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National incidence of pediatric mastoiditis in the United States, 2000-2012: creating a baseline for public health surveillance

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Abstract

Between 2000–2012, the national estimated incidence rate of pediatric mastoiditis, a rare but serious complication of acute otitis media (AOM), was highest in 2006 (2.7 per 100,000 population) and lowest in 2012 (1.8 per 100,000 population). This measure provides a baseline for public health surveillance in the pneumococcal conjugate vaccine era as stewardship efforts target antibiotic use in AOM.

Keywords

Mastoiditis; acute otitis media; antibiotic stewardship

Introduction

Mastoiditis is a rare but serious complication of acute otitis media (AOM). AOM accounts for almost one-quarter of antibiotic prescriptions for children in ambulatory settings[1, 2] and therefore is an important antibiotic stewardship target. Visits with AOM diagnoses decreased in recent years, coinciding with declines in antibiotic prescriptions for AOM.[3, 4] The American Academy of Pediatrics recommends watchful waiting in selected cases of AOM but cautions that withholding antibiotics in all cases could lead to increases in suppurative complications, such as mastoiditis.[5]

Mastoiditis surveillance can be used as a public health metric to identify if increases in this rare complication coincide with decreases in rates of diagnosis and associated antibiotic treatment for AOM. This approach has been used in other countries, such as Sweden[6] and the United Kingdom.[7] The introduction of pneunomococcal conjugate vaccines (PCV; PCV7 in 2000 and PCV13 in 2010) has been associated with reductions in and changing of the epidemiology of AOM.[8, 9] The objective of this study is to establish regional and temporal

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trends in the incidence of pediatric mastoiditis in the United States in the PCV-era (2000–2012) as a baseline for public health surveillance of unintended consequences of reducing antibiotic use for AOM.

Materials and Methods

Data sources and study population

We identified incident mastoiditis discharges among children (<18 years) in the Kid's Inpatient Database (KID), part of the Healthcare Cost and Utilization Project. We defined a mastoiditis case as a hospital discharge with acute or unspecified mastoiditis using the following primary *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9) codes: acute mastoiditis with no complications (383.00), subperiosteal abscess of mastoid (383.01), acute mastoiditis with complications (383.02), and unspecified mastoiditis (383.9). We excluded discharges with an additional ICD-9 code for chronic mastoiditis (383.1). One year of data from KID is released every three years; we used all available years since 2000. HCUP databases are considered limited datasets and non-human subjects, as determined by the National Center for Emerging and Zoonotic Infectious Diseases human subjects advisor.

We derived population size from the U.S. Census Bureau Vintage 2015 Bridged-Race Postcensal Population Estimates for each year, region, age, and sex group. Although race is available in both KID and census estimates, it was excluded from this analysis as categorizations differed between the two sources.

Statistical Analysis

We estimated national incidence and 95% confidence intervals (CI) using methods for complex samples. We estimated annual incidence rates nationally, by age group (<2 and 2–17 years), sex, and region (Northeast, Midwest, South and West) by dividing the estimated number of incident cases by census estimates for each group. Age was dichotomized based upon different guideline-recommended AOM management strategies for children aged <2 and 2–17 years old.[5] Estimates from KID have variance due to sampling variability while census estimates do not. To account for this difference, 95% confidence intervals (CIs) for incidence rates were calculated using the corresponding upper and lower limit estimates of mastoiditis incidence from KID divided by census estimates. We estimated rate ratios using a no-interaction negative binomial model adjusting for age, sex, and region with the year 2000 as the referent. As there was significant interaction between region and year, we estimated region-level trends using a model accounting for this interaction and adjusting for age and sex. Statistical tests were conducted at the $\alpha = 0.05$ level. All analyses were conducted using SAS 9.4 (Cary, NC).

We also performed sensitivity analyses using (1) acute diagnosis codes in the primary diagnosis position, and (2) acute and unspecified codes in any of the first 15 discharge codes, the maximum number of diagnostic codes in all years of data.

