Published in final edited form as:

J Am Coll Radiol. 2012 November ; 9(11): 799–807. doi:10.1016/j.jacr.2012.06.005.

Impact of Socioeconomic Status on Ionizing Radiation Exposure from Medical Imaging in Children

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Abstract

Purpose—To characterize cumulative exposure to ionizing radiation from diagnostic imaging (CEDI) in pediatric patients, and investigate its relationship to patients' socioeconomic status (SES) and comorbid medical conditions (CMC).

Methods—An IRB approved HIPAA compliant retrospective cohort study of 19,000 pediatric patients seen within the outpatient clinic system of an academic tertiary care urban medical center during the month of January 2006, that estimated the CEDI from all procedures performed within three years of the index visit (until January 2009). SES was estimated from census tract geocoding. CMC were identified from the electronic medical record.

Results—19063 patients had an imaging test within the index month. Mean age was 8.9 years (SD=6.3). Most had private insurance (56%), with 36% receiving Medicaid and 8% private payors. 27% (SD=16) reside in poverty areas, with 62% living in areas of which more than 20% of residents were living below the poverty level. There were differences in CEDI ($p<.0001$) by age, insurance type, and percent poverty in census tract of residence, but not among racial groups ($p=.6508$). The association between poverty and CEDI was generally explained by the 26 Elixhauser diagnoses with the exception of rheumatoid arthritis (RA).

Conclusion—Patients living in areas of greater poverty were exposed over time to more radiation from diagnostic testing than those living in areas with a lower percentage of residents living in poverty. This association was explained almost entirely by the presence of disease burden. We found no direct association between SES and CEDI.

Keywords

Radiation dose; radiation exposure; exposure to patients and personnel; socioeconomic factor; access to health care; pediatrics

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Data from this study has been presented at RSNA 2010.

Competing interests

Authors report no competing interests.

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INTRODUCTION

Although the benefits of radiographic imaging are generally accepted, the side effects of ionizing radiation exposure from CT scans, fluoroscopy, and nuclear medicine studies are receiving more attention. A recent study indicates that approximately 40% of children under 18 years in the US are exposed to at least one ionizing radiation exam over a three year period from medical imaging procedures [1]. Studies suggest that radiation exposure may be more hazardous in children due to the fact that their tissues are still growing and may be more prone to somatic genetic damage. Additionally children's greater life expectancy provides a longer observation time for adverse events [2–8]. CT use has increased rapidly with an estimated 70 million CT scans performed in 2007 in the US [9]. Based primarily on epidemiologic data from atomic bomb survivors, it is estimated that 1.5–2% of future cancers in the United States may be attributable to current CT use, and that 29,000 cancers may be attributable to the CTs performed in 2007 [10]. Furthermore, some have estimated that the mortality from radiation exposure is 1 death per 4000 scans, and 1 excess cancer per 1000 scans [11].

Understanding the factors associated with utilization of radiologic imaging is important in correcting possible differences in the delivery of healthcare services according to patient demographic characteristics (health disparities). Lower SES, lack of health insurance, and belonging to a disadvantaged race or ethnicity are associated with increased disease prevalence, decreased access to care, and worse health outcomes across a broad spectrum of diseases [12–16]. In a study of adult patients undergoing myocardial perfusion imaging, those patients without health insurance underwent fewer tests involving radiation and had lower cumulative effective doses than patients with any health insurance [17]. Our objective is to test the association in children between socioeconomic status (SES) and medical radiation exposure/diagnostic imaging utilization in the United States (US) healthcare setting. We hypothesize that because of increased disease burden, lower SES may contribute to an increase in exposure to medical ionizing radiation. Our population is primarily African American and Latino children living in varying degrees of poverty, who have been followed for three years at an urban medical center. We tested our hypothesis by evaluating the association between cumulative radiation exposure from diagnostic imaging (CEDI) and socioeconomic status, race, ethnicity, and insurance status, controlling for comorbidities.

METHODS

Data Sources

This is a retrospective cohort study of patients from a tertiary care academic urban medical center with specialized pediatric outpatient, inpatient and emergency facilities. We accessed our institution's computerized medical record system using Clinical Looking Glass™ (CLG, Version 3.3, Bronx, NY), an interactive software application, to derive radiation exposure (estimated effective dose), geocoding (census tract of residence), comorbidity reports, demographics, and insurance status. The study was approved by the medical center's Institutional Review Board for the Protection of Human Subjects (IRB) and was compliant with the Health Insurance Portability and Accountability Act.

