/table?q=Indiana%20rural%20vs%20urban&y=2010&tid=DECENNIALCD1132010.P2) which allows for comparisons between urban and rural residences. We, therefore, wished to study the questions: (1) is there an increased rate of SCFE in food desert communities? (2) is the prevalence of SCFE higher in poverty areas? and (3) are there differences in SCFE patients by rural versus urban residence?

METHODS

After IRB approval, all patients with an idiopathic SCFE treated at our institution from January 2010 to March 2021 were identified from the CPT codes of 27176, 27177, 27178, 27179, and 27181, the ICD 9 codes of 732.2, and the ICD 10 code of M93.0xxx. The electronic records

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TABLE 1. Indiana Idiopathic SCFE Patients Comparing Those Living in a Food Desert or Not

		Living in a Food Desert (Low-Income and Low-Access Definition)		
	All	Food Desert	No Food Desert	*P*
n	177	47	130	—
Age at diagnosis (y)	12.1 ± 1.7	12.0 ± 1.7	12.1 ± 1.8	0.53
Southwick SCFE angle (degrees)	38 ± 20	40 ± 21	37 ± 19	0.66
Weight %ile	94 ± 10	95 ± 9	94 ± 10	0.78
Height %ile	76 ± 26	79 ± 27	75 ± 26	0.35
BMI %ile	93 ± 16	93 ± 17	93 ± 16	0.29
Symptom duration (mo)	4.1 ± 5.1	3.4 ± 5.4	4.3 ± 5.0	0.058
Sex				
Female	79	18	61	0.39
Male	98	29	69	—
Race				
Nonwhite	69	27	42	0.0014
White	106	18	88	—
SCFE laterality				
Left	95	23	72	0.50
Right	82	24	58	—
SCFE type				
Stable	136	35	101	0.69
Unstable	41	12	29	—
SCFE severity				
Mild	70	17	53	0.86
Moderate/severe	102	27	75	—
Obese (>95th %ile for age)				
No	42	10	32	0.69
Yes	135	37	98	—
Overweight (>90th %ile for age)				
No	31	9	22	0.82
Yes	146	38	108	—
Insurance type				
Government	116	36	80	0.074
Commercial/managed care	61	11	50	—
Locale				
Rural	44	0	44	$<10^{-6}$
Urban	133	47	86	—
Census Tract Data				
Poverty rate per census tract	18.9 ± 13.2	31.0 ± 12.0	14.5 ± 10.8	$<10^{-6}$
Median family income per census tract (US$)	61075 ± 21400	41836 ± 10861	67883 ± 20036	$<10^{-6}$
Households 1 mile from supermarket getting SNAP (%)	7.09 ± 8.07	14.00 ± 10.78	4.13 ± 3.85	$<10^{-6}$

%ile indicates percentile; SCFE, slipped capital femoral epiphysis; SNAP, Supplemental Nutrition Assistance Program.

and radiographs were reviewed to confirm the diagnosis. The data collected were age, symptom duration, weight/height of the patient at diagnosis, child's sex, race, type of insurance, SCFE laterality, and stable/unstable nature of the SCFE as previously defined.[5] Race was classified as White or nonWhite. Insurance status was condensed into 2 groups: government (self-pay, Medicaid, Medicaid managed care, and other government insurance) and nongovernment (BCBS, nonMedicaid managed care, other commercial carriers). Self-pay was included in the government group as self-pay usually means the patient/parents have no insurance and are likely lower-income families, similar to the Medicaid population group. Weight and height were converted to percentiles using online CDC growth charts with the SimulConsult app (https://simulconsult.com/resources/measurement.html?type=weight). The child's BMI (kg/m^2) and percentile were calculated using the Baylor College of Medicine app (https://www.bcm.edu/cnrc-apps/bodycomp/bmiz2.html). The severity of the SCFE was measured using the lateral epiphyseal-shaft angle (LESA) as defined by Southwick[6] and classified as mild (<30°), moderate (30 to 50°), or severe (>50°).[7] Only data from the first SCFE encounter was used for a child with a sequential bilateral SCFE, and for a child with a simultaneous bilateral SCFE, the data for the hip having the greatest length of symptoms was used.