Results

During the study period, the estimated annual number of discharges with a primary diagnosis of mastoiditis ranged from 1,326 (95% CI 1,180–1,471) to 1,969 (95% CI 1,776–2,163) (see Supplemental Digital Content 1). The per population estimated mastoiditis incidence rates increased from 2.3 (95% CI 2.1–2.6) per 100,000 population in 2000 to 2.7 (95% CI 2.4–2.9) per 100,000 in 2006, then decreased to 1.8 (95% CI 1.6–2.0) per 100,000 in 2012 (Table 1). The incidence rate was over 20% lower in 2012 than in 2000 (adjusted Rate Ratio [aRR] 0.8, 95% CI 0.6–0.9); this was the only year with significantly lower incidence rates than 2000. Rates were higher among those younger than 2 years and among males (Table 1).

Temporal trends varied by region with no single region consistently having the highest or lowest rates (Table 1). Incidence rates decreased from 2000 to 2012 in all regions except the Midwest. These decreases were only significant in the West and the South (West: aRR 0.6, 95% CI 0.5–0.8; South: aRR 0.6, 95% CI 0.5–0.8). The South had the highest rates of mastoiditis in 2000–2006 and the Northeast had the highest rates in 2009–2012.

Sensitivity analyses demonstrated that estimates using the broadest case definition (acute and unspecified diagnosis codes in any position) were 2–3 times higher than estimates using the narrowest definition (acute diagnosis codes in the primary position; see Supplemental Digital Content 2). Overall trends by year, geographic area, age group, and sex were similar across case definitions.

Discussion

Mastoiditis incidence rates in the United States increased from 2000 to 2006 and then decreased from 2006 to 2012. Compared with 2000, incidence rates were only significantly lower in 2012. No one region consistently had the highest or lowest rates in every year of the study period. The declining mastoiditis incidence rates in the latter half of the study period (2006 to 2012) coincided with decreasing visits with a diagnosis of AOM and subsequent antibiotic prescriptions for AOM observed in other published studies during the same period.[3, 8, 9]

Although the total number of antibiotic prescriptions for AOM declined, this trend was driven by decreasing visits with an AOM diagnosis; the proportion of AOM diagnoses treated with antibiotics decreased only slightly.[3] Observed decreases in AOM diagnoses are likely multifactorial and related to vaccine uptake, including PCV introduction and the universal annual influenza vaccination recommendation, application of stricter diagnostic criteria, and perhaps changes in care-seeking behaviors.[3, 5, 8, 9] Despite 2004 and 2013 guidelines from the American Academy of Pediatrics recommending watchful waiting, concern over complications, including mastoiditis, may have discouraged physicians from adopting watchful waiting in AOM management.[10] Antibiotic treatment decreases the relative risk of mastoiditis by half.[7] However, because mastoiditis is very rare, the absolute increase that would be expected without antibiotic treatment would be two additional mastoiditis cases per 10,000 cases of AOM.[7] The American Academy of Pediatrics

guidelines recommend antibiotics in many cases of AOM, in part, to prevent increases in the incidence of suppurative complications, including mastoiditis.[5] In the context of declining rates of AOM diagnosis and associated treatment, it is reassuring that our study demonstrates that mastoiditis incidence has not increased in recent years.

Annual mastoiditis incidence rates were lowest in the West or Midwest, regions with lower rates of AOM diagnoses and associated antibiotic use.[2] This pattern argues against underdiagnosis and undertreatment of AOM in those regions. Reasons for regional differences are unknown, but possibilities include differences in underlying risk factors, higher rates of AOM, and coding differences.

Sensitivity analyses show variation in incidence rate estimates by case definition, highlighting the role of both true incidence and coding practices in mastoiditis incidence estimation using discharge codes. Temporal and regional trends are consistent across definitions, suggesting true incidence changes rather than measurement differences. Additional conditions, such as bacterial meningitis, sigmoid sinus thrombosis, and intracranial abscesses could potentially add to our understanding of the safety of reducing antibiotic use for AOM. However, mastoiditis, as the most common severe complication of AOM, may provide a more easily observable metric.