Study Population

The population was defined to include all patients 21 years of age and under at the time of an initial visit during January, 2006 at any of the institution's 14 outpatient clinic sites that all use the electronic medical record system. Patient records were reviewed through January 2009 to identify all medical imaging studies performed over this time period. Patients who died during the three years of follow-up were excluded to minimize potential bias due to

numerous exams preceding their death, and truncation of their observation period. Patients with less than 3 years of followup were also excluded. Age, gender, race, and ethnicity were self reported by the patient or guardian at registration. Ethnicity was defined as either 'Hispanic or Latino' or 'non Hispanic or Latino.' Insurance information was based on the source of payment recorded for the original outpatient encounter, and was subsequently categorized as private insurance, medicare, medicaid, or no insurance (self-pay).

Socioeconomic Status

The percentage of people living below the poverty level in a census tract has previously been used as a measure of socioeconomic status [18]. To validate this approach in this cohort, 100 randomly selected addresses geocoded by the CLG geocoding report were compared with the census tract on the US Bureau of the Census geocoding website [19]. 82% of addresses were assigned the same census tract by both methods, 10% could not be geocoded by the census website, and a small fraction (8%) were assigned a different census tract. To account for the possible nonlinearity of the relationship between census tract percent of persons living below the poverty level and radiation exposure, the percent poverty categories of 0%–10%, >10%–20%, >20%–30%, >30%–40%, >40%–50%, >50% were created. Bronx county has one of the highest poverty rates (28.3 % in 2009) in the nation and the study population therefore did not replicate the previously used cutoff of greater than 20%, the federal definition of a poverty area, as the highest poverty group [20].

Exam Utilization and Estimation of Radiation Dose

All diagnostic radiology exams, nuclear medicine exams, and cardiac catheterizations were recorded for 3 years from the original outpatient visit date for each patient. These included all procedures performed at multiple imaging facilities including inpatient, emergency, and outpatient settings. A mean radiation dose was assigned to the common examinations performed in radiology, nuclear medicine, and invasive cardiology based on literature reported values[21, 22] available prior to initiation of this cohort. The estimated radiation doses for all exams for the three year period of each patient were then summed, yielding a total estimated cumulative radiation dose in mSv. Actual measured radiation exposures vary widely and also tend to be higher than estimated mean calculated exposures [22, 23, 24].

Comorbidities

As socioeconomic status is associated with disease risk, we incorporated comorbidities into our analyses to account for increases in imaging procedures due to increased burden of disease. We determined the presence of each of 26 Elixhauser diagnoses for each patient using ICD9 codes for the entire 3 year study period. Elixhauser diagnoses have been shown to be positively associated with mortality and hospital charges [25].

Statistical Analysis

Descriptive statistics are presented as means and standard deviations for continuous variables, and relative frequencies for categorical variables. Multiple linear regression analysis with a monitored backwards variable elimination procedure was used to derive models of the relationship between cumulative radiation exposure and patient characteristics, with estimated cumulative radiation dose as the dependent variable. Because the distribution of estimated cumulative radiation was not normal, transformations of scale were attempted to better approximate assumptions of normally distributed error terms. However, with most patients receiving very low doses or no radiation, and the dataset was sufficiently large, errors were reasonably normal and thus assumptions of the multiple linear regression analyses were not violated. Bivariate analyses between CEDI and demographics and insurance were performed using Kruskal-Wallis tests for categorical or short scale ordinal

variables or Wilcoxon Rank Sum tests for dichotomous variables. Variables significantly associated with CEDI were included in multivariate models. Primary analyses included CEDI as the dependent variable and age and its effect on poverty, and poverty and its effect on diagnosis as independent variables. Sensitivity analyses were performed for the entire dataset with CEDI as the dependent variable and the following independent variables: age, gender, ethnicity, race, census tract percent poverty as either continuous or categorical variables, insurance categories and diagnosis, as well as within insurance group. Variables retained in final models were those significant at $p < .05$. Analyses were performed using SAS Version 9.1.2, Cary NC.

