

# Household Cleaning Product-Related Injuries Treated in US Emergency Departments in 1990–2006

**AUTHORS:** Lara B. McKenzie, PhD, MA,<sup>a,b</sup> Nisha Ahir, MD,<sup>a</sup> Uwe Stolz, PhD, MPH,<sup>c</sup> and Nicolas G. Nelson, MPH<sup>a</sup>

<sup>a</sup>Center for Injury Research and Policy, Research Institute at Nationwide Children's Hospital, Columbus, Ohio; <sup>b</sup>Department of Pediatrics, College of Medicine, Ohio State University, Columbus, Ohio; and <sup>c</sup>Arizona Emergency Medicine Research Center, University of Arizona, Tucson, Arizona

## KEY WORDS

household cleaning products, poisoning, injuries, emergency department, National Electronic Injury Surveillance System

## ABBREVIATIONS

CI—confidence interval

ED—emergency department

NEISS—National Electronic Injury Surveillance System

OR—odds ratio

[www.pediatrics.org/cgi/doi/10.1542/peds.2009-3392](http://www.pediatrics.org/cgi/doi/10.1542/peds.2009-3392)

doi:10.1542/peds.2009-3392

Accepted for publication May 13, 2010

Address correspondence to Lara B. McKenzie, PhD, MA, Research Institute at Nationwide Children's Hospital, 700 Children's Dr, Columbus, OH 43205. E-mail: [lara.mckenzie@nationwidechildrens.org](mailto:lara.mckenzie@nationwidechildrens.org)

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2010 by the American Academy of Pediatrics

**FINANCIAL DISCLOSURE:** *The authors have indicated they have no financial relationships relevant to this article to disclose.*



**WHAT'S KNOWN ON THIS SUBJECT:** Household cleaning products are responsible for many unintentional poisonings in children and are consistently in the top 5 categories for pediatric poisoning exposure.



**WHAT THIS STUDY ADDS:** Rates of cleaning product-related injuries among children treated in EDs decreased 46% during the 17-year study period. The products associated most often with injuries were bleach (37.1%) and low-molecular weight hydrocarbons, acids/alkalis, and detergents (30.4%).

## abstract

FREE

**OBJECTIVE:** The goal was to examine comprehensively the patterns and trends of household cleaning product-related injuries among children treated in US emergency departments.

**METHODS:** Through use of the National Electronic Injury Surveillance System database, cases of unintentional, nonfatal, household cleaning product-related injuries were selected by using product codes for drain cleaners, ammonia, metal polishes/tarnish removers, turpentine, dishwasher detergents, acids, swimming pool chemicals, oven cleaners, pine oil cleaners/disinfectants, laundry soaps/detergents, toilet bowl products, abrasive cleaners, general-purpose household cleaners, noncosmetic bleaches, windshield wiper fluids, caustic agents, lye, wallpaper cleaners, room deodorizers/fresheners, spot removers, and dishwashing liquids. Products were categorized according to major toxic ingredients, mode of action, and exposure.

**RESULTS:** An estimated 267 269 children  $\leq 5$  years of age were treated in US emergency departments for household cleaning product-related injuries. The number of injuries attributable to household cleaning product exposure decreased 46.0% from 22 141 in 1990 to 11 964 in 2006. The product most-commonly associated with injury was bleach (37.1%). Children 1 to 3 years of age accounted for 72.0% of cases. The primary mechanism of injury was ingestion (62.7%). The most common source or container was spray-bottles (40.1%). Although rates of household cleaner-related injuries from regular bottles or original containers and kitchenware decreased during the study period, spray-bottle injury rates showed no decrease.

**CONCLUSION:** Although national rates of household cleaning product-related injuries in children decreased significantly over time, the number of injuries remains high. *Pediatrics* 2010;126:000

Children  $\leq 5$  years of age account for the majority of all poisoning exposures.<sup>1–3</sup> In 2006, children  $\leq 5$  years of age were involved in  $>1.2$  million cases of poisoning exposure, accounting for 51.0% of all poisoning exposures.<sup>1</sup> These findings are most likely related to the explorative nature of children in this age group, along with curiosity, mobility, and a desire to put things in their mouths.<sup>4–6</sup> More than 80% of poisoning exposures occur in the home, the environment in which children  $\leq 5$  years of age spend most of their time.<sup>4,5,7</sup>

Pediatric poisonings generally are unintentional ( $>99.0\%$  of all poisoning exposures), and exposure to cleaning products in the home is responsible for many unintentional poisonings of children.<sup>1</sup> In 2004–2006, unintentional ingestion of a household cleaning product was the second most common cause of pediatric poisonings.<sup>1–3</sup> In recent decades, cleaning products have consistently been in the top 5 categories of pediatric poisoning exposure.<sup>8</sup> Fortunately, the high frequency of exposure to these toxic products has not resulted in concomitant high mortality rates for children  $\leq 5$  years of age (29 deaths [2.0% of all poisoning fatalities] in 2006). In 2006, however, 10 318 children required some form of medical treatment as a result of poisoning attributable to exposure to household cleaners, and 744 of those children exhibited symptoms that were life-threatening or that resulted in significant residual disability.<sup>1,9</sup>

The Poison Prevention Packaging Act of 1970 was enacted by Congress and is enforced by the US Consumer Product Safety Commission; it requires that certain household substances (furniture polish, drain cleaners, and oven cleaners) be sold in child-resistant packaging.<sup>10</sup> In fact, child-resistant packaging is partially responsible for the decreased numbers of deaths re-

sulting from pediatric poisoning in the United States.<sup>1</sup> Other reasons for the decreases in mortality rates include product reformulation, increased parental awareness of toxic product effects, and the development of poison control centers.<sup>8</sup> Despite the aforementioned changes and the variety of existing poisoning-prevention strategies, children still account for the majority of unintentional poisoning exposures. The proportions of childhood injuries and poisonings resulting from household cleaning products remained constant in previous decades.<sup>1,11</sup>

The goal of this study was to examine comprehensively the patterns and trends of household cleaning product-related injuries among children  $\leq 5$  years of age who were treated in US emergency departments (EDs) between 1990 and 2006. To our knowledge, no published studies have examined poisonings from household cleaning products among children  $<5$  years of age for this extended time period by using a nationally representative sample. This study examined poisonings resulting from household cleaning products and associated demographic, injury, and product characteristics.

