The Public Health Impact of Pediatric Caustic Ingestion Injuries

Christopher M. Johnson, MD; Matthew T. Brigger, MD, MPH

Objective: To determine the current public health burden of injuries due to caustic ingestion in children.

Design: The 2009 Kids' Inpatient Database provides data on a sample of all pediatric hospital discharges in the United States during that year. Children with caustic ingestion injuries requiring hospitalization were identified by corresponding codes from the International Classification of Diseases, Ninth Revision. Database analysis generated national estimates of summary statistics.

Setting: A national database.

Patients: Representative sample of all hospital discharge data on patients 18 years or younger.

Main Outcome Measures: Public health burden related to caustic injury, including potential factors related to admission outcome, the necessity of a procedure during the admission, admission length of stay, and total charges for the admission.

Results: We estimated the prevalence of pediatric caustic ingestion injuries requiring hospitalization in the United States in 2009 to be 807 (95% CI, 731-882) children. The annual economic burden was estimated at $22,900,000 (95% CI, $15,400,000-$30,400,000) in total hospital charges. The mean charge per patient was estimated at $28,860 (95% CI, $19,799-$37,922) with a median of $9,848. The mean length of admission was 4.13 (95% CI, 3.22-5.03) days with a median of 2 days. Among the 807 patients, 45.3% underwent esophagoscopy, and those admitted to teaching hospitals were more likely to undergo a procedure during their stay (P = .02). Logistic regression models suggested significant median income (P < .001) and sex (P < .001) variations.

Conclusions: The current public health burden of pediatric caustic ingestion injuries may be less than commonly cited. This finding supports the notion that legislative efforts have been successful. Despite these successes, these injuries continue to impose a significant burden on health care resources.


In the late 19th and early 20th centuries, lye became commercially available for household use.1 Consequently, an increasing number of injuries due to caustic ingestion were encountered by physicians. These injuries represent a source of significant morbidity and mortality in the pediatric population. For children with a history strongly indicative of an accidental caustic ingestion or with symptoms of a caustic ingestion, endoscopy is recommended and is the primary method of staging the extent of injury after ingestion.2 Acute injuries can range from mild esophageal burns to necrosis and perforation of the esophagus and/or stomach.

Because of the substantial morbidity and mortality associated with these injuries, the medical community demanded legislative action. Through persistent efforts, the Federal Caustic Act of 1927 was enacted requiring appropriate labeling of caustic substances, such as lye.3 Further legislation included the Poison Prevention Packaging Act of 1970, which directs the US Consumer Product Safety Commission to require childproof containers and improved labeling of caustics and other potentially harmful household products.

Although not well documented, the prevalence of caustic ingestion injuries appears to have decreased significantly with these legislative measures, and the prevention of caustic ingestion injuries in children is generally touted as a public health success. Despite this apparent success, current data regarding the true public health burden of such ingestions are not readily known. In fact, a review of the literature demonstrates a surprisingly small collection of data regarding the epidemiology of caustic ingestions. Furthermore, policies have remained essentially static since 1972. Having accurate epidemiologic data is essential to analyze the effect of these legislative measures better and to investigate national trends and variations to
National estimates of the public health burden of pediatric caustic ingestion injuries are shown in Table 1. Based on the weighted estimate, the prevalence of pediatric caustic ingestion injuries requiring hospitalization in the United States during 2009 was 807 (95% CI, 731-882) patients 18 years or younger. Using US census population estimate data from 2009 (which cites roughly 74.5 million children younger than 18 years in 2009), an incidence of 1.08 per 100 000 children per year can be estimated. Age was bimodal in distribution with 59.2% (95% CI, 53.6%-63.8%) of children being younger than 4 years of age. Children with such injuries incurred hospital charges greater than $22 million and accounted for an estimated 3330 (95% CI, 2555-4104) inpatient days.