RESULTS

A total of 19063 patients had an outpatient visit between January 1st and January 31st, 2006, and were followed for three years. Distributions of children from infancy to 21 years by demographic characteristics and insurance type are shown in Table 1. The mean age was 8.9 years (SD=6.3), with 34% under 5. The most prevalent racial groups were African American (33.1%) and multiracial (14.9%); 36.4% of the population was of Hispanic ethnicity. Most children were covered under private insurance (56%), with an additional 36% receiving Medicaid. Across census tracts, 27% (SD=16) of children from this population live in poverty, with 62% living in areas of which more than 20% of residents were living below the poverty level.

Descriptive statistics for percent poverty and CEDI stratified by demographic characteristics and insurance type are also shown in Table 1. Differences in mean levels of poverty were significant for age, with both the very young and the oldest children more likely to be living in higher poverty areas, and for sex, with females more likely to live in higher poverty areas. Percent poverty differed by race with Native Americans, African Americans, Pacific Islanders more likely to live in higher poverty areas than Asians or Caucasians, and by ethnicity with Hispanics more likely to live in higher poverty areas ($p < .0001$). As expected, children receiving Medicaid were more likely to live in higher poverty areas than those with either no or private insurance, and were more likely to be Native American, African American or Hispanic ($p = .0016$, $p < .0001$, and $p < .0001$, respectively; data not shown). With regard to CEDI, 82.5% of children received no ionizing radiation, and less than 1% received more than 10 mSv. Differences among age groups with regard to CEDI were significant, with those 16 to 21 years having notably higher levels of cumulative radiation exposure than younger children ($p < .0001$). Differences among insurance types were significant, with those on Medicaid or Medicare receiving significantly more radiation than those with private or no insurance ($p < .0001$). There were no significant differences by gender, race or ethnicity.

The distribution of children with one or more Elixhauser diagnosis is shown in Table 2. For each diagnosis, descriptive statistics for percent poverty and CEDI are presented, along with corresponding P-values indicating the significance of the difference between those with and without the diagnosis. The most prevalent diagnosis was chronic pulmonary disease, affecting more than one-fourth of all children. Other diagnoses affecting more than 2% of children include deficiency anemia, fluid and electrolyte disorders, and depression. More than one-third of children had at least one Elixhauser diagnosis. In bivariate analyses, Elixhauser diagnoses more prevalent in higher poverty areas include: chronic pulmonary disease, hemiplegia or paraplegia, complicated hypertension, other neurological disorders, fluid and electrolyte disorders, deficiency anemia, drug abuse, psychoses, and depression; having at least one diagnosis was associated with living in areas of significantly greater poverty. For Elixhauser diagnoses with sufficient sample sizes for analysis ($n \geq 10$), children with the diagnosis were exposed to significantly greater CEDI than those without the

diagnosis. CEDI was notably greater for such diagnoses as myocardial infarction, metastatic solid tumor, lymphoma, and blood loss anemia.

Table 3 presents results of multiple linear regression models to determine the effect of percent poverty of living environment on CEDI controlling for diagnosis. Each model accounts for age and how age modifies the effect of poverty on CEDI, as well as diagnosis and how poverty modifies the effect of diagnosis on CEDI. Given the two interaction terms in each initial model, analyses of interaction terms were reviewed to determine if sample sizes within subgroups were sufficient to consider results reliable (i.e. 10 subjects in each subgroup dichotomized at the median). After controlling for diagnosis and age, poverty was not significantly associated with CEDI with the exception of rheumatoid arthritis. For this diagnosis only, the interaction between poverty and diagnosis was significantly associated with CEDI ($p < .0001$), indicating that children with rheumatoid arthritis who live in greater poverty areas have much higher than expected CEDI compared with those with RA who live in areas of lesser poverty and those without the disease. The interaction between poverty and disease was significant for moderate to severe disease; in examining these results more closely, there is a significant difference in CEDI between those living in greater poverty areas and those not among those *without* moderate or severe liver disease. These findings are illustrated in Figures 1 and 2. Sensitivity analyses supported all findings.