## METHODS

### Data Source

Data for patients who were treated between January 1, 1990, and December 31, 2006, were obtained through the National Electronic Injury Surveillance System (NEISS), which is operated by the US Consumer Product Safety Commission. The NEISS provides data on consumer product-related and sports activity-related injuries that are treated in US EDs. The NEISS receives data from a network of  $\sim 100$  hospitals, which represents a stratified probability sample of 6100 hospitals with  $\geq 6$  beds and a 24-hour ED. The network includes urban, suburban, ru-

ral, and children's hospitals. Data collected by the NEISS are weighted to yield national estimates for consumer product-related and sports activity-related injuries.<sup>12</sup> The NEISS was established in 1972, and revisions in the sampling frame were made in 1978, 1990, and 1997. At all sampled hospitals, ED medical charts are viewed by professional NEISS coders, and data regarding patients' age and gender, injury diagnosis, body part injured, locale where the injury occurred, product or products involved, and disposition from the ED, as well as a brief narrative describing the incident, are recorded. Data from the US Census Bureau were used to calculate injury rates per 10 000 children  $\leq 5$  years of age.<sup>13,14</sup>

### Case Selection Criteria

All NEISS cases identified by the NEISS product codes for household cleaners, including drain cleaners, ammonia, metal polishes, tarnish removers, turpentine, dishwasher detergents, acids, swimming pool chemicals, oven cleaners, pine oil cleaners and disinfectants, laundry soaps or detergents, toilet bowl products, abrasive cleaners, general-purpose household cleaners, noncosmetic bleaches, windshield wiper fluids, caustic agents (excluding lye), lye, wallpaper cleaners, room deodorizers or fresheners, detergents not specified, spot removers, and dishwashing liquids, were reviewed. Case inclusion and exclusion criteria and variable categories were developed after review of a subset of narratives. All case narratives were reviewed to ensure that they involved household cleaning products; ambiguous narratives and a subset of all cases were reviewed by  $\geq 1$  other author, and disagreements were resolved through consensus. Injuries resulting from household cleaning products used in a locale outside the home or used atypically were excluded, as were incidents with a diagnosis of submersion or al-

lergic dermatitis (eg, allergic reaction to a new laundry detergent after use of a freshly laundered towel) and those involving boric acid, methacrylic acid, battery acid, or ammonia inhalants. Cases involving hand soap, shampoo, or other personal cleaning products were excluded. The single case fatality was excluded.

## Variables

### Categories

Data regarding patient age, injury diagnosis, body part injured, locale of injury, disposition, and household cleaning product involved were coded as categorical variables. Patients were separated into 6 age groups (<1, 1, 2, 3, 4, or 5 years of age) for analyses. The variable of locale (the location where the injury took place) was grouped into 2 categories (home or other). The variable of gender was used as reported by the NEISS data set.

### Body Regions and Dispositions

The body parts injured were grouped according to body region, in categories of head (including nose and ears), mouth, eyes, trunk and/or extremities (including upper and lower trunk and pubic region, neck, 25%–50% of the body, upper leg, knee, lower leg, ankle, foot, toe, upper arm, elbow, lower arm, wrist, hand, and finger), and “all parts of the body.” The code for all parts of the body is assigned by NEISS coders for poisonings, because of their systemic effects. Disposition was categorized as not hospitalized (ie, treated and released or examined and released without treatment) or hospitalized (ie, treated and transferred to another hospital, treated and admitted for hospitalization, or held for observation).

### Household Cleaning Products

The specific household cleaning products were grouped into 6 categories on the basis of similarity of chemical composition and/or characteristics, that

is, low-molecular weight hydrocarbons (including pine oil cleaning products, spot removers, and turpentine), acids and/or alkalis (including acids, lye, caustic agents, oven cleaners, drain cleaners, toilet bowl products, and dishwasher detergents), bleach, detergents (including laundry soaps and detergents, dishwashing liquids, and detergents not otherwise specified), ammonia (including ammonia, bleach plus ammonia mixtures, and mixtures of bleach plus ammonia plus another product), and other products (including general-purpose household cleaners, wallpaper cleaners, room deodorizers, abrasive cleaners, metal polishes, tarnish removers, and 2- or 3-product mixtures).

### Product-Related Variables

Case narratives were used to generate 3 new variables, namely, mechanism of injury (ingestion, inhalation, or contact), source or container (kitchenware or cookware; spray-bottles; regular bottles or original-containers; cleaning equipment, such as mops, buckets, or rags; food or drink containers; or actual items that had been cleaned recently, such as floor, toilet bowl, or sink), and person (patient, adult, or other child) handling the cleaning product at the time of injury (eg, an adult accidentally sprayed a cleaning product in a child's eyes).