Procedures were performed on an estimated 508 (95% CI, 452-564) children, of whom 366 (95% CI, 320-412) underwent at least 1 esophagoscopy. Those who under-
went esophagoscopy represent 45.4% (95% CI, 39.4%-51.3%) of all patients in our sample. Other procedures queried in the database but not listed in Table 1 include esophagectomy, tracheostomy, and exploratory laparotomy; however, the relative infrequency of these procedures in our sample prevented the determination of a statistically significant national estimate per the Agency for Healthcare Research and Quality data use agreement.

Other data presented in Table 1 include hospital location, hospital teaching status, hospital type, race, and median annual household income. Most patients in the sample were admitted to teaching hospitals and hospitals in urban locations. Patients admitted for these injuries tended to fall into the lowest median annual income quartile.

Regression models were constructed using hospital region within the United States, hospital location, rural vs urban, sex, hospital teaching status, admission month, and median annual income quartile of the patient’s zip code as independent variables. A logistic regression model investigating factors associated with children who had a caustic ingestion injury that was severe enough to warrant hospital admission identified male sex ($P < .001$), status as a teaching hospital ($P < .001$), and lower median annual income quartile ($P < .001$) as being associated variables (Table 2). Not surprisingly, a higher number of children who sustained caustic ingestion injuries live in zip codes in the bottom quartile of median annual income in the United States. A logistic regression relating whether a child underwent a procedure in the setting of a caustic ingestion injury identified only hospital teaching status ($P = .02$) as an associated variable (Table 3). To state this more clearly, patients admitted to a teaching hospital for a caustic ingestion injury were more likely to undergo a procedure. Poisson regression models investigating factors associated with increasing length of stay (Table 4) and increasing total charges (Table 5) in the setting of a caustic ingestion injury failed to demonstrate a significant relationship with any of the tested variables. Table 4 indicates that total charges are significantly associated with length of stay; however, this relationship is expected given that the hospital will undoubtedly charge for additional admission days.

As stated previously, a review of the literature demonstrates a surprisingly small collection of data regarding the epidemiology of caustic ingestions. We identified a single report that was specifically designed to evaluate and quantify epidemiologic data for caustic ingestions. Christensen assessed computer record files at 9 hospitals from January 1, 1976, through December 31, 1991, in a county in Denmark. The incidence rate of hospitalization for caustic ingestion injuries was calculated to be 10.8 per 100,000 children younger than 16 years during that period.

Comparative information relative to the United States can be obtained only by extrapolation from publications regarding pediatric poisonings. Rodriguez and Satin accessed the National Hospital Discharge Survey to obtain data on pediatric poisonings from 1979 through 1983. Although most data are composite in nature, an annual incidence rate of caustic ingestion injury of 6.1 per 100,000 children can be calculated from the raw data. Perhaps the most intriguing report was published in 1971 in the New England Journal of Medicine by Leape et al. Although the publication consisted of only a small case series and an animal experiment that demonstrated the rapid and catastrophic effects of liquid lye, it had a major effect on public health policy. Dr Leape is credited, along with then Senator Robert Dole, as being responsible for persuading the Consumer Product Safety Commission to remove concentrated lye from the commercial market. Of particular significance to this review is the opening paragraph, where, citing data from the National Clearinghouse for Poison Control Centers in 1969, Leape et al report that 523 children younger than 5 years were documented to have ingested lye; the authors subsequently cite an estimate that only approximately 10% of all ingestions are reported to poison control centers. According to Leape et al, “One may thus crudely estimate that the total number of accidental lye ingestions per year in children under 5 years of age is approximately 5000.” The importance of this figure cannot be understated. A brief review of the literature repeatedly shows a prevalence of 5000 to 15,000 cases of pediatric caustic ingestion injuries in the United States each year. These numbers directly or indirectly reference the report by Leape et al or a study published in 1986 by Rothstein (which referenced the former article and reported an uncited reference to 15,000 cases per year) as the source of their data. These citations clearly represent a problem because more recent articles citing these data were published as long as 35 years after the report by Leape et al.

