

ONLINE FIRST

Incidence of Pediatric Acute Mastoiditis

1997-2006

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Objectives: To evaluate the incidence of acute mastoiditis in children in the United States over the years 1997 through 2006 and to explore possible explanations for the conflicting conclusions of recent studies of this topic.

Design: Comparison of periodic incidence over a decade.

Setting: Academic and community, general, and pediatric specialty hospitals in the United States.

Patients: Children younger than 18 years in the United States treated and discharged with a diagnosis of acute mastoiditis during the years 1997 through 2006.

Main Outcome Measures: To compare true incidence of acute mastoiditis in the pediatric population of the United States, data from Healthcare Costs and Utilization Project—Kids' Inpatient Database (HCUP-KID) was examined for nationally weighted estimates of hospital discharges, demographics (age and sex), hospital characteristics, and insurance characteristics.

Results: No significant change was found in the incidence of acute mastoiditis over the study period (from 1.88 to 1.62 per 100 000 person-years) (regression coefficient -0.024 [95% CI, -0.110 to 0.024]) ($P = .37$). Children admitted with acute mastoiditis had an increased odds of presenting to a teaching hospital (odds ratio [OR], 1.38 [95% CI, 1.31-1.45]) ($P < .001$), a children's hospital (OR, 1.08 [95% CI, 1.03-1.14]) ($P = .001$), and to a metropolitan location (OR, 1.10 [95% CI, 1.02-1.18]) ($P = .016$) over calendar time.

Conclusions: The incidence of acute mastoiditis in the United States is not increasing. The changes in hospital factors identified over the course of this study may explain the perception of increased incidence identified in studies that have not used population-level data.

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ACUTE OTITIS MEDIA (AOM) remains one of the most common pediatric infections. While usually limited in symptom duration, it may progress to suppurative complications with the potential for serious morbidity and even mortality.¹ In the preantibiotic era, 1 in 40 deaths in a large hospital was attributed to intracranial complications of AOM.² Acute mastoiditis (AM), an infectious inflammatory process of the posterior temporal bone, arises almost exclusively as a result of AOM and historically was the most common infectious condition requiring hospitalization among infants and children.³ The introduction of antibiotics into routine clinical practice produced a marked decline in incidence of AM over the last century, reducing the risk of mastoiditis by at least half. Despite this reduction, AM remains the most common complication of AOM.⁴

A review of the literature on AM over the past decade demonstrates considerable conflict over whether the incidence of AM is shifting. Suggested explanations for changes in incidence of AM include increasing antibiotic resistance, the practice of "watchful waiting" for AOM, serotype replacement following vaccination, and changes in access to services.⁴⁻⁷ Some authors claim a concerning increase in the incidence of AM.⁸⁻¹⁰ However, others report the opposite or state that the evidence is inconclusive.^{4,5,11,12} Further contributing to the uncertainty is the variation that exists in defining *incidence*: some studies measure *true incidence* (a change in new cases over time in a defined population, such as a nationwide study), while others arrive at incidence more indirectly by reporting changes in occurrence in single institutions. While the more indirect studies are helpful, they lack the perspective of true incidence studies and are prone to reflect the bias of regional referral patterns.

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Table 1. Patient Demographics and Other Characteristics

Characteristic	Patients, No. (%)				OR (95% CI)	P Value
	1997	2000	2003	2006		
Discharges	1311	1252	1309	1329	NA	NA
Male	807 (62)	742 (59)	743 (57)	775 (58)	0.96 (0.91-1.01)	.09
Age, y						
<1	198 (15)	203 (16)	178 (14)	228 (17)	NA	NA
1-4	523 (40)	491 (39)	463 (35)	488 (37)	NA	NA
5-9	339 (26)	352 (28)	375 (29)	219 (17)	NA	NA
10-14	213 (16)	174 (14)	225 (17)	219 (17)	NA	NA
15-17	37 (3)	32 (3)	68 (5)	57 (4)	NA	NA
Medicaid	414 (32)	415 (33)	521 (40)	576 (43)	1.2 (1.14-1.26)	<.001
Teaching hospital	616 (47)	746 (60)	802 (61)	877 (66)	1.28 (1.22-1.34)	<.001
Metropolitan location	1152 (88)	1091 (87)	1152 (88)	1206 (91)	1.10 (1.02-1.18)	.02
Children's hospital	546 (42)	465 (37)	519 (40)	628 (47)	1.08 (1.03-1.14)	.001
Large hospital size	721 (55)	701 (56)	739 (57)	705 (53)	0.98 (0.93-1.03)	.38