### Statistical Analyses

Data were analyzed by using SPSS 17.0 (SPSS Inc, Chicago, IL) and Stata SE 10 (Stata Corp, College Station, TX). A sample weight was assigned to each case by the Consumer Product Safety Commission, on the basis of the inverse probability of selection, and weights were used to generate national estimates. Means were reported with SDs. Bivariate comparisons were conducted by using  $\chi^2$  tests, and the strength of association was assessed by using odds ratio (ORs) and associ-

ated 95% confidence intervals (CIs). Trend significance of the numbers of household cleaning product-related injuries over time was analyzed by using linear regression. Statistical significance was assessed by using  $\alpha = .05$ . All statistical analyses accounted for the complex sampling frame of the NEISS. All data reported in this article are national estimates unless specified as actual unweighted case numbers. National estimates were based on weighted data for 7923 patients who were  $\leq 5$  years of age and were treated for household cleaning product-related injuries. The institutional review board of the Research Institute at Nationwide Children's Hospital approved this study.

## RESULTS

### Demographic Features and Overall Injury Trends

Between 1990 and 2006, an estimated 267 269 children (95% CI: 227 200–307 338 children)  $\leq 5$  years of age were treated in US EDs for household cleaning product-related injuries (Table 1). The number of cases decreased 46.0% from 22 141 in 1990 to 11 964 in 2006 ( $R^2 = 0.841$ ;  $P < .001$ ). The rate of injuries per 10 000 US population  $\leq 5$  years of age decreased by 50.3% over the 17-year period, from 9.83 cases per 10 000 in 1990 to 4.88 cases per 10 000 in 2006 ( $R^2 = 0.854$ ;  $P < .001$ ) (Fig 1). The majority of unintentional household cleaning product-related injuries involved children 1 to 3 years of age, who accounted for 192 288 cases (72.0% of total). Children 1 year of age constituted 45.9% of cases and had the highest injury rate (3.08 injuries per 10 000 US population) (Table 2). Boys accounted for 58.8% of all cases. The rate of household cleaning product-related injuries from all product categories (except other) decreased significantly during the 17-year study period (Fig 2). The rate of household cleaning

**TABLE 1** Characteristics of Patients With Household Cleaning Product-Related Injuries Treated in US EDs in 1990–2006

| Characteristic                 | No. <sup>a</sup> |                   | Weighted Proportion (95% CI) <sup>b</sup> |
|--------------------------------|------------------|-------------------|-------------------------------------------|
|                                | Actual Cases     | National Estimate |                                           |
| Total                          | 7923             | 267 269           | 100                                       |
| Age                            | 7923             | 267 269           | 100                                       |
| <1 y                           | 841              | 30 055            | 11.2 (10.2–12.4)                          |
| 1 y                            | 3715             | 122 647           | 45.9 (44.1–47.7)                          |
| 2 y                            | 2052             | 69 641            | 26.1 (24.7–27.5)                          |
| 3 y                            | 725              | 25 100            | 9.4 (8.6–10.3)                            |
| 4 y                            | 384              | 12 097            | 4.5 (4.0–5.2)                             |
| 5 y                            | 206              | 7729              | 2.9 (2.5–3.4)                             |
| Gender                         | 7922             | 267 263           | 100                                       |
| Male                           | 4728             | 157 144           | 58.8 (57.4–60.1)                          |
| Female                         | 3194             | 110 119           | 41.2 (39.9–42.6)                          |
| Injury diagnosis               | 7495             | 252 659           | 100                                       |
| Poisoning                      | 5231             | 172 850           | 68.4 (65.4–71.3)                          |
| Chemical burn                  | 1108             | 40 157            | 15.9 (14.0–18.0)                          |
| Dermatitis/conjunctivitis      | 757              | 26 260            | 10.4 (8.8–12.3)                           |
| Contusion/abrasion             | 241              | 7608              | 3.0 (2.3–3.9)                             |
| Foreign body                   | 158              | 5784              | 2.3 (1.7–3.1)                             |
| Injured body region            | 7892             | 266 395           | 100                                       |
| Entire body <sup>c</sup>       | 5284             | 174 529           | 65.5 (68.5–62.4)                          |
| Eyes                           | 1862             | 65 114            | 24.4 (21.9–27.1)                          |
| Head <sup>d</sup>              | 364              | 13 507            | 5.1 (4.5–5.8)                             |
| Trunk/extremities <sup>e</sup> | 243              | 8149              | 3.1 (2.5–3.7)                             |
| Mouth                          | 139              | 5096              | 1.9 (1.5–2.5)                             |
| Case disposition               | 7906             | 265 386           | 100                                       |
| Not hospitalized               | 7406             | 250 395           | 94.4 (92.7–94.8)                          |
| Hospitalized <sup>f</sup>      | 503              | 14 991            | 5.6 (4.7–6.7)                             |

<sup>a</sup> Some values may differ because of missing data.

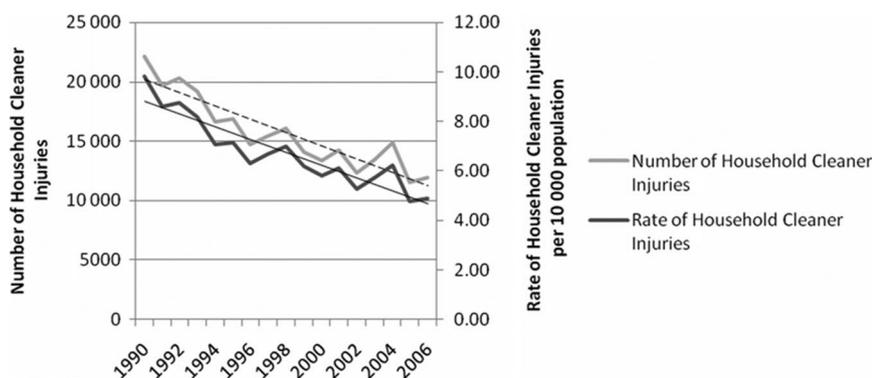
<sup>b</sup> Proportions may not add up to 100 because of rounding.