From the patient's address, the US Census Bureau tract for each patient was obtained using the link https://geomap.ffiec.gov/FFIECGeocMap/GeocodeMap1.aspx. The census tract code was then used to obtain information regarding population, urban/rural location, poverty rate, low access to food markets, income, and if such tract was in a food desert. This information came from the Indiana food desert file[8] collated by the SAVI Community Information System, Polis Center at IUPUI.[9]

Statistical Analysis

Continuous variables are expressed as the mean ± 1 SD. Categorical variables are expressed as frequencies and percentages. Differences between continuous variables were analyzed using nonparametric statistics due to nonnormal distributions (Mann-Whitney *U* test–2 variables, Kruskal Wallis test–3 or more variables). Differences between categorical variables were analyzed by the Pearson χ^2 test and the Fisher exact test for 2×2 analyses when the expected number of cells was less than 5. All analyses were performed with Systat 13 software. Although a significance threshold of 0.05 is often used, we report exact *P* values, encouraging readers to evaluate them in the context of multiple testing and magnitude of effect estimates, with some suggesting a *P* of 0.005.[10–16]

RESULTS

There were 177 unique patients (Table 1): there were 79 girls, 98 boys, 106 White, and 69 nonWhite patients, with 2 patients not having an identified race. The average age at diagnosis was 12.1 ± 1.7 years, the average symptom duration 4.1 ± 5.1 months, and the average weight percentile 94 ± 10. The average SCFE angle was 38° ± 20°. There were 44 patients from rural (24.9%) and 133 (75.1%) from urban census tracts; the average poverty rate for the census tracts was 18.9%.

TABLE 2. Demographics of Indiana SCFE Patients Comparing those living in a Low-Food Access or Low-Income US Census Bureau Tracts

	Low-Food Access			Low-income		
Variable	**Yes**	**No**	***P***	**Yes**	**No**	***P***
n	93	84	-	82	95	—
Age at diagnosis (y)	12.0 ± 1.6	12.1 ± 1.9	0.35	12.3 ± 1.7	11.9 ± 1.8	0.24
Southwick SCFE angle (degrees)	39 ± 20	37 ± 20	0.68	41 ± 21	36 ± 19	0.14
Weight %ile	93 ± 11	96 ± 9	0.18	96 ± 7	93 ± 12	0.022
Height %ile	76 ± 30	76 ± 22	0.52	79 ± 23	73 ± 28	0.38
BMI %ile	90 ± 19	95 ± 12	0.19	95 ± 13	90 ± 18	0.066
Symptom duration (mo)	3.1 ± 4.3	5.2 ± 5.7	0.0015	4.8 ± 6.1	3.4 ± 4.1	0.49
Sex						
Female	42	37	1.00	28	51	0.01
Male	51	47		54	44	—
Race						
Nonwhite	44	25	0.014	43	26	0.0006
White	47	59	—	37	69	—
SCFE laterality						
Left	48	47	0.65	44	51	1.00
Right	45	37	—	38	44	—
SCFE type						
Stable	69	67	0.46	64	72	0.86
Unstable	24	17	—	18	23	—
SCFE severity						
Mild	36	34	0.88	28	42	0.22
Moderate/severe	54	48	—	51	51	—
Obese (>95th %ile for age)						
No	27	15	0.11	12	30	0.013
Yes	66	69	—	70	65	—
Overweight (>90th %ile age)						
No	22	9	0.029	9	22	0.046
Yes	71	75	—	73	37	—
Insurance type						
Government	60	56	0.87	67	49	0.00003
Commercial/managed care	33	28	—	15	46	—
Locale						
Rural	4	40	$<10^{-6}$	1	43	$<10^{-6}$
Urban	89	44	—	81	52	—
Census Tract Data						
Poverty rate per census tract	19.9 ± 14.5	17.8 ± 11.7	0.61	29.5 ± 11.9	9.7 ± 4.8	$<10^{-6}$
Median family income per census tract (US$)	60080 ± 22808	62164 ± 19822	0.36	44913 ± 16626	74854 ± 14155	$<10^{-6}$
Households 1 mile from supermarket getting SNAP (%)	14.34 ± 11.06	7.76 ± 5.68	0.0001	10.54 ± 10.94	4.71 ± 3.81	0.007

%ile indicates percentile; SCFE, slipped capital femoral epiphysis; SNAP, Supplemental Nutrition Assistance Program.