DISCUSSION

From our multi-racial and ethnic population in which the majority of children live in areas with more than 20% living below the poverty level, those living in areas of greater poverty had higher levels of cumulative ionizing radiation exposure. However, analyses that controlled for age and diagnosis attribute this finding primarily to burden of disease. Our results are consistent with those of prior studies, which demonstrate an association between lower socioeconomic status and greater disease burden [26, 27]. We found that more than one-third of children had at least one Elixhauser diagnosis, and those affected live in notably poorer environments. Contrary to expectations regarding barriers to accessing healthcare by poorer patients, our analyses show that mean levels of CEDI in general do not differ between children living in census tracts with greater versus lower poverty after controlling for diagnosis and age.

There was only one diagnosis, rheumatoid arthritis, for which poverty was associated with CEDI. For children with this diagnosis living in areas of 10% or more poverty, mean CEDI was more than twice that of those living in areas of less than 10% poverty; for children without this diagnosis, the difference in mean CEDI was not as pronounced. Only one study examined the relationship between socioeconomic status and juvenile rheumatoid arthritis (JRA), and indicated that children in families with higher incomes were more likely to have the diagnosis; however investigators did not examine effects of imaging and treatment [28]. This finding warrants further investigation focusing on this population of JRA patients. The current data concerns limited variables pertaining to the whole population of patients studied. Prospective detailed analysis of this clinic population may shed light on the finding.

In a 2011 report, the use of ionizing radiation was generally higher among boys than girls under 15 years, and increased dramatically in older children [1]. Though consistent with what we observe, these results are limited to children with private insurance. With regard to differences among racial groups, results from our study differed from those of Einstein in that they found that white patients had higher cumulative effective doses of ionizing radiation, whereas we found no differences [17]. Consistent with our findings, they also found that patients without health insurance had lower cumulative effective doses than patients with any health insurance [17]. Two previous studies have investigated the

relationship between socioeconomic status and diminished access to ionizing medical imaging in large populations. A Canadian study found that the highest income quintile was more likely than the lowest income quintile to receive nearly all radiological exams [29]. However, a Taiwanese study found that lower socioeconomic status was associated with a higher rate of CT utilization [30]. It is important to note that both of these studies were performed in systems with different healthcare and insurance systems than was analyzed in this study. Neither of these studies reported cumulative radiation exposure estimates. In a study paralleling our cohort of children but with adult patients, we similarly report that radiation exposure is directly related to comorbidities rather than SES [31].

Several studies have discussed diminished imaging utilization in mammography, bone densitometry and cardiac catheterization as they relate to lower SES in adults [32–37]. The international consistency of these findings, including countries with socialized health care, indicates that insurance is not the only factor limiting access to radiological imaging. We have shown no differences in race or ethnicity with regard to CEDI, and for only one of the 26 Elixhauser diagnoses, JRA, was there an association between poverty and CEDI. We did demonstrate that those children enrolled in Medicaid or Medicare received significantly more radiation than those with private or no insurance. Patients with Medicaid or Medicare will be those who are poor and have an Elixhauser diagnosis. They will be enrolled in order to obtain required services. Those without insurance (less than 10% of the sample) have no means of payment and would not be expected to have ready access to healthcare services regardless of their medical comorbidities. It is also possible that this 10% represents those who were not located within the catchment area throughout the study period and were not able to benefit from social services afforded to those enrolled in Medicare or Medicaid.

In a review from 2009, it was reported that for every 4000 CT scans there would be one excess death from radiation-induced malignancy [11]. Although imaging data have not supported a causal relationship with cancer, evidence from Japanese populations demonstrate a dose-response relationship [3]. Authors estimate that in 15 developed countries, between 0.6% and 1.8% of all malignancies occurred as a result of diagnostic medical radiation, based on the estimate that a CEDI of 50 mSv was considered high [11]. Thus we agree that physicians caring for such patients must seek to limit radiation exposure whenever possible to lessen the lifetime risk of malignancy [38]. In children ages 5 to 21 diagnosed with osteosarcoma, excess cancer incidence and excess mortality decreased dramatically with age, with rates for 15 to 21 year olds 15% or less of values for children 5 to 10 [39]. For the 34 children in our sample diagnosed with metastatic solid tumors or lymphoma as well as for children with other diagnoses, we agree with the need to minimize patient exposure to ionizing radiation associated with medical imaging, with specific attention paid to young children, in considering the advantages of such imaging.