<sup>c</sup> Entire body is the coding category used by the NEISS for poisonings.

<sup>d</sup> Head included nose and ears.

<sup>e</sup> Trunk/extremities included 20% to 50% of the body, upper and lower trunk, pubic region, neck, upper leg, knee, lower leg, ankle, foot, toe, shoulder, upper arm, elbow, lower arm, wrist, hand, and finger.

<sup>f</sup> Hospitalized included patients treated and transferred to another hospital, treated and transferred for hospitalization, treated and admitted, or held <24 hours for observation.



**FIGURE 1** Numbers ( $\beta = -559.6$ ;  $R^2 = 0.841$ ;  $P < .001$ ) and rates ( $\beta = -0.259$ ;  $R^2 = 0.854$ ;  $P < .001$ ) of household cleaner-related injuries treated in US EDs in 1990–2006.

product-related injuries for children  $\leq 3$  years of age decreased significantly over time; the decrease for children 4 to 5 years of age was not statistically significant (Fig 3). Information

on the locale at the time of injury was recorded in 78.8% of cases. The majority of household cleaning product-related injuries occurred at home (98.8%).

## Household Cleaning Products

Bleach accounted for 37.1% of household cleaning product-related injuries, followed by low-molecular weight hydrocarbons, acids/alkalis, and detergents (30.4%). Ammonia products accounted for 2.5% of cases. Exposure to household cleaning products containing acids/alkalis increased the odds of hospitalization (OR: 4.68 [95% CI: 3.34–6.56]), compared with exposure to cleaning products containing bleach, low-molecular weight hydrocarbons, detergents, or others; similarly, exposure to cleaning products containing ammonia increased the odds of hospitalization by 1.96 (95% CI: 1.01–3.81), compared with exposure to cleaning products containing bleach, low-molecular weight hydrocarbons, detergents, or others (Table 3). Bleach, compared with all other products, was more likely to be stored in kitchenware (OR: 7.303 [95% CI: 5.18–10.29]) than in other sources or containers. Detergents (OR: 1.99 [95% CI: 1.14–3.46]) and ammonia (OR: 1.95 [95% CI: 1.17–3.27]), compared with all other products, were more likely to be stored in the original packaging or regular bottles than in other sources or containers. Acids/alkalis, compared with other products, were more likely (OR: 2.94 [95% CI: 1.96–4.41]) to be found on recently cleaned items stored in any other sources or containers.

## Diagnoses, Body Regions, and Hospitalizations

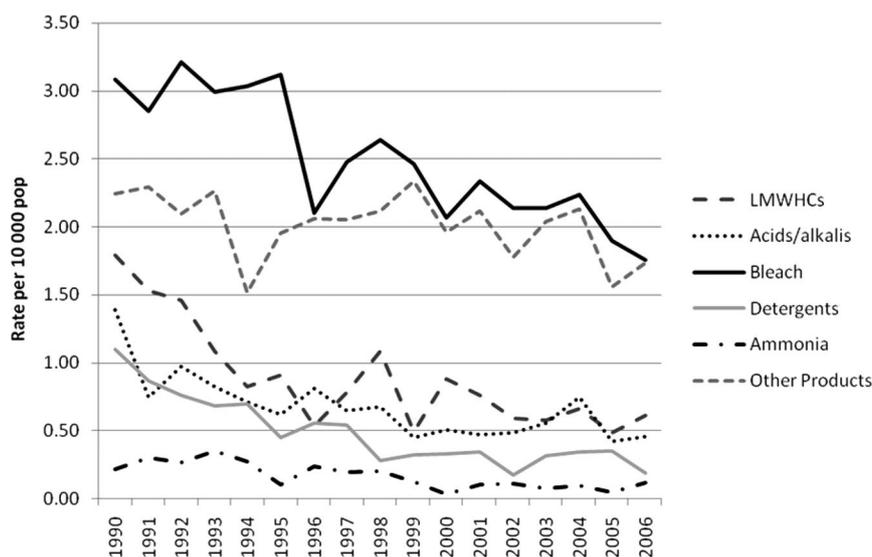
Poisoning was the most common diagnosis, accounting for 68.4% of all household cleaning product-related injuries, followed by chemical burns (15.9%) and dermatitis and/or conjunctivitis (10.4%). All parts of the body represented the body region injured most commonly (65.5% of cases). Patients who were hospitalized accounted for 5.6% (95% CI: 4.7%–6.7%) of all cases. A diagnosis of poisoning increased the odds of hospi-

