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Infectious Disease-related Emergency Department Visits Among Children in the United States

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Abstract

Background—Although most research on infectious diseases (IDs) has focused on hospitalizations, this provides an incomplete picture of healthcare utilization. We describe the burden and epidemiologic features of ID-related emergency department (ED) visits among U.S. children.

Methods—Cross-sectional analysis of the Nationwide Emergency Department Sample, a nationally-representative sample of ED patients. We identified children who presented to the ED with a primary diagnosis of ID. Outcomes measures were ID-related ED visits, hospitalizations through the ED, and ED charges.

Results—During 2011, we identified 1,914,509 ID-related ED visits among U.S. children, corresponding to a weighted estimate of 8,524,357 ED visits. This accounted for 28% of all ED visits by children. The frequency of ID-related ED visits was 10,290 visits per 100,000 children. The most common diagnoses were upper respiratory infection (41%), otitis media (18%), and lower respiratory infection (14%). Overall, 62% of ID-related ED visits were made by children with Medicaid; 35% were by those in the lowest income quartile. Among the ID-related ED visits, 424,725 (5%) resulted in hospitalization, with 513 hospitalizations per 100,000 children. The most common reason for hospitalization was lower respiratory infection, which accounted for 40% of all ID-related hospitalizations from the ED. Median charge per ED visit was \$718, with total annual charges of \$9.6 billion.

Conclusions—The public health burden of IDs, as measured by ED visits, subsequent hospitalizations, and associated charges, was substantial. We also found that children with markers of lower socioeconomic status comprised a disproportionately high proportion of ID-related ED visits.

Keywords

infectious disease; respiratory infection; bronchiolitis; emergency department; hospitalization

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INTRODUCTION

The increase in life expectancy during the 20th century was largely due to reductions in infectious disease (ID) mortality among children.¹ However, the epidemiologic transition to chronic diseases is not complete;² IDs remain a major public health burden in the U.S..³ For example, national estimates indicated that there were approximately 40 million hospitalizations for IDs between 1997 and 2006, with an upward trend in the hospitalization rate.⁴ In this context, the U.S. government identified the reduction of morbidity and mortality from IDs as one of the *Healthy People 2020* objectives through better prevention, surveillance, and treatment.³ To develop and implement these strategies effectively, quantifying and characterizing ID-related healthcare utilization is critical.

To date, most epidemiologic research on IDs has focused on examining hospitalizations and the most common specific reasons for hospitalization (e.g., bronchiolitis).^{2, 4-9} By contrast, fewer studies have examined the epidemiology of ID-related ED visits; none of these has focused on U.S. children.^{10, 11} Focusing solely on hospitalizations provides an incomplete picture of the healthcare utilization and discounts the importance of upstream emergency department (ED) visits.¹² Furthermore, ED visits are increasingly interpreted by policymakers as an important measure in monitoring the integration of the healthcare delivery systems.^{13, 14} Despite this apparent public health significance, the burden and epidemiologic features of ID-related ED visits in children remains to be elucidated.

To address this knowledge gap in the literature, we used a nationally-representative database to quantify the frequency of ID-related ED visits and subsequent hospitalizations, and associated healthcare spending among U.S. children.

METHODS AND MATERIALS

Study Design and Setting

We conducted a cross-sectional analysis of data from the 2011 Nationwide Emergency Department Sample (NEDS),¹⁵ a component of the Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality (AHRQ). The NEDS is a nationally-representative sample of all hospital-based EDs in the U.S., which is defined by the American Hospital Association as all nonfederal, short-term, general, and other specialty hospitals.¹⁵ The NEDS was constructed by using administrative records from the HCUP State Inpatient Databases and the State Emergency Department Databases. The State Inpatient Databases contain information on patients initially seen in the ED and then hospitalized to the same hospital; the State Emergency Department Databases capture information on ED visits that do not result in a hospitalization (treat-and-release visits or transfers to another hospital). Taken together, the resulting NEDS represents all ED visits regardless of disposition and contains information on short-term outcomes for patients hospitalized through the ED. The NEDS represents an approximately 20% stratified sample of U.S. hospital-based EDs, containing 29.4 million records of ED visits from 951 hospitals in 2011. Weights are available to obtain national estimates at the visit- and hospital-level, pertaining to 131 million ED visits. Additional details of the NEDS can be found

elsewhere.¹⁵ The institutional review board of Massachusetts General Hospital approved this analysis.

