Safety Interventions and Liquid Laundry Detergent Packet Exposures

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abstract

OBJECTIVES: To investigate exposures to liquid laundry detergent packets among children <6 years old in the United States and to evaluate the impact of the American Society for Testing and Materials voluntary product safety standard.

METHODS: Data from the National Poison Data System involving exposures to liquid laundry detergent packets from 2012 to 2017 were analyzed.

RESULTS: From January 2012 to December 2017, there were 72,947 single and polysubstance exposures to liquid laundry detergent packets. Most exposures (91.7%) were documented among children <6 years old. The annual number and rate of exposures for children <6 years old increased by 110.4% and 111.9%, respectively, from 2012 to 2015. From 2015 to 2017, the number and rate of exposures in this age group decreased by 18.0%. Among individuals ≥6 years old, the annual number and rate of exposures increased by 292.7% and 276.7%, respectively, from 2012 to 2017. Annual hospital admissions among children <6 years old increased by 63.4% from 2012 to 2015 and declined by 55.5% from 2015 to 2017. Serious outcomes among children <6 years old increased by 78.5% from 2012 to 2015 and declined by 32.9% from 2015 to 2017.

CONCLUSIONS: The number, rate, and severity of liquid laundry detergent packet exposures have decreased modestly in recent years among children <6 years old, likely attributable, in part, to the voluntary product safety standard and public awareness efforts. Exposures among older children and adults are increasing. Opportunities exist to strengthen the current product safety standard to further reduce exposures.

WHAT'S KNOWN ON THIS SUBJECT: Liquid laundry detergent packets are an important poisoning hazard to young children. The number of exposures has increased since the introduction of these products in the United States. Exposure-prevention efforts include a product safety standard and public awareness efforts.

WHAT THIS STUDY ADDS: Liquid laundry detergent packet exposures among children <6 years old increased 110.4% from 2012 to 2015 and then decreased by 18.0% through 2017, likely attributable, in part, to the 2015 safety standard, whereas exposures among individuals ≥6 years increased.
In the early 2000s in Europe and in 2012 in the United States, laundry detergent packets appeared on the market.1–4 These small, single-use packets contain a concentrated detergent enveloped in a water-soluble membrane.3–5 Since their introduction, they have become increasingly popular among consumers.

Traditional liquid or powder detergents have long been recognized as a potential poisoning hazard.6–8 However, exposure to laundry detergent packets is associated with more serious medical outcomes than traditional detergent exposure, including central nervous system and respiratory depression,5,9–11 ocular injuries,12,13 pneumonitis,5,10,14 and death.15,16 Young children are often disproportionally represented among these exposures because of their exploratory behaviors and their attraction to the toy- and candy-like appearance of many detergent packets.

Liquid laundry detergent packets have received increased attention as an important poisoning hazard during recent years. Scholarly publications include case series and limited studies of regional or national data,3,14,17,18 large national studies,15,16,19 as well as international reports.4,20,21 There has been widespread media coverage and increased public awareness regarding the potential dangers of laundry detergent packets to young children.22,23 Manufacturers of laundry detergent packets have responded with changes in product packaging and design, product warning labels, and public awareness campaigns.24 In 2015, American Society for Testing and Materials (ASTM) International published the F3159-15 voluntary safety standard for liquid laundry packets.25 Legislation was also introduced that year in the US Congress that proposed creating a mandatory safety standard for detergent packets.26

The effects of the voluntary safety standard and the effects of related interventions on liquid laundry detergent packet exposures in the United States have not been evaluated. Our objective for this study is to assess the changes in the number and rate of liquid laundry detergent packet exposures among US children <6 years old associated with the introduction of the ASTM F3159-15 voluntary safety standard and with related interventions from 2012 to 2017. These safety interventions targeted children <6 years old, and therefore changes in the number and rate of liquid laundry detergent packet exposures are also analyzed among US individuals ≥6 years old to provide a comparison group.

METHODS

Data Sources

Study data were obtained from the National Poison Data System (NPDS), which is maintained by the American Association of Poison Control Centers (AAPCC). The