**TABLE 2** Characteristics of Household Cleaner-Related Injuries Treated in US EDs in 1990–2006

| Characteristic                            | No. <sup>a</sup> |                   | Weighted Proportion (95% CI) <sup>b</sup> |
|-------------------------------------------|------------------|-------------------|-------------------------------------------|
|                                           | Actual Cases     | National Estimate |                                           |
| Mechanism of injury                       | 7778             | 261 602           | 100                                       |
| Ingestion                                 | 5010             | 164 042           | 62.7 (59.5–65.8)                          |
| Contact                                   | 2668             | 93 880            | 35.9 (32.8–39.1)                          |
| Inhalation                                | 100              | 3680              | 1.4 (1.1–1.9)                             |
| Source or container                       | 3146             | 105 917           | 100                                       |
| Spray-bottles                             | 1162             | 42 460            | 40.1 (35.7–44.6)                          |
| Regular bottles or original containers    | 980              | 31 834            | 30.1 (26.5–33.9)                          |
| Kitchenware                               | 504              | 15 211            | 14.4 (12.1–17.0)                          |
| Items cleaned recently                    | 258              | 8577              | 8.0 (6.7–9.7)                             |
| Cleaning equipment                        | 167              | 5265              | 5.0 (4.1–6.0)                             |
| Food/drink containers                     | 75               | 2570              | 2.4 (1.8–3.3)                             |
| Person handling product at time of injury | 7923             | 267 268           | 100                                       |
| Patient                                   | 7577             | 253 883           | 95.0 (94.1–95.8)                          |
| Other child                               | 262              | 10 048            | 3.8 (3.1–4.5)                             |
| Adult                                     | 84               | 3337              | 1.2 (1.0–1.6)                             |
| Product categories                        | 7923             | 267 267           | 100                                       |
| Bleach                                    | 2982             | 99 284            | 37.2 (34.5–39.9)                          |
| Low-molecular weight hydrocarbons         | 1001             | 35 124            | 13.1 (11.9–14.4)                          |
| Acids/alkalis                             | 799              | 26 889            | 10.1 (9.13–11.1)                          |
| Detergents                                | 551              | 19 338            | 7.2 (6.3–8.3)                             |
| Ammonia                                   | 211              | 6647              | 2.5 (2.1–3.0)                             |
| Other                                     | 2379             | 79 985            | 29.9 (27.7–32.3)                          |

<sup>a</sup> Some values may differ because of missing data.

<sup>b</sup> Proportions may not add up to 100 because of rounding.

**FIGURE 2**

Rates of household cleaner-related poisonings treated in US EDs between 1990 and 2006, according to product category. Low-molecular weight hydrocarbons (LMWHCs):  $\beta = -0.061$ ;  $R^2 = 0.634$ ;  $P < .001$ ; acids/alkalis:  $\beta = -0.036$ ;  $R^2 = 0.555$ ;  $P \leq .001$ ; bleach:  $\beta = -0.082$ ;  $R^2 = 0.780$ ;  $P < .001$ ; detergents:  $\beta = -0.045$ ;  $R^2 = 0.778$ ;  $P < .001$ ; ammonia:  $\beta = -0.015$ ;  $R^2 = 0.640$ ;  $P < .001$ ; other products:  $\beta = -0.021$ ;  $R^2 = 0.186$ ;  $P = .084$ .

talization by 2.69 times (95% CI: 1.81–3.97 times), compared with other diagnoses.

### Mechanisms of Injury

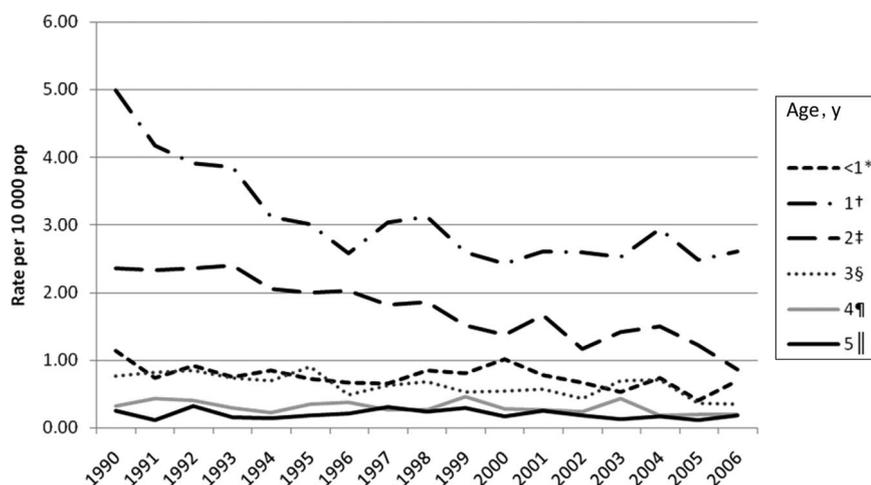
The mechanism responsible for the majority of all household cleaning

product-related injuries was ingestion (62.7%), followed by contact with the product (35.9%). When a spray-bottle was the source of the household cleaning product, patients had 18.27 times (95% CI: 13.95–23.92 times) higher

odds of having contact with the product (versus ingestion or inhalation mechanisms), compared with all other sources. When the patient was the primary handler of the product at the time of injury (rather than someone else, such as a parent or another child), the odds of injury resulting from ingestion were 13.1 times (95% CI: 8.6–20.0 times) higher, compared with another mechanism of exposure.

### Sources of Household Cleaning Products

Products stored in spray-bottles were the source of exposure in 40.1% of cases, whereas products stored in regular bottles or original containers were the source of exposure in 30.1% of cases. Kitchenware (such as pots and pans) was the source of the exposure in 14.4% of cases. During the study period, the numbers of household cleaning product-related injuries resulting from products stored in regular bottles or original containers ( $P = .004$ ) and kitchenware ( $P < .001$ ) decreased, whereas the numbers of household cleaning product-related injuries resulting from products stored in spray-bottles increased over time, from 30.3% in 1990 to 40.8% in 2006 ( $P = .001$ ). The person handling the product at the time of injury was most commonly the patient; however, another child (other than the patient) was handling the product in 3.8% of cases. A diagnosis of poisoning (compared with any other diagnosis) was 13 times more likely (OR: 13.41 [95% CI: 9.14–19.70]) when the source of the household cleaning product was kitchenware or a food container, compared with other sources. Children 3 to 5 years of age (compared with children  $\leq 2$  years of age) had 2.87 times (95% CI: 1.65–5.00 times) higher odds



**FIGURE 3**

Rates of household cleaner-related poisonings treated in US EDs between 1990 and 2006, according to child age. Less than 1 year:  $\beta = -0.019$ ;  $R^2 = 0.313$ ;  $P = .019$ ; 1 year:  $\beta = -0.116$ ;  $R^2 = 0.655$ ;  $P < .001$ ; 2 years:  $\beta = -0.088$ ;  $R^2 = 0.899$ ;  $P < .001$ ; 3 years:  $\beta = -0.023$ ;  $R^2 = 0.517$ ;  $P \leq .001$ ; 4 years:  $\beta = -0.009$ ;  $R^2 = 0.243$ ;  $P = .045$ ; 5 years:  $\beta = -0.003$ ;  $R^2 = 0.063$ ;  $P = .332$ .

of being exposed to household cleaning products stored in food or drink containers than through other sources. When the source was a spray-bottle (compared with all other sources), the patient's eyes were 13.74 times (95% CI: 10.67–17.69 times) more likely to be injured than all other body parts.