Study Population

ED visits for patients age 19 years who had an *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* code for an ID in the primary diagnosis field (i.e., the first listed diagnosis on the record) were eligible for our analysis. IDs were defined by using a previously described classification scheme for *ICD-9-CM* codes, with inclusion of perinatal period-specific codes.^{2, 4}

In addition to overall ID-related ED visits, 21 mutually exclusive subgroups were examined.^{2, 4} The following ID groups were used for subgroup-specific analyses (Supplemental Table 1 for corresponding codes, Supplemental Digital Content): viral central nervous system infections; meningitis; otitis media; upper respiratory infections; lower respiratory infections; infections of heart; enteric infections; abdominal and rectal infections; hepatobiliary infections; urinary tract infections; infections of female pelvic organs; infections involving bone; cellulitis; mycoses; septicemia; HIV/AIDS; tuberculosis; infections due to internal prosthetic device, implant, and graft; postoperative infections; infections specific to the perinatal period; and viral infections, not otherwise specified. According to the previous literature,² ED visits with a newborn diagnosis indicating a birth (*Clinical Classifications Software* code 218), were excluded. Additionally, visits with primary diagnosis codes of symptoms (e.g., fever) and inadequately defined primary diagnosis codes (e.g., diarrheal diseases not-otherwise-specified) were not included as ID-related ED visits.

Measurements

The NEDS contains information on patient demographics, ED visit month, diagnoses, ED disposition, hospital disposition, and charges for hospital services. Cost data are not available. Socioeconomic status was estimated using the patient's primary insurance (payer) and the national quartiles for median household income based on the patient's home ZIP code. We grouped primary payer into Medicaid, Medicare, private payers, self-pay, and other types.

Hospital characteristics include the geographic region, urban-rural status, and teaching status. Geographic regions (Northeast, South, Midwest, and West) were defined according to the Census Bureau boundaries.¹⁶ Urban-rural status of the ED was defined according to the Urban Influence Codes.¹⁷ The hospital's teaching status was obtained from the American Hospital Association Annual Survey of Hospitals.¹⁵

Statistical Analysis

The primary outcome measures were ID-related (overall and subgroups) ED visits and hospitalizations through the ED. The frequencies of these events (along with 95% confidence intervals [CIs]) were estimated as the weighted number of ID-related ED visits and hospitalizations per 100,000 U.S. children of the corresponding age group per year. Denominators were the 2011 population estimates obtained from the U.S. Census Bureau.¹⁸

Records for ID-related ED visits were examined by age group (i.e., age <1 year [infants], 1–4 years, and 5–19 years, according to the previous literature⁴), sex, primary insurance, quartile for median household income, hospital region, urban-rural status, teaching status, and ED visit month.

Other outcome measures of interest included in-hospital all-cause mortality and charges for ED services. In-hospital all-cause mortality was defined as the number of ED and inpatient any cause deaths divided by total number of ID-related ED visits. ED charges reflected the total fees for ED services, not including professional fees and non-covered charges. We calculated the weighted median with interquartile range (IQR) of visit-level charges because charges were not normally distributed. We also estimated the total charges with 95% CI as a weighted sum of visit-level charges.

In a sensitivity analysis to assess the consistency of the results across years, we repeated the analysis using data from the 2010 NEDS. All analyses used SAS-callable SUDAAN, version 11.0 (Research Triangle Institute, Research Triangle Park, NC) to obtain proper variance estimations that accounted for the complex sampling design. Because no unique patient identifiers were provided with ED records, the unit of analysis for the study was an ED visit. If the number of unweighted observations in a stratum was <10, the national estimates were considered to be unreliable and were not presented according to the HCUP recommendations.^{15 9}

RESULTS

Frequencies, Characteristics, and Seasonality of ID-related ED Visits

We identified a total of 1,914,509 ED visits for IDs among children in the U.S., corresponding to a weighted estimate of 8,524,357 ED visits in 2011 (Table 1). This accounted for 27.6% (95%CI, 27.1%–28.1%) of all U.S. ED visits being made by children. The frequency of overall ID-related ED visits was 10,290 visits per 100,000 children (95%CI, 9,527–11,052 visits per 100,000 children; Supplemental Table 2, Supplemental Digital Content). Infants accounted for only 16.5% (95%CI, 15.9%–17.1%) of all these ID-related ED visits, but their frequency of ED visit was highest among the three age groups (35,173 ED visits per 100,000 infants [approximately 1 ED visits for every 3 infants]). The largest proportion of ID-related ED visits was among children aged 5–19 years (45.1%; 95%CI, 44.0%–46.1%); however, their frequency of ED visit was lowest among the age groups (6,128 visits per 100,000 children).