While the assertion cited above that a significant number of cancers are caused by medical radiation has been questioned [40, 41], the need to minimize unnecessary ionizing radiation has been widely accepted. The American College of Radiology White Paper on Radiation Dose in Medicine cites research indicating a significant cancer increase at radiation levels above 50 mSv and notes that it would not be uncommon for patients receiving multiple CT scans to have an estimated exposure above this level [24]. Due to these concerns, the International Commission on Radiological Protection recommends that occupational effective radiation doses be limited to an effective dose of 100 mSv over 5 years with a maximum of 50 mSv in any year [42]. Assuming that we limit the effective dose to 60 mSv over the three years of followup, then it is estimated that 34 children (.18%) had CEDI values exceeding this threshold, 4 of whom had no Elixhauser diagnosis.

Limitations of the study include inaccuracy of census tract geocoding and the inability to approximate socioeconomic status of individual patients. Insurance status captured at the index visit may have changed over the three years. Also, a single hospital system's imaging facilities may lead to potential underestimation of cumulative radiation exposure. While it is possible that subjects obtained imaging services outside of the net cast by the Clinical Looking Glass software, the true magnitude is unknown. The medical center provides primary care to 2/3 of the poorest children living in the Bronx, and subspecialty care to nearly all of these children. The majority of outpatient encounters that generate imaging requests via the EMR automatically generate a scheduling request within the radiology information system, which spans four inpatient sites and five outpatient imaging centers. We are currently designing prospective analyses of the subsets of the cohort within each Elixhauser diagnosis group. This prospective methodology will allow us to more accurately account for these confounders.

Estimated doses rather than actual doses were used which would tend to underestimate true findings; however, uniform correction would likely not alter results. Use of shielding and whether scans were repeated were unavailable. Factors unique to our institution or its patient population such as its greater proportion of African Americans and smaller proportion of Caucasians, limit generalizability further. Additionally, children could have received imaging at other institutions, which would serve to underestimate CEDI reported here. While we accounted for greater use of ionizing radiation due to increased morbidity by incorporating Elixhauser diagnoses in analyses, we may have omitted other diagnoses associated with increased radiation.

CONCLUSION

Although medical imaging provides valuable information in the appropriate settings, many tests can only be done using ionizing radiation. Exposure to ionizing radiation at levels from diagnostic testing is associated with an increased risk of forming solid tumors, and that this risk is particularly notable in young children and those with cancer [39]. This study confirms previous work showing that patients of lower SES have greater disease burden. Contrary to expectations with regard to barriers to care, patients in this cohort living in areas with greater concentrations of persons living in poverty had higher levels of CEDI than those living in areas with lower concentrations. This association was explained by the presence of disease burden. We found no direct association between SES and CEDI. Our study demonstrates that poorer children have increased burden of disease and as a consequence, receive more CEDI. Although disparities in disease burden resulting from poverty are unlikely to change rapidly, awareness of higher overall potential radiation exposure from diagnostic testing, and conscious efforts to utilize non-ionizing alternatives may be used to reduce consequences of imaging in a poorer and sicker pediatric population.

Acknowledgments

Dr. Freeman's contribution was made possible by NIH Grant 5 P60 MD000514-06, National Center on Minority Health & Health Disparities Comprehensive Center of Excellence in Health Disparities Research, Bronx Center to Reduce and Eliminate Ethnic and Racial Health Disparities.

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TAKE HOME POINTS

- Disease burden increases as zip code poverty percentage increases.
- Total accumulated ionizing radiation from diagnostic imaging increases with disease burden.
- Controlling for socioeconomic status, disease burden accounted for all differences in ionizing radiation exposure

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Interaction: Moderate or Severe Liver Disease, Poverty and CEDI

Figure 1.

Interaction: Rheumatoid Arthritis, Poverty and CEDI

Figure 2.