## DISCUSSION

During the 17-year study period, >260 000 cases of household cleaning product-related injuries were treated in US EDs throughout the nation. These estimates most likely reflect the ubiquitous nature of household cleaning

products and the ease of accessibility to children.<sup>8</sup> Household cleaning products are alluring to children because of their color, scent, and brightly colored packaging.<sup>4</sup> In our study, children 1 to 3 years of age accounted for the largest proportion of cases, which may be a reflection of their unique developmental stages, with emphasis on exploration, and general inquisitiveness about their environment.

Contact with the cleaning product (rather than ingestion or inhalation) was the mechanism of injury in more than one-third of cases. Spray-bottles, the most common storage source,

were associated with contact injuries and someone other than the patient handling the product at the time of injury. In addition, cleaning products stored in spray-bottles were more commonly associated with injuries to the eyes and head. Spray-bottles were the only major storage source that showed an increase, despite the overall decrease in household cleaning product-related injuries over time. The increase in spray-bottle storage containers is an area worthy of further research.

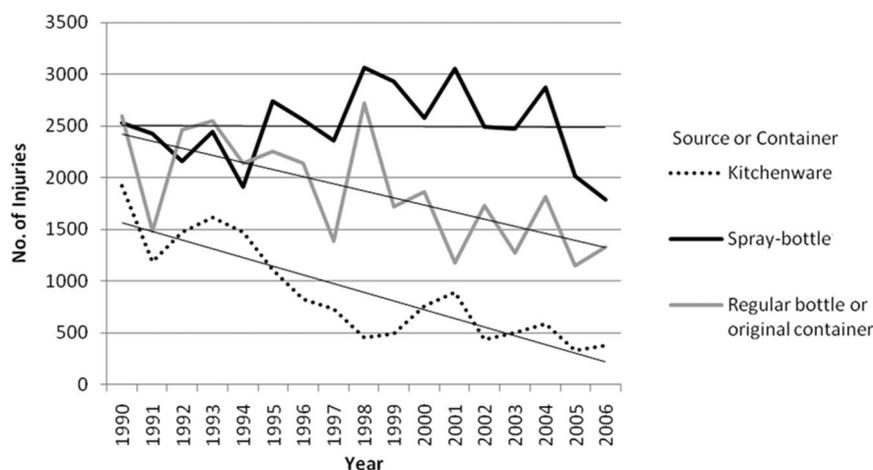
Bleach was the cleaning product involved most commonly in injury. The 2008 Annual Report of the American Association of Poison Control Centers reported that bleach was responsible for 14 640 reported poisoning exposures among children <6 years of age, with 2 deaths (all ages).<sup>15</sup> Previous research showed that bleach is the most-commonly ingested household product.<sup>16</sup> Liquid household bleach contains varying concentrations of sodium hypochlorite, sodium peroxide, and sodium perborate (the most-commonly used bleaches are 5.25% sodium hypochlorite solutions).<sup>17</sup> The ingestion of large quantities of bleach (>5 mL/kg) may be associated with corrosive damage because of the acidic effect bleach has when it comes in contact with mucosal surfaces (resulting in coagulative necrosis).<sup>17</sup> Al-

**TABLE 3** Hospitalization and Source or Container, According to Type of Product, for Household Cleaner-Related Injuries Treated in US EDs in 1990–2006

| Product                           | n (%) <sup>a</sup> |                         |                         |                                        |                         |                        |                         |               |
|-----------------------------------|--------------------|-------------------------|-------------------------|----------------------------------------|-------------------------|------------------------|-------------------------|---------------|
|                                   | Hospitalized       | Source or Container     |                         |                                        |                         |                        |                         |               |
|                                   |                    | Kitchenware             | Spray-Bottles           | Regular Bottles or Original Containers | Cleaning Equipment      | Food/Drink Containers  | Items Cleaned Recently  | Total         |
| Acids/alkalis                     | 4611 (17.2)        | 172 (1.4) <sup>b</sup>  | 5541 (45.0)             | 3290 (26.7)                            | 755 (6.1) <sup>b</sup>  | 384 (3.1) <sup>b</sup> | 2185 (17.7)             | 12 325 (100)  |
| Ammonia                           | 532 (8.0)          | 183 (6.9) <sup>b</sup>  | 603 (22.8) <sup>b</sup> | 1195 (45.2)                            | 268 (10.1) <sup>b</sup> | 58 (2.2) <sup>b</sup>  | 338 (12.8) <sup>b</sup> | 2646 (100)    |
| Bleach                            | 3615 (3.7)         | 11 357 (30.3)           | 5972 (16.0)             | 14 033 (37.5)                          | 1996 (5.3)              | 1120 (3.0)             | 2954 (7.9)              | 37 431 (100)  |
| Detergents                        | 589 (3.1)          | 401 (11.9) <sup>b</sup> | 880 (26.1) <sup>b</sup> | 1533 (45.4)                            | 252 (7.5) <sup>b</sup>  | 38 (1.1) <sup>b</sup>  | 269 (8.0) <sup>b</sup>  | 3372 (100)    |
| Low-molecular weight hydrocarbons | 1949 (5.6)         | 1871 (13.5)             | 5553 (39.9)             | 4886 (35.1)                            | 621 (4.5) <sup>b</sup>  | 475 (3.4) <sup>b</sup> | 501 (3.6) <sup>b</sup>  | 13 907 (100)  |
| Other                             | 3693 (4.6)         | 1227 (3.4)              | 23 912 (66.0)           | 6897 (19.0)                            | 1373 (3.8)              | 494 (1.4) <sup>b</sup> | 2330 (6.4)              | 36 234 (100)  |
| Total                             |                    | 15 211 (14.4)           | 42 461 (40.1)           | 31 834 (30.1)                          | 5265 (5.0)              | 2569 (2.4)             | 8577 (8.1)              | 105 917 (100) |