Based on the weighted estimate derived from the 2009 KID, the estimated prevalence of severe pediatric caustic ingestion injury in the United States necessitating hospital admission in 2009 was 807 children. Incidence in the United States in 2009 was estimated to be 1.08 per 100,000 children. A direct comparison with commonly cited incidence data would be difficult or impossible given that the most frequently cited source is at best a gross estimation. Furthermore, the estimate from the report by

![Figure](http://archotol.jamanetwork.com/pdfaccess.ashx?url=/data/journals/otol/926110/)
Leape et al\textsuperscript{7} is based on poison control data, whereas the data presented herein encompass only those children who required hospitalization. From a public health standpoint, children who are admitted to a hospital undoubtedly represent those patients with a higher level of severity who may incur significant hospital charges and potentially develop long-term sequelae. When compared with incidence data from the article by Rodriguez and Sattin\textsuperscript{6} (which also referenced hospital admission data), these figures represent a substantial decrease. As such, the burden of caustic ingestion injuries in children appears to have decreased over time in the United States, and past public health interventions appear to have been successful. However, children with caustic ingestion injuries accounted for more than $22 million in hospital charges and more than 3300 inpatient days in 2009 despite the successes of public health policies currently in place.

The age distribution is bimodal, which has been previously reported.\textsuperscript{12} Most cases occur in children younger than 4 years; however, a second rise in prevalence corresponds to the late teenage years, which primarily represents intentional ingestions as part of suicide attempts.\textsuperscript{2} Patients in the older group have been reported to have significantly higher complication rates because the intentional nature of the injury allows more caustic agent to be ingested.\textsuperscript{12}

In terms of procedures performed, about half of the patients underwent an esophagoscopy. According to a recently published review article,\textsuperscript{2} endoscopy is recom-

\begin{table}
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\caption{Logistic Regression Indicators for Sustaining a Caustic Ingestion Injury Requiring Hospital Admission}
\begin{tabular}{|l|c|c|}
\hline
Variable & Coefficient (95\% CI) & \(P\) Value \\
\hline
Sex & \(-0.455\) \((-0.644\) to \(-0.267\)) & \(<.001\) \\
Admission month & \(-0.007\) \((-0.034\) to \(-0.019\)) & .58 \\
Median annual household income & \(-0.190\) \((-0.275\) to \(-0.104\)) & \(<.001\) \\
Hospital region & \(0.055\) \((-0.049\) to \(0.159\)) & .30 \\
Urban hospital location & \(0.215\) \((-0.192\) to \(0.622\)) & .30 \\
Hospital teaching status & \(1.122\) \((0.875\) to \(1.370)\) & \(<.001\) \\
\hline
\end{tabular}
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\begin{table}
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\caption{Logistic Regression Indicators for Undergoing a Procedure in the Setting of a Caustic Ingestion Injury}
\begin{tabular}{|l|c|c|}
\hline
Variable & Coefficient (95\% CI) & \(P\) Value \\
\hline
Sex & \(-0.307\) \((-0.840\) to \(-0.226)\) & .26 \\
Admission month & \(0.015\) \((-0.056\) to \(0.086)\) & .68 \\
Median annual household income & \(-0.030\) \((-0.265\) to \(0.205)\) & .80 \\
Hospital region & \(-0.040\) \((-0.257\) to \(0.176)\) & .71 \\
Urban hospital location & \(0.179\) \((-0.660\) to \(2.217)\) & .29 \\
Hospital teaching status & \(0.994\) \((0.172\) to \(1.816)\) & .02 \\
Total charges & \(3.09 \times 10^{-7}\) \((-3.13 \times 10^{-4}\) to \(3.74 \times 10^{-6})\) & .86 \\
\hline
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\begin{table}
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\caption{Poisson Regression Indicators for Increasing Length of Admission in the Setting of a Caustic Ingestion Injury}
\begin{tabular}{|l|c|c|}
\hline
Variable & Coefficient (95\% CI) & \(P\) Value \\
\hline
Sex & \(-0.136\) \((-0.483\) to \(0.211)\) & .44 \\
Admission month & \(0.001\) \((-0.050\) to \(0.052)\) & .98 \\
Median annual household income & \(-0.013\) \((-0.144\) to \(0.118)\) & .84 \\
Hospital region & \(-0.120\) \((-0.251\) to \(0.012)\) & .07 \\
Urban hospital location & \(0.397\) \((-0.218\) to \(1.012)\) & .20 \\
Hospital teaching status & \(0.188\) \((-0.316\) to \(0.691)\) & .46 \\
Total charges & \(3.44 \times 10^{-4}\) \((2.44 \times 10^{-4}\) to \(4.45 \times 10^{-4})\) & \(<.001\) \\
\hline
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\begin{table}
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\caption{Poisson Regression Indicators for Increasing Total Charges in the Setting of a Caustic Ingestion Injury}
\begin{tabular}{|l|c|c|}
\hline
Variable & Coefficient (95\% CI) & \(P\) Value \\
\hline
Sex & \(-0.443\) \((-0.945\) to \(0.060)\) & .08 \\
Admission month & \(-0.046\) \((-0.122\) to \(0.030)\) & .23 \\
Median annual household income & \(0.004\) \((-0.295\) to \(0.302)\) & .98 \\
Hospital region & \(-0.065\) \((-0.442\) to \(0.313)\) & .74 \\
Urban hospital location & \(0.843\) \((-0.224\) to \(1.909)\) & .12 \\
Hospital teaching status & \(0.717\) \((-0.106\) to \(1.540)\) & .09 \\
\hline
\end{tabular}
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recommended for children who have a history strongly suggestive of ingestion of a caustic substance, those who are symptomatic, those with oral cavity burns, and those in whom the ingestion was intentional. Assuming that these recommendations are followed in most cases, a logical conclusion is that a large proportion of children are admitted to the hospital for observation even if suspicion of significant injury is low. Also in regard to procedures performed, patients admitted to a teaching hospital because of caustic ingestion injuries were more likely to have undergone a procedure. This fact is intriguing in that procedures could have been performed more frequently simply because trainees need the experience but could also be explained by a higher level of acuity at teaching hospitals. Unfortunately, the KID does not provide further insight to this intriguing finding.