Children with Medicaid accounted for approximately two-thirds of ID-related ED visits (62.0%; 95%CI, 60.5%–63.4%; Table 1) while this population accounted for 50.6% (95%CI, 49.3%–51.2%) of non-ID-related ED visits made by US children. By contrast, those with a private insurance accounted for a smaller proportion (25.9%; 95%CI, 24.4%–27.4%) of ID-related ED visits. Additionally, more than one third of ID-related ED visits were made by children from areas with the lowest quartile for household income (35.2%; 95%CI, 32.6%–37.9%), whereas this population accounted for 30.9% (95%CI, 28.6%–33.3%) of non-ID-related ED visits made by children.

There was a clear seasonality of ID-related ED visits, with a peak occurring in the winter months of December through March, across all age groups (Figure 1). The national estimate of overall ID-related ED visits according to month ranged from 431,400 visits in July to 875,533 visits in February.

ED Visits by ID Subgroup

Overall, the most frequently listed ID subgroup in 2011 was upper respiratory infection, accounting for 40.8% (95%CI, 40.3%–41.4%) of all ID-related ED visits (Supplemental Table 3, Supplemental Digital Content). The frequency of upper respiratory infection was 4,198 ED visits per 100,000 children (95%CI, 3,892–4,504 visits per 100,000 children; Supplemental Table 2, Supplemental Digital Content). The next most commonly listed subgroup was otitis media, which accounted for 17.7% (95%CI, 17.3%–18.1%) of all ID-related ED visits. This was followed by lower respiratory infection (14.4%; 95%CI, 14.0%–14.9%), including pneumonia and bronchiolitis. Likewise, in the sensitivity analysis of ID-related ED visits in 2010 (Supplemental Table 4, Supplemental Digital Content), upper respiratory infection, otitis media, and lower respiratory infection remained the most frequently listed ID subgroups in children.

With respect to age group, there were modest differences in the proportion of ID-related ED visits attributable to the disease subgroups. Although lower respiratory infection accounted for 14.4% of overall ID-related ED visits, infants had a higher proportion of lower respiratory infection (23.7%; 95%CI, 22.8%–24.8%; Supplemental Table 3, Supplemental Digital Content). More specifically, among the infants, bronchiolitis accounted for 15.0% (95%CI, 13.9%–16.2%) of all ID-related ED visits.

Hospitalizations, Mortality, and Charges

Among 8,524,357 ID-related ED visits in 2011, 424,725 resulted in hospitalizations (5.0%; 95%CI, 4.4%–5.7%). The frequency of overall ID-related hospitalizations through the ED was 513 per 100,000 children (95%CI, 420–605 per 100,000 children; Supplemental Table 2, Supplemental Digital Content), with a highest frequency among infants (3,074 hospitalization per 100,000 infants; 95%CI, 2,472–3,724 hospitalizations per 100,000 infants). Overall, the most frequently listed subgroup in the ID-related hospitalizations was lower respiratory infection, accounting for 40.4% (95%CI, 39.3%–41.5%; Supplemental Table 3, Supplemental Digital Content). Particularly, among the hospitalized infants, lower respiratory infection accounted for 60.0% (95%CI, 58.2%–61.8%) of all ID-related hospitalizations from the ED; bronchiolitis accounted for 42.2% (95%CI, 40.0%–44.5%).

The mortality rate was low, both overall (mortality rate, 0.01%; 95%CI, 0.01%–0.02%) and across age groups (Table 2). An estimated 1,054 children died during their ID-related ED visits and associated hospitalizations in 2011. Among these, the most common ID subgroup was sepsis (49.3% of deaths; 95%CI, 34.5%–64.1%), followed by lower respiratory infection (25.1%; 95%CI, 20.0%–30.9%).

In 2011, the total national charges for ID-related ED visits among children were \$9.6 billion (95%CI, \$9.1 billion–\$10.1 billion; Table 2). The median charge for an ID-related ED visit was \$718 (IQR, \$406–\$1,222).