<sup>a</sup> Some values may differ because of missing data. Proportions may not add up to 100 because of rounding.

<sup>b</sup> Estimate was based on <20 actual cases and may not be statistically stable.



**FIGURE 4**

Trends in sources of household cleaner-related injuries treated in US EDs in 1990–2006. Kitchenware:  $\beta = -1.328$ ;  $R^2 = 0.000$ ;  $P = .946$ ; spray-bottle:  $\beta = -68.3$ ;  $R^2 = 0.428$ ;  $P = .004$ ; regular bottle or original container:  $\beta = -84.1$ ;  $R^2 = 0.757$ ;  $P < .001$ .

though bleach did account for the majority of household cleaning product exposures, exposure to bleach did not increase the odds of hospitalization, whereas exposure to acids/alkalis and products containing ammonia did increase the odds of hospitalization.

Although ammonia alone was responsible for only 2.5% of cases, ammonia can be particularly dangerous when combined with bleach. Ammonia mixed with a chlorine-containing product (such as chlorine bleach) can produce fatal chloramine gas. Low-molecular weight hydrocarbons, acid/alkalis, and detergents together accounted for almost one-third of cases. Automatic dishwasher detergents can produce skin irritations or burns and are poisonous if swallowed. Dishwasher powder or tablets contain caustic compounds and are very corrosive. Unintentional ingestion of caustic compounds can lead to serious upper respiratory and gastrointestinal injuries, because of liquifaction and coagulation necrosis, and severe inflammation. Laundry detergents may contain sodium carbonate/silicate, which is highly alkaline (pH 10–12). These substances have the potential to cause significant gastrointestinal damage if ingested and

severe upper airway compromise if inhaled.<sup>18</sup>

This study found that the numbers and rates of household cleaning product-related injuries decreased significantly during the study period. These decreases were seen in all product categories and across all ages except 4 to 5 years. These decreases may be explained in part by improved poisoning-prevention strategies. Despite these successes, young children account for the majority of unintentional poisonings, and the proportion of childhood poisonings resulting from household cleaning products has remained constant over the past decade.<sup>1–3</sup> One explanation for the number of childhood poisonings remaining constant is that “child-resistant” containers may be rendered less effective through improper closure because of user inattention, distortion because of multiple openings and closings, or poor lid quality.<sup>4</sup> Furthermore, the extent to which parents adopt and consistently maintain proper poison-storage practices has been noted in the literature. Previous studies showed that many families do not adopt the recommended storage practices for household cleaning products.<sup>19,20</sup> For exam-

ple, one study found that 38% to 55% of parents reported keeping poisons locked in a cabinet; however, home observations found that almost none of the families stored poisons correctly.<sup>21</sup> The rates of safe poison storage may be even lower in low-income, urban settings; a study by Santer and Stocking<sup>22</sup> found that few homes had a locked storage space for poisons and household cleaning products were stored “suboptimally.”

This study has several limitations. The total numbers of household cleaning product-related injuries most likely were underestimated, because the NEISS sampling frame captures only injuries treated in EDs. Therefore, the estimates in this study may not be representative of household cleaning product-related injuries treated through calls to poison control centers, at urgent care centers, by family physicians or pediatricians, or in other health care settings. Our study does not address fatalities that might have resulted from household cleaners, because the NEISS generally is not regarded as useful for identifying fatal injuries. The American Association of Poison Control Centers reported that in 2008 there were 14 deaths attributed to household cleaner-related poisonings for all ages.<sup>15</sup> Data regarding mechanism of injury, source or container, and person handling the product at the time of injury were gleaned from case narratives and thus are subject to reporting or interpretation errors. Despite these limitations, the strengths of this study are its large, nationally representative sample and its 17-year study period.

## CONCLUSIONS

Although our findings demonstrate decreases in household cleaning product-related injuries over time, efforts to prevent these types of injuries are still needed. Previous research

and recommendations from the American Academy of Pediatrics and others have suggested storing poisonous substances in locked cabinets, out of sight and reach of children<sup>23</sup>; buying

products with child-resistant packaging; keeping products in their original containers; and properly disposing of leftover or unused products. It also may be prudent to develop educational

programs and materials regarding household cleaning product-related injury prevention, specifically addressing the use and storage of spray-bottles.