Abbreviations: NA, not applicable; OR, odds ratio.

In our review of the literature, we uncovered little published data using population-level data to evaluate a change in incidence of AM in the United States. The aim of the current study was to determine the incidence of AM in the pediatric population in the United States and to evaluate changes over calendar time. We used the Kids' Inpatient Database (KID), a set of inpatient pediatric hospital databases in the Healthcare Utilization Project (HCUP) family, created by the Agency for Healthcare Research and Quality, the health services arm of the US Department of Health and Human Services. As a federal-state-industry partnership, HCUP-KID provides national estimates for pediatric hospital discharges, and is the only all-payer inpatient care database for children in the United States.¹³

METHODS

This study was exempt from institutional review board approval at the University of Michigan. The data source for this study is the HCUP-KID. The investigators completed the HCUP Data Use Agreement Training Course and signed the HCUP Data Use Agreement form prior to accessing the data. HCUPnet is the online query system based on the data from the HCUP that offers summary statistics for the HCUP databases, including the KID database. Detailed information on the design, content, and methodology of HCUP-KID and HCUPnet is published elsewhere.^{13,14}

The HCUP-KID databases for the years 1997, 2000, 2003, and 2006 were queried to identify all discharges associated with a principal diagnosis of AM using the *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes 383.00 ("acute mastoiditis") and/or 383.01 ("subperiosteal abscess of mastoid") as the principal diagnosis. The ICD-9-CM code 383.02 ("acute mastoiditis with other complications—Gradenigo's syndrome") was not included a priori because this condition was considered to be both sufficiently distinct from the condition of interest and sufficiently uncommon to justify exclusion.

The database provided detailed information on pediatric discharges (patient age, ≤ 20 years, except for 1997, when the patient age was ≤ 18 years). The primary outcome variable was the estimated number of hospital discharges for each of the study

years. To calculate incidence, the number of hospital discharges was divided by the population of the United States in the appropriate age group from US census data and intercensus estimates.^{15,16} Linear regression was used to evaluate the relationship between the incidence of AM and calendar time. Secondary analysis sought to explore the relationship between admissions for AM over time and a number of patient and hospital characteristics.

Patient characteristics studied included sex and primary payer (private or Medicaid). Hospital characteristics assessed included teaching status, children's hospital categorization, and location (whether the hospital was in a metropolitan area [*urban*] or a nonmetropolitan area [*rural*], as defined by AHA Annual Survey).¹⁷ Logistic regression was used to evaluate change over time with hospital characteristics. The data obtained from HCUP-KID were entered into the data analysis and statistical software package STATA 10.0 (StataCorp LP). The alpha level was set at 0.05 for all statistical tests.

RESULTS

POPULATION DESCRIPTION

The HCUPnet KID database for the distinct 3-year intervals ending 1997, 2000, 2003, and 2006 included a total of 5201 discharges with AM representing 6 348 537, 6 351 345, 6 468 925, and 6 578 069 national discharges, respectively. There were no significant differences in the patient demographic characteristics of age and sex distribution over the study period (**Table 1**). Male predominance was consistently demonstrated. Children aged between 1 and 4 years had the highest distribution of cases, nearly double the percentage of infants (age <1 year). The percentage of children with AM possessing private insurance decreased over the study period compared with those with either no insurance or public insurance. In each progressive measurement interval, children with AM had 1.2 times the odds of having Medicaid (odds ratio [OR] range, 1.14-1.26) ($P < .001$) and 1.16 times the odds of being uninsured (OR range, 1.02-1.32) ($P = .03$).