DISCUSSION

In a large, nationally-representative sample of ED visits among children in the U.S., we found that the public health burden of IDs – as measured by ED visits and subsequent hospitalizations – was enormous. Indeed, we estimated that, in 2011, there were more than 8.5 million ID-related ED visits (28% of all U.S. ED visits made by children) and 400,000 hospitalizations, all contributing to substantial healthcare expenditures. Although costs were not available, charges were almost \$10 billion. Our analysis also demonstrated that children with markers of lower socioeconomic status comprised a disproportionately high proportion of ID-related ED visits in the U.S..

Burden of ID-related ED Visits

To date, most epidemiologic research on children with IDs has focused on hospitalizations.^{2, 4, 9} For example, an analysis of the National Inpatient Sample estimated that there were 7.1 million ID-related hospitalizations in the U.S. children between 1998 and 2006.⁴ Consistent with our findings, the study reported that lower respiratory infection (e.g., bronchiolitis, pneumonia) was the most common subgroup among all ID-related hospitalizations. Although hospitalization statistics show the impact of severe IDs, focusing solely on these events provides an incomplete picture of the healthcare utilization and discounts the importance of the upstream events, including ED visits.¹² Indeed, our data demonstrated that only 5% of the ED visits resulted in hospitalizations. Data on ID-related ED visits, therefore, better reflect the magnitude of its public health burden. To the best of our knowledge, this is the first to specifically examine the epidemiologic characteristics of ID-related ED visits among children in the U.S.. This nationally-representative sample of ED visits demonstrated a large burden of IDs in 2011. The literature suggests that implementation of vaccines (e.g., pneumococcal conjugate vaccines, rotavirus vaccines) has reduced the incidence of preventable IDs and associated healthcare utilization.^{19–22} These findings support a cautious optimism that some ID-related ED visits and associated hospitalizations can be prevented and the societal burden reduced. However, the large ongoing burden underscores the importance of continued preventive efforts for tens of millions of children.

Disparities in ID-related ED Visits

The frequency of ED visits for any particular condition is a function of not only incidence of the disease but also healthcare utilization patterns.¹⁰ Prior studies have associated higher risks of ID-related hospitalizations with social and healthcare-related determinants, such as socioeconomic distress and limited access to outpatient care.^{2, 23–25} For example, an analysis of a nationally-representative sample of U.S. hospitalizations in 2003 reported a high proportion of ID-related hospitalizations among infants with Medicaid and lower household income.² In agreement with these data, our study also demonstrated that these vulnerable populations accounted for a disproportionately high proportion of ID-related ED visits, reflecting potential health disparities. For example, our data demonstrated that 62% of ID-related ED visits were made by children with Medicaid while 42% of the U.S. children had public health plan coverage in 2011.²⁶ The causal role of socioeconomic status to the disparity in the ID-related ED utilization is unclear. The literature suggests that a higher

prevalence of risk factors for IDs (e.g., parental smoking) in these populations, along with differences in health beliefs and behaviors, and more limited access to healthcare resource, might lead to a higher ED utilization with IDs.^{27–29} These data underscore the importance of targeted interventions in these areas (e.g., an improved access to prevention-oriented outpatient care and to primary care resources for low-acuity ID-related illness) as ways to curb ID-related morbidity and healthcare utilization. In addition to the socioeconomic disparities, we also found regional variation in the incidence of ID-related ED visits. This finding is consistent with previous epidemiologic research on hospitalized children with IDs (i.e., a higher hospitalization rate in the South).^{2, 4} While our analysis of administrative data is unable to answer the underlying mechanisms, our data should facilitate further investigations on this topic.

Potential Limitations

This study has several potential limitations. First, as with any studies using administrative data, there may be potential for errors in recording diagnoses; therefore, misclassification of ED visits is possible. For example, some of ED visits with infectious gastroenteritis might have been classified as diarrheal diseases, thereby leading to an underestimation of this disease burden. Nevertheless, HCUP data are highly accurate, rigorously tested, and widely used to estimate diagnoses and visit frequency.^{2, 4–6, 19} Additionally, we identified ID-related ED visits with an ID listed as the primary diagnosis in an effort to limit potential misclassification, although this would also have led to an underestimation of ED visits for IDs. Second, a lack of patient identifiers precluded us from examining longer-term outcomes, such as ED revisits and readmissions. It is possible that a small proportion of patients might have reported to the EDs multiple times in the study period. Third, estimated median household income (based on the patient's home ZIP code) and insurance status are not "completely accurate" but rather they are proxy measures of patients' socioeconomic status. Fourth, the dataset only contains hospital charges, which may not accurately reflect actual hospital costs but provides a rough gauge of expenditures. Finally, our study focused on the ED utilization; we recognize that many children may have reported to non-ED settings with IDs, such as primary care physician's office and other ambulatory care sites. Thus, our findings do not represent the total frequency of IDs but rather the frequency of ED visits for IDs with associated hospitalizations and charges. Nevertheless, because we focused on the burden of the ID-related ED visits, our observations are of direct relevance to the millions of U.S. children visiting the ED each year.