Table 1
Distribution of Demographic Characteristics and Insurance in Children 0–21 years by Poverty and CEDI (N=19063)

	Frequency Distribution		Percent Poverty of Living Environment			3-year CEDI (mSv)		
	n	%	Mean	SD	Differences: P-value	Mean	SD	Differences: P-value
AGE (years)					<.0001			<.0001
Under 5	6458	33.88	0.27	0.16		.50	8.73	
5–9	4449	23.34	0.27	0.16		.38	4.00	
10–15	4244	22.26	0.27	0.16		.76	7.66	
16–21	3911	20.52	0.28	0.16		1.61	11.14	
GENDER					0.0064			.5132
Male	9212	48.33	0.27	0.16		0.80	8.65	
Female	9847	51.67	0.27	0.16		0.72	7.89	
RACE					<.0001			.6508
American Indian	91	.48	0.32	0.14		0.99	5.48	
Asian	324	1.70	0.23	0.16		1.45	20.39	
African American	6303	33.06	0.28	0.16		0.80	8.76	
Multi racial	2839	14.89	0.31	0.15		1.23	11.60	
Pacific Islander	11	.06	0.29	0.12		0.14	0.28	
White	1946	10.21	0.20	0.16		0.57	6.05	
ETHNICITY					<.0001			.8353
Hispanic	6874	36.37	0.31	0.15		1.03	8.30	
INSURANCE					<.0001			<.0001
Medicaid	6825	35.80	0.32	0.14		1.06	9.63	
Medicare	61	0.32	0.34	0.13		2.15	6.83	
None	1496	7.85	0.27	0.17		0.29	2.31	
Private	10680	56.03	0.24	0.16		0.62	7.84	
PERCENT POVERTY					--			<.0001
<10%	3909	20.76	--	--		0.44	3.85	
10 TO <20%	3207	17.03	--	--		0.83	9.43	
20 TO <30%	3637	19.32	--	--		1.00	11.31	

	Frequency Distribution		Percent Poverty of Living Environment			3-year CEDI (mSv)		
	n	%	Mean	SD	Differences: P-value	Mean	SD	Differences: P-value
30 TO <40%	3311	17.58	--	--		0.69	6.64	
40 TO <50%	3356	17.82	--	--		0.75	6.61	
>=50%	1409	7.48	--	--		1.11	11.90	
TOTAL	19063	100.00	0.27	0.16	--	.76	8.27	--

Table 2

Distribution of Demographic Characteristics, Insurance and Diagnoses in Children 0–21 years by Poverty and CEDI (N=19063)

	Frequency Distribution		Percent Poverty of Living Environment			3-year CEDI(mSv)		
	n	%	Mean	SD	P-value	Mean	SD	P-value
DIAGNOSES								
Myocardial Infarction	2	0.01	0.48	0.02	--	160.50	163.30	--
Congestive_Heart_Failure values	18	0.10	0.33	0.14	0.0927	21.83	65.20	<.0001
Peripheral Vascular Disorders	16	0.09	0.32	0.14	0.2200	4.57	8.62	<.0001
Cerebrovascular Disease	42	0.23	0.28	0.16	0.5802	7.75	13.69	<.0001
Dementia	4	0.02	0.15	0.06	--	0.03	0.05	--
Chronic Pulmonary Disease	4883	27.14	0.29	0.16	<.0001	0.99	7.30	<.0001
Peptic Ulcer Disease	11	0.06	0.26	0.16	0.8851	4.73	6.79	<.0001
Mild Liver Disease	76	0.42	0.29	0.15	0.2032	2.54	5.84	<.0001
Diabetes without complications	178	0.99	0.28	0.16	0.4105	1.83	6.47	<.0001
Hemiplegia or Paraplegia	157	0.87	0.31	0.18	0.0114	4.84	12.96	<.0001
Moderate or Severe Liver Disease	176	0.98	0.28	0.15	0.1308	5.47	10.34	<.0001
Metastatic Solid Tumor	14	0.08	0.29	0.14	0.6689	140.70	139.80	<.0001
Valvular Disease	130	0.72	0.29	0.15	0.1740	1.96	5.55	<.0001
Pulmonary Circulation Disorders	12	0.07	0.26	0.16	0.8165	15.79	23.96	<.0001
Complicated Hypertension	124	0.69	0.32	0.17	0.0016	12.62	46.89	<.0001
Other Neurological Disorders	324	1.80	0.29	0.15	0.0495	5.37	25.98	<.0001
Hypothyroidism	163	0.91	0.29	0.17	0.1315	2.89	8.43	<.0001
Lymphoma	20	0.11	0.32	0.16	0.1242	110.10	118.30	<.0001
Rheumatoid arthritis collagen va	63	0.35	0.29	0.15	0.2577	9.59	36.07	<.0001
Coagulopathy	102	0.57	0.30	0.17	0.1569	15.59	45.26	<.0001
Fluid and Electrolyte Disorders	621	3.45	0.28	0.15	0.0207	4.62	21.45	<.0001
Blood Loss Anemia	13	0.07	0.29	0.16	0.6691	32.21	74.25	<.0001
Deficiency Anemia	976	5.42	0.31	0.16	<.0001	3.44	22.68	<.0001
Drug Abuse	49	0.27	0.32	0.13	0.0082	10.10	40.38	<.0001
Psychoses	267	1.48	0.30	0.14	0.0004	1.56	6.33	<.0001