## REFERENCES

1. Bronstein AC, Spyker DA, Cantilena LR Jr, Green J, Rumack BH, Heard SE. 2006 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS). *Clin Toxicol (Phila)*. 2007; 45(8):815–917
2. Lai MW, Klein-Schwartz W, Rodgers GC, et al. 2005 Annual Report of the American Association of Poison Control Centers' national poisoning and exposure database. *Clin Toxicol (Phila)*. 2006;44(6):–7:803–932
3. Watson WA, Litovitz TL, Rodgers GC Jr, et al. 2004 Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. *Am J Emerg Med*. 2005;23(5):589–666
4. Bertinelli A, Hamill J, Mahadevan M, Miles F. Serious injuries from dishwasher powder ingestions in small children. *J Paediatr Child Health*. 2006;42(3):129–133
5. Safe Kids USA. Poison Prevention Fact Sheet. Available at: [www.safekids.org/our-work/research/fact-sheets/poison-prevention-fact-sheet.html](http://www.safekids.org/our-work/research/fact-sheets/poison-prevention-fact-sheet.html). Accessed June 29, 2010
6. Perry HE. Pediatric poisonings from household products: hydrofluoric acid and methacrylic acid. *Curr Opin Pediatr*. 2001; 13(2):157–161
7. Polakoff JM, Lacouture PG, Lovejoy FH Jr. The environment away from home as a source of potential poisoning. *Am J Dis Child*. 1984;138(11):1014–1017
8. Liebelt EL, DeAngelis CD. Evolving trends and treatment advances in pediatric poisoning. *JAMA*. 1999;282(12):1113–1115
9. Meyer S, Eddleston M, Bailey B, Desel H, Gottschling S, Gortner L. Unintentional household poisoning in children[in German]. *Klin Padiatr*. 2007;219(5):254–270
10. US Consumer Product Safety Commission. Poison Prevention Packaging Act of 1970, 15 USC §§ 1471–1476. Available at: [www.cpsc.gov/cpscpub/pubs/384.pdf](http://www.cpsc.gov/cpscpub/pubs/384.pdf). Accessed June 30, 2010
11. Litovitz TL, Smilkstein M, Felberg L, Klein-Schwartz W, Berlin R, Morgan JL. 1996 Annual Report of the American Association of Poison Control Centers Toxic Exposure Surveillance System. *Am J Emerg Med*. 1997; 15(5):447–500
12. US Consumer Product Safety Commission. The National Electronic Injury Surveillance System: A Tool for Researchers. Bethesda, MD: US Consumer Product Safety Commission; 2000
13. US Census Bureau. Intercensal estimates of the United States Population by age and sex, 1990–2000. Available at: [www.census.gov/popest/archives/EST90INTERCENSAL/US-EST90INT-datasets.html](http://www.census.gov/popest/archives/EST90INTERCENSAL/US-EST90INT-datasets.html). Accessed June 29, 2010
14. US Census Bureau. National population estimates for the 2000s. Available at: [www.census.gov/popest/national/asrh/2007-natres.html](http://www.census.gov/popest/national/asrh/2007-natres.html). Accessed November 19, 2009
15. Bronstein AC, Spyker DA, Cantilena LR Jr, Green JL, Rumack BH, Giffin SL. 2008 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 26th Annual Report. *Clin Toxicol (Phila)*. 2009;47(10):911–1084
16. Harley EH, Collins MD. Liquid household bleach ingestion in children: a retrospective review. *Laryngoscope*. 1997;107(1): 122–125
17. McGuigan MA. Common culprits in childhood poisoning: epidemiology, treatment and parental advice for prevention. *Paediatr Drugs*. 1999;1(4):313–324
18. Einhorn A, Horton L, Altieri M, Ochsen-schlager D, Klein B. Serious respiratory consequences of detergent ingestions in children. *Pediatrics*. 1989;84(3):472–474
19. Gielen AC, McDonald EM, Wilson ME, et al. Effects of improved access to safety counseling, products, and home visits on parents' safety practices: results of a randomized trial. *Arch Pediatr Adolesc Med*. 2002; 156(1):33–40
20. Sawalha AF. Storage and utilization patterns of cleaning products in the home: toxicity implications. *Accid Anal Prev*. 2007; 39(6):1186–1191
21. Gielen AC, Wilson ME, McDonald EM, et al. Randomized trial of enhanced anticipatory guidance for injury prevention. *Arch Pediatr Adolesc Med*. 2001;155(1):42–49
22. Santer LJ, Stocking CB. Safety practices and living conditions of low-income urban families. *Pediatrics*. 1991;88(6):1112–1118
23. American Academy of Pediatrics. The Injury Prevention Program. Available at: [www.healthychildren.org/English/safety-prevention/all-around/Pages/Keep-Your-Home-Safe-From-Poisons.aspx?nfstatus=401&nftoken=00000000-0000-0000-0000-000000000000&nftstatusdescription=ERROR%3a+No+local+token](http://www.healthychildren.org/English/safety-prevention/all-around/Pages/Keep-Your-Home-Safe-From-Poisons.aspx?nfstatus=401&nftoken=00000000-0000-0000-0000-000000000000&nftstatusdescription=ERROR%3a+No+local+token). Accessed June 30, 2010

## Household Cleaning Product-Related Injuries Treated in US Emergency Departments in 1990–2006

Lara B. McKenzie, Nisha Ahir, Uwe Stolz and Nicolas G. Nelson  
*Pediatrics* originally published online August 2, 2010;

### Updated Information & Services

including high resolution figures, can be found at:  
<http://pediatrics.aappublications.org/content/early/2010/08/02/peds.2009-3392>

### Permissions & Licensing

Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:  
<http://www.aappublications.org/site/misc/Permissions.xhtml>

### Reprints

Information about ordering reprints can be found online:  
<http://www.aappublications.org/site/misc/reprints.xhtml>

# American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®



# PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

## **Household Cleaning Product-Related Injuries Treated in US Emergency Departments in 1990–2006**

Lara B. McKenzie, Nisha Ahir, Uwe Stolz and Nicolas G. Nelson  
*Pediatrics* originally published online August 2, 2010;

The online version of this article, along with updated information and services, is  
located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/early/2010/08/02/peds.2009-3392>

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 345 Park Avenue, Itasca, Illinois, 60143. Copyright © 2010 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