Table 2. Pediatric Acute Mastoiditis Incidence

Year	Patients, No.	National Pediatric Population, No.	Incidence per 100 000	Regression Coefficient (95% CI)	P Value
Acute Mastoiditis (ICD-9-CM Codes 383.00 and 383.01)					
1997	1311	69 437 579	1.88	-0.024	.37
2000	1252	80 539 363	1.55	(-0.110 to 0.024)	
2003	1309	81 132 452	1.61		
2006	1329	81 899 061	1.62		
Acute Mastoiditis (ICD-9-CM Code 383.00)					
1997	1088	69 437 579	1.57	-0.49	.68
2000	1078	80 539 363	1.34	(-0.48 to 0.39)	
2003	1116	81 132 452	1.38		
2006	1054	81 899 061	1.29		
Acute Mastoiditis With Subperiosteal Abscess (ICD-9-CM Code 383.01)					
1997	223	69 437 579	0.32	0.045	.49
2000	174	80 539 363	0.22	(-0.18 to 0.27)	
2003	193	81 132 452	0.24		
2006	275	81 899 061	0.34		

Abbreviation: ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

INCIDENCE

No significant change was identified in the incidence of AM (ranging from 1.88 to 1.62 per 100 000 person-years) (regression coefficient, -0.02 [95% CI, -0.110 to 0.024]) ($P = .37$). Similarly, no change in the incidence of either ICD-9-CM codes 383.00 or 383.01 were identified when considered individually (**Table 2**).

HOSPITAL CHARACTERISTICS

For each progressive interval in the HCUP sampling, children discharged with AM had 1.38 times the odds (95% CI, 1.31-1.45) of being discharged from an academic center ($P < .001$). Similarly, the odds of a child with AM being treated both at a pediatric hospital (OR, 1.08 [95% CI, 1.03-1.14]) ($P = .001$) and in an urban center (OR, 1.10 [95% CI, 1.02-1.18]) ($P = .02$) increased over calendar time.

COMMENT

Incidence and prevalence are critical in population studies and fundamental to epidemiologic research. Incidence should be understood to represent the frequency of disease occurrence in susceptible individuals as they are observed over time. Although *occurrence* and *incidence* are similar, it is misleading to assume that they are synonymous. Incidence can be further delineated by whether the population at risk is closed and observed for a defined period, in which case the denominator is simply the number of individuals at risk, and the numerator is those affected: *cumulative incidence*. Conversely a rate of incident cases can be calculated by including time in the denominator, producing *incidence rate*: the number of cases in an at-risk population per amount of at-risk time, usually expressed as person-time. Calculating individual at-risk time can be impractical when a large at-risk population is studied over time, and hence estimating the time at risk is accomplished by averaging. In this study, we selected 3-year intervals as the average, pro-

viding 4 distinct person-time values, and expressed these as cases per 100 000 persons.

In this study we have demonstrated that over the last decade, there has not been a significant change in the incidence of AM in the pediatric population of the United States. This finding is of importance, given the concern over changing antimicrobial prescribing patterns and emergence of antibiotic-resistant pathogenic microorganisms. It is also apparent that the distribution of AM in the pediatric population has been relatively constant. Children aged between 1 and years continue to have the highest proportion of cases. This of course is consistent with the incidence of AOM in the pediatric population. It should also be noted that the slight male predominance noted in this study is consistent as well with the slightly disproportionate male representation in pediatric AOM incidence.¹⁸

Though always of interest, the number of articles dedicated to the topic of AM incidence has grown substantially. Reviewing the literature, we identified a total of 33 articles discussing the topic of AM incidence since 1994, with only 4 published before the year 2000. We limited our review to include only those studies that (1) were based on data not previously published; (2) were published in English; (3) addressed the issue of disease incidence; and (4) could be classified as either reporting true incidence or not. One additional study was excluded, although it calculated true incidence, because it failed to address incidence change over time but rather focused on comparing incidence among countries. We stratified the remaining 22 studies^{3-8,10-12,19-31} along with the present study by whether the incidence calculation was based on a defined at-risk population (**Table 3**). Interestingly, 63% of occurrence-based studies reported an increase in incidence, whereas none of the true incidence studies reported an increase, a difference that was statistically significant (Fisher exact test, $P = .04$). This finding highlights the importance of accurately calculating incidence based on defined at-risk populations.