Our study has several limitations. The first limitation is that we could not account for many factors that may contribute to acute mastoiditis, such as antecedent OM, antibiotic use, vaccination status, and underlying health. Although we can contextualize our findings with published data on these factors, we cannot directly correlate incidence with these factors in our study population. Another limitation is that estimates are only available every three years from KID (next release 2016 data in mid-2018). This may impede our ability to see year-over-year shifts, which is potentially important in identifying trends. A third limitation is that KID aggregates state-level data with variability in the number of states submitting data and in the data fields submitted over time. A strength of our study is the ability to estimate national incidence of this rare disease. The inclusion of a sensitivity analysis is also a strength as it allows us to account for both changes in true incidence and coding practices.

This study of mastoiditis among U.S. children from 2000 to 2012 estimated incidence rates over time and across regions, sexes, and age groups in the PCV era. These estimates may serve as a baseline for public health surveillance of this rare complication and could be used to monitor for uninteded consequences of reducing antibiotic use for AOM, potentially informing antibiotic stewardship efforts.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Conflicts of Interest and Source of Funding:

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Table 1.

National estimated incidence rate of mastoiditis[a] per 100,000 population, Kid's Inpatient Database (KID), 2000–2012

	Estimated mastoiditis[a] incidence rate per 100,000 population (95% CI)[b]				
	2000	**2003**	**2006**	**2009**	**2012**
Total	2.3 (2.1, 2.6)	2.5 (2.3, 2.8)	2.7 (2.4, 2.9)	2.3 (2.1, 2.6)	1.8 (1.6, 2.0)
Sex					
Female	2.0 (1.7, 2.3)	2.1 (1.9, 2.4)	2.3 (2.0, 2.6)	2.0 (1.7, 2.3)	1.6 (1.4, 1.8)
Male	2.6 (2.3, 3.0)	2.8 (2.5, 3.1)	2.9 (2.6, 3.3)	2.6 (2.3, 2.9)	2.0 (1.8, 2.3)
Age, in years					
<2	6.2 (5.2, 7.2)	5.3 (4.5, 6.0)	7.1 (6.2, 8.0)	7.0 (6.0, 8.1)	3.5 (2.9, 4.0)
2–17	1.9 (1.6, 2.1)	2.2 (1.9, 2.4)	2.1 (1.9, 2.3)	1.7 (1.5, 1.9)	1.6 (1.4, 1.8)
Region					
Northeast	2.1 (1.6, 2.5)	2.5 (1.9, 3.1)	2.5 (1.9, 3.1)	2.6 (1.9, 3.3)	2.0 (1.5, 2.6)
Midwest	1.7 (1.0, 2.4)	2.5 (1.9, 3.1)	2.4 (1.8, 3.0)	2.2 (1.5, 2.9)	1.8 (1.3, 2.2)
South	2.9 (2.3, 3.4)	2.7 (2.2, 3.2)	2.9 (2.3, 3.6)	2.5 (2.0, 3.0)	1.9 (1.5, 2.2)
West	2.4 (1.9, 2.9)	2.3 (1.8, 2.9)	2.6 (2.0, 3.2)	2.0 (1.6, 2.5)	1.6 (1.2, 2.0)
Adjusted Rate Ratio[c] (95% CI)	**Referent**	**1.0 (0.9, 1.2)**	**1.1 (1.0, 1.3)**	**1.0 (0.9, 1.2)**	**0.8 (0.6, 0.9)**

[a] Defined as a discharge with ICD-9 codes 383.00, 383.01, 383.02, 383.9 in the primary position.

[b] Upper and lower 95% CIs of incidence rates were calculated using the corresponding limits from estimates of incident mastoiditis cases derived from the KID divided by the census estimate.

[c] Estimated using a no-interaction negative binomial model adjusted for age, sex, and region. Ratio and confidence intervals calculated using incidence point estimate.