For the years 2014–2018,[8,9] 17.5% (1,135,595) of the 6,483,802 Indiana residents lived in food deserts. A food desert was present in 5 of 464 (1.1%) rural and 286 of 1043 (27.4%) urban census tracts ($P<10^{-6}$). Of the 177 SCFE patients, 47 (26.5%) SCFE lived in a food desert with an expected value in our state of Indiana of 31 in a food desert (0.175×177) ($P=0.028$).

Differences in Patients by Food Desert Status

The only notable finding, barring those anticipated based on socioeconomic variables (poverty rate and median family income) (Table 1), is that SCFE patients living in a food desert were more commonly nonWhite (60% vs. 32%, $P=0.0014$) and no rural SCFE patients lived in a food desert compared with 33.8% of urban patients ($P<10^{-6}$).

As the definition of a food desert involves both income level as well as food accessibility, we performed analyses by income level and food access separately (Table 2). Notable findings were that those living in low-income tracts had a lower percentage of female SCFE patients (34% vs. 54%, $P=0.01$). Overweight children (>90th percentile weight for age) were more frequent in both the low-food access group (76.3% vs. 23.7%, $P=0.029$) and the low-income group (89.0% vs. 11.0%, $P=0.046$). Those living in rural census tracts were less likely to be in a low-income tract (4.3% vs. 95.7%, $P<10^{-6}$) as well as a low-food access tract (1.2% vs. 98.8%, $P<10^{-6}$).

Poverty Status and Urban versus Rural Residence

The percentage of the Indiana population <18 years of age below the poverty level in 2020 was 17.6% (https://data.census.gov/cedsci/table?q=Indiana%20poverty%20rate&tid=ACSST5Y2020.S1701) and in 2010 was 21.7% (https://data.census.gov/cedsci/table?q=Indiana%20poverty%20rate&tid=ACSST1Y2010.S1701), for a 19.65% average. The number of SCFE patients over this same time span living in poverty tracts was 33 (18.9%), with an expected number of 35 (177×0.1965) ($P=0.78$).

TABLE 3. Demographics of Indiana Idiopathic SCFE Patients by Urban Versus Rural Residence

	Urban	Rural	*P*
n	133	44	—
Age at diagnosis (y)	12.1 ± 1.7	12.0 ± 1.9	0.69
Southwick SCFE angle (degrees)	39 ± 20	36 ± 18	0.41
Weight %ile	95 ± 10	93 ± 11	0.17
Height %ile	79 ± 24	67 ± 30	0.04
BMI %ile	93 ± 16	92 ± 17	0.089
Symptom duration (mo)	4.1 ± 5.5	3.9 ± 4.0	0.29
Sex			
Female	50	20	1.00
Male	74	24	—
Race			
Nonwhite	63	6	0.000033
White	68	38	—
SCFE laterality			
Left	72	23	0.86
Right	61	21	—
SCFE type			
Stable	103	33	0.84
Unstable	30	11	—
SCFE severity			
Mild	52	18	0.86
Moderate/severe	78	24	—
Obese (>95th %ile for age)			
No	28	14	0.16
Yes	105	30	—
Overweight (>90th %ile age)			
No	21	10	0.36
Yes	112	34	—
Insurance type			
Government	98	18	0.0002
Commercial/managed care	35	26	—
Living in a food desert (low income and low access)			
Yes	47	0	$<10^{-6}$
No	86	44	—
Census tract data			
Poverty rate per census tract	21.7 ± 13.9	10.57 ± 5.38	$<10^{-6}$
Median family income per census tract (US$)	57435 ± 22751	71994 ± 11146	$<10^{-6}$
Households 1 mile from supermarket getting SNAP (%)	7.36 ± 9.30	6.38 ± 3.20	0.037

%ile indicates percentile; SCFE, slipped capital femoral epiphysis; SNAP, Supplemental Nutrition Assistance Program.