Regional variation was present in terms of total hospital charges per patient. We found a higher burden of injury in urban hospitals and in patients who lived in zip codes in the bottom quartile of median annual income in the United States. This finding is consistent with available pediatric poisoning data that indicate that low-income urban households are more likely to store dangerous household products improperly.\textsuperscript{15} Further analysis of this regional variation is difficult owing to the limitations of the database; however, this information can serve as a basis for additional study.

The primary weakness of this study is that the KID is based on administrative data that require accurate coding and reporting, so the data are only as accurate as those that were coded. Another limitation is that this database represents only those incidents for which hospital admission was warranted. We assumed that minor or asymptomatic cases are triaged by poison control centers or in the emergency department. Those cases not requiring hospitalization can be assumed to have a less significant public health impact.

\section*{CONCLUSIONS}

Based on the weighted estimate, the prevalence of pediatric caustic ingestion injuries in the United States during 2009 appears to be much lower than the figure widely stated in the literature. The finding of a decreased prevalence of caustic injuries makes sense given the public health interventions currently in place. Despite these successes, children with caustic ingestion injuries are estimated to incur hospital charges greater than $22 million and account for more than 3300 inpatient days in 2009. Further investigation is necessary to better define specific populations and to identify opportunities for targeted public health intervention.

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\section*{Correspondence}

Christopher M. Johnson, MD, Department of Otolaryngology, Naval Medical Center San Diego, 38400 Bob Wilson Dr, San Diego, CA 92134.

\section*{Author Contributions}

Drs Johnson and Brigger each take responsibility for the content and gave final approval of the version to be submitted. Study concept and design: Johnson and Brigger. Acquisition of data: Johnson and Brigger. Analysis and interpretation of data: Johnson and Brigger. Drafting of the manuscript: Johnson and Brigger. Critical revision of the manuscript for important intellectual content: Johnson and Brigger. Statistical analysis: Johnson and Brigger. Study supervision: Brigger.

\section*{Conflict of Interest Disclosures}

None reported.

\section*{Disclaimer}

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, the Department of Defense, or the US government.

\section*{REFERENCES}