	Frequency Distribution		Percent Poverty of Living Environment			3-year CEDl(mSv)		
	n	%	Mean	SD	P-value	Mean	SD	P-value
Depression	471	2.62	0.32	0.14	<.0001	2.38	8.31	<.0001
ELIXHAUSER DIAGNOSIS					<.0001			<.0001
None	12237	64.19	0.26	0.16		.24	2.40	
Any	6826	35.81	0.29	0.16		1.69	13.38	
TOTAL	19063	100.00	0.27	0.16		.76	8.27	

Table 3

Multivariate associations between 3-Year CEDI and percentage of people living below the poverty level in a census tract and Presence/Absence of Elixhauser Diagnoses^{*}

	CEDI v. %Poverty	CEDI v. Diagnosis	CEDiv. Interaction: Poverty [*] Diagnosis ^ψ
DIAGNOSES	P-value	P-value	P-value
Myocardial Infarction	¥	¥	¥
Congestive Heart Failure	0.1343	0.3336	¥
Peripheral Vascular Disorders	0.1810	0.0708	0.2246
Cerebrovascular Disease	0.1843	0.0002	0.1377
Dementia	¥	¥	¥
Chronic Pulmonary Disease	0.2103	0.2169	0.8995
Peptic Ulcer Disease	0.1848	0.4233	0.0770
Mild Liver Disease	0.1862	0.3902	0.7732
Diabetes without complications	0.1815	0.2230	0.4070
Hemiplegia or Paraplegia	0.1433	0.0042	0.9009
Moderate or Severe Liver Disease ^ψ	0.2134	<.0001	0.0010
Metastatic Solid Tumor	0.1080	<.0001	¥
Valvular Disease	0.1803	0.7370	0.7507
Pulmonary Circulation Disorders	0.1770	<.0001	¥
Complicated Hypertension	0.2293	<.0001	0.2597
Other Neurological Disorders	0.1704	<.0001	0.3107
Hypothyroidism	0.1897	0.0332	0.3831
Lymphoma	0.0642	<.0001	¥
Rheumatoid arthritis collagen va ^ψ	0.2150	0.7748	<.0001
Coagulopathy	0.1677	<.0001	0.5313
Fluid and Electrolyte Disorders	0.0789	0.0001	0.0542
Blood Loss Anemia	0.2740	<.0001	¥
Deficiency Anemia	0.1473	<.0001	0.0987
Drug Abuse	0.2432	0.0369	¥
Psychoses	0.1704	0.1825	0.2129
Depression	0.1861	0.1485	0.6620
ANY ELIXHAUSER DIAGNOSES	0.0297	<.0001	0.2266

^{*} for all analyses, the interaction between age and poverty was significant ($p<.05$) indicating that older children living in greater poverty have much higher levels of CEDI than older children living in less poverty, relative to what is observed in younger children.

^ψ $p<.05$ indicates the interaction between poverty and diagnosis was significant and that poverty was a significant effect modifier of the relationship between diagnosis and CEDI: 1) those without moderate or severe liver disease living in higher poverty areas had significantly greater CEDI than those without the disease who live in lower poverty areas; the difference in CEDI between those living in higher v. lower poverty areas among those with the diagnosis was not significant; 2) among those with rheumatoid arthritis, CEDI was significantly greater in those living in higher poverty areas than those living in lower poverty areas; among those without rheumatoid arthritis, the difference in CEDI between those living in higher v. lower poverty areas was not significant.

¥ too few (<10) patients in one or more of the subsets stratified by poverty and diagnosis group.