We next analyzed for differences in the 177 patients by rural versus urban location (Table 3). Of the 177 patients, 44 (25%) lived in rural tracts, with an expected number using Indiana population data of 49 (28%) ($P = 0.55$). Those living in rural census tracts were less likely to be living in a food desert (19.3% vs. 1.6% - $P < 10^{-6}$), had a lower poverty rate ($P < 10^{-6}$) with thus a higher median family income, and were more likely to be white (86% vs. 52%, $P = 0.00003$).

DISCUSSION

SCFE is associated with obesity.[1,2,17–20] The cause of this obesity in SCFE children has not yet been explored and is likely multifactorial; 1 explanation is residence in a food desert. This study explored the prevalence of Indiana SCFE patients living in food deserts compared with the overall Indiana population and found that SCFE patients more commonly lived in food deserts. There were no differences in SCFE severity, symptom duration, stable/unstable nature of the SCFE, body weight, height, and BMI percentiles for those SCFE patients living in a food desert compared with those not living in a food desert. Living in a food desert did not impact variables that typically portend a poorer prognosis, such as SCFE severity[21] and stable/unstable nature of the SCFE.[5,22–24]

In this study, we found that there was a higher than expected of SCFE children living in food deserts compared with the general Indiana population. One possible explanation is that children living in food deserts may have a greater vitamin D deficiency due to their inability to access milk with vitamin D supplements. Unfortunately, information regarding the availability and sales/consumption of milk fortified with vitamin D is not given in the census tract data. The issue of vitamin D deficiency and its etiology in SCFE is controversial. Some studies have theoretically suggested such an association.[25,26] In clinical series, some show a correlation between SCFE and vitamin D levels[27,28] whereas others show no correlation.[29–32] However, there are no definitive, large-size studies demonstrating a significant correlation between SCFE and vitamin D levels compared with the general population.

A Swedish study spanning 1910–1982 noted that SCFE patients were mostly boys, with a greater proportion from rural areas.[33] Clearly, the proportion of children living in rural compared with urban areas has changed over time. Thus, it is not fair to directly compare our Indiana findings spanning 2010–2021 to those from Sweden spanning 1910–1982.[33] We found no difference in the proportion of SCFE patients living in rural versus urban areas compared with the general population. However, those living in rural areas had a lower poverty rate and were less likely to be living in a food desert.

When looking at the SCFE patients living in census tracts having low-food access (Table 2), it was surprising that while more were living in a food desert (as expected), the average symptom duration was less (3.1 vs. 5.2 mo,

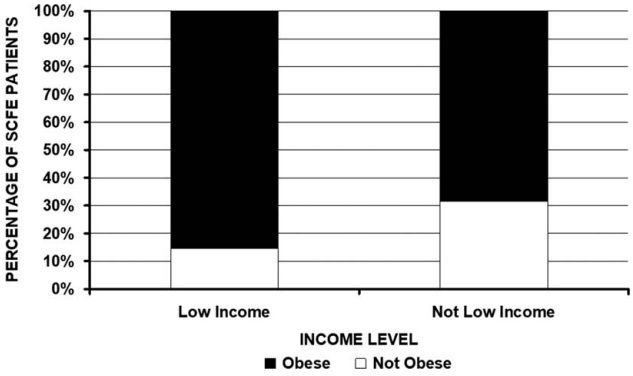

FIGURE 1. Obesity status (>95th percentile weight for age) of SCFE patients by income level was greater in the low-income group ($P = 0.013$). SCFE indicates slipped capital femoral epiphysis.

$P = 0.0015$), with no difference in SCFE severity. This confirms a recent study[34] showing that neither type of medical insurance nor socioeconomic status were associated with a delay in diagnosis or SCFE severity. In fact, it could be interpreted that those having low-food access had quicker access to medical care for the symptoms of SCFE. This is the opposite of many other studies where specialty medical care access for children was inhibited by the type of medical insurance.[35–39] This may be because Indiana families with Medicaid insurance can obtain transportation to medical facilities by Medicaid "cabs" within 48-72 hours. Perhaps this is unique to our state, as differences in acceptance of a Medicaid patient vary widely across the United States,[39] and in 1 study there was a direct correlation between acceptance of a Medicaid patient and physician reimbursement.[39] It is also plausible that transportation access may influence a particular physician's practice regarding the willingness to take on a new Medicaid patient.