By using a nationally-representative sample of ED visits among children in the U.S., we estimated that, in 2011, there were more than 8.5 million ID-related ED visits and 400,000 associated hospitalizations, all contributing to considerable healthcare expenditure. Our findings reinforce the fact that IDs among children remain a source of substantial morbidity and healthcare utilization in an already-stressed healthcare system. Our findings should encourage policy makers to continue efforts to curb morbidity by preventable IDs; the work is not yet done. Additionally, our data also demonstrated that children with markers of lower socioeconomic status accounted for a disproportionately high proportion of ID-related ED visits. The causal pathway through which these factors affect healthcare utilization is complex. For researchers, our observations should prompt further investigation of the

particular needs and healthcare barriers in the vulnerable population to further reduce the inequalities in healthcare.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Frequency of Infectious Disease Emergency Department Visits among Children in the United States in 2011, according to Month of Visit

Table 1

Infectious Disease-related Emergency Department Visits among Children in the United States in 2011, according to Patient and Hospital Characteristics

Characteristics	Unweighted sample, No.	Weighted sample, No.	Proportion of infectious disease ED visits (95% CI)
Overall	1,914,509	8,524,357	—
Age group			
<1 year	311,761	1,405,685	16.5% (15.9%–17.1%)
1–4 years	734,752	3,277,364	38.4% (37.9%–39.0%)
5–19 years	867,996	3,841,307	45.1% (44.0%–46.1%)
Sex			
Male	930,212	4,148,589	48.7% (48.4%–48.9%)
Female	984,290	4,375,687	51.3% (51.1%–51.6%)
Type of health insurance			
Medicaid	1,186,629	5,270,353	62.0% (60.5%–63.4%)
Medicare	10,875	48,093	0.6% (0.3–1.0%)
Private	483,466	2,200,413	25.9% (24.4%–27.4%)
Self-pay	157,957	683,510	8.0% (7.6%–8.5%)
Other	71,633	305,415	3.6% (3.1%–4.1%)
Quartiles for median household income			
\$1–\$38,999	673,781	2,959,506	35.2% (32.6%–37.9%)
\$39,000–\$47,999	522,445	2,340,051	27.9% (26.0%–29.8%)
\$48,000–\$63,999	439,834	1,970,925	23.5% (21.7%–25.4%)
\$64,000 or more	250,139	1,132,348	13.5% (11.9%–15.2%)
Region			
Northeast	289,384	1,353,424	15.9% (13.8%–18.2%)
Midwest	398,028	2,104,818	24.7% (21.4%–28.4%)
South	872,819	3,554,248	41.7% (38.1%–45.4%)
West	354,445	1,512,673	17.7% (15.2%–20.6%)
Location/teaching status			
Metropolitan teaching	712,016	3,435,826	40.3% (36.3%–44.4%)
Metropolitan nonteaching	819,158	3,423,473	40.2% (36.8%–43.6%)
Nonmetropolitan	383,502	1,665,864	19.5% (17.7%–21.5%)

CI, confidence interval; ED, emergency department

Table 2

Clinical Outcomes and Charges of Infectious Disease-related Emergency Department Visits among Children in the United States, 2011

	Overall	Age <1 year	Age 1–4 years	Age 5–19 years
In-hospital mortality (95%CI)	0.01% (0.01%–0.02%)	0.02% (0.01%–0.02%)	0.01% (0.01%–0.02%)	0.01% (0.01%–0.02%)
Charge for ED services (\$)				
Total charges (millions) (95%CI)	9,600 (9,135–10,063)	1,475 (1,374–1,577)	3,084 (2,918–3,251)	5,031 (4,976–5,267)
Charge per visit, median (IQR)	718 (406–1,222)	725 (406–1,261)	678 (393–1,129)	748 (422–1,293)

CI, confidence intervals; ED, emergency department; IQR, interquartile range.