Our findings suggest that the occurrence changes reported in the literature are likely attributable to a change

Table 3. Comparison of Previous Studies and Present Study by Population Type

Source, Year of Publication	Time Period	Evidence for Increase
Non-Population-Based Studies (Prevalence of Increased Incidence, 12 of 19 [63%])		
Hoppe et al, ⁶ 1994	1975-1992	Yes
Vera-Cruz et al, ¹⁹ 1999	1993-1997	No
Antonelli et al, ²⁰ 1999	1987-1997	Yes
Kvestad et al, ²¹ 2000	1989-1998	No
Spratley et al, ⁷ 2000	1993-1998	Yes
Bahadori et al, ²² 2000	1986-1999	Yes
Ghaffar et al, ²³ 2001	1955-1979	Yes
	1983-1999	
Urwald et al, ²⁴ 2002	1998-2001	No
Vassbotn et al, ²⁵ 2002	1980-2000	No
Ruiz Diaz et al, ²⁶ 2002	1994-2001	Yes
Zapalac et al, ²⁷ 2002	1993-2000	Yes
Niv et al, ²⁸ 2004	1990-2002	Yes
Nussinovitch et al, ²⁹ 2004	1983-1985	Yes
	1993-1995	
Palma et al, ¹¹ 2007	1994-2005	No
Benito and Gorricho, ¹⁰ 2007	1996-2005	Yes
Ho et al, ⁵ 2008	1996-2005	No
Thorne et al, ³ 2009	2000-2007	Yes
Finnbogadóttir et al, ⁸ 2009	1984-2002	Yes
Stenfeldt and Hermansson, ³⁰ 2010	1996-2005	No
Population-Based Studies (Prevalence of Increased Incidence, 0 of 4 [0%])		
Petersen et al, ³¹ 1998	1977-1997	No
Kvaerner, ¹² 2007	1999-2005	No
Thompson et al, ⁴ 2009	1990-2006	No
Present study	1997-2006	No

in practice patterns rather than changes in disease incidence. Kvaerner¹² demonstrated an example of this by reporting that when 2 health care facilities merged, the merger led to a perception of increased AM volume, but in fact national figures revealed no increased incidence. In our present study, the progressive increase in the percentage of cases of AM managed at children's hospitals, teaching institutions, and in metropolitan facilities would clearly skew the incidence results derived from single institutional studies in the absence of a defined at-risk population. As these academic centers are the most likely to report their observations in the literature, a misperception of trend can be born. An increased occurrence of cases, while perhaps justifying reallocation of resources in a given institution or department, does not necessarily reflect the national trend.

One limitation of this study is the use of administrative data, with the resulting potential for errors in coding and inability to verify clinical information. Limitations of this claims-based database have been discussed at length elsewhere.^{32,33} Second, in our query, we selected only those cases of AM as the primary discharge diagnosis. Consequently, we failed to include those cases of AM as a secondary concern or development. However, limiting our query to primary diagnoses was performed a priori and applied consistently across the study duration, which should limit any potential bias caused by potentially missing cases where AM was coded as a secondary diagnosis.

In conclusion, the current study, using population-level data from a sample of all pediatric discharges in the United States, does not show evidence of an increasing incidence of AM over the study period. Changes in hospital factors associated with discharges for a diagnosis of AM over the course of the study, namely an increase in the odds of presenting to academic pediatric hospitals, may explain the perception of increased incidence in studies using individual hospital-level data.

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