SCFE families living in a food desert were more likely to get Supplemental Nutrition Assistance Program (SNAP) benefits than those outside a food desert (Table 1). This raises the question of whether SNAP benefits actually help; they help with financial assistance, but if the parents do not have transportation to reach a supermarket to use the SNAP benefits, then they are useless. This implies that not only financial assistance but also improved access (ie, transportation, or bringing the food closer to the homes through trucks, etc.) should be provided. In 1 study, diet and food security increased for SNAP participants living in an urban food desert after programs that opened a full-service supermarket.[40] Addressing these sociopolitical issues is beyond the realm of individual health care providers.

Socioeconomic status and social deprivation have been recently explored in patients with SCFE, both in the UK[1,41] and the United States.[34] In Indiana, using the Area Deprivation Index,[42] there was no apparent increase in the proportion of SCFE children living in the least deprived to most deprived deciles. In this study, when using actual poverty level rates, there was no increase in the number of SCFE patients living in poverty. However, we noted that SCFE patients who were obese ($> 95^{th}$ percentile weight for age) were more commonly from low-income census tracts (52% vs. 29%, $P = 0.013$) (Table 2) (Fig. 1). In the UK, the incidence of SCFE increases with increasing poverty levels,[41] with those children living in the least affluent quintile predicted to develop an SCFE 2.5 times more often than those living in the most affluent quintile.

There are certain limitations to this study. The first is that it is not possible to match each patient to a particular prevalence of food desert and poverty rate for each year, as food desert and poverty rate data are averages over several years. While this study spanned 10 years, it is unlikely that there was a significant shift from year to year by food desert, poverty, and ADI status for each US census tract. Second, it is not known if any particular patient/family living in a food desert or poverty census tract was actually in poverty or had difficulty accessing healthy food. It is possible that a patient's family living in a particular census tract associated with a high poverty rate might, in actuality, be an outlier, with an income above the poverty level and transportation allowing access to healthy food sources. Finally, not all SCFE patients in Indiana are cared for at our institution – did our institution experience a selection bias in receiving those with more severe SCFEs or Medicaid/self-pay insurance? This is unlikely as the average SCFE angle was 38 degrees with no difference by insurance status.[34] This along with the fact that rural patients were less impoverished and had less Medicaid insurance coverage strongly suggests that outlying orthopaedic surgeons in smaller communities refer their SCFE patients to our center regardless of insurance status, rather than caring for them locally.

This study has shown that SCFE patients are more likely to reside in food deserts and that obese SCFE patients are more commonly from low-income tracts. However, not all SCFE patients who are obese live in food deserts. Perhaps parental modeling plays a role, as a child is 10 to 12 times more likely to have obesity when they have 2 obese parents compared with having 2 parents of healthy weight.[43–45] Food preferences are acquired in childhood due to surrounding environments, as parents have a great influence on childhood eating habits.[46–48] In addition, children who live with single mothers, children with nonworking parents, children with nonprofessional parents, and children whose mothers did not complete high school are significantly more likely to become obese.[45] This may explain the income level differences seen in Figure 1. Contrary to a Swedish study from a half-century ago, [33] we did not find any difference in the number of SCFE patients living in rural versus urban areas. However, those SCFE patients living in rural areas were less likely to live in a food desert with less poverty. Finally, we only studied food deserts. Other topics to study would be food swamps and the modified retail food environment index. A food swamp is where there is an abundance of food retailers that sell energy-dense, less healthy foods that "swamp" out the healthy food choices that might still be available.[49,50] A food swamp is defined as ≥ 4 corner stores within 0·25 miles of a home. The modified retail food environment index is defined as the number of healthy food retailers divided by the sum of the number of healthy and less healthy food retailers.[51] Unfortunately, data by the US census tracts for food swamps or retail food environment indices does not presently exist for Indiana.

In conclusion, there does appear to be a link between the prevalence of Indiana SCFE patients with residence in a food desert but not with rural/urban residence or poverty status. Further investigation is needed to ascertain if these findings apply to other states within the United States as well as other parts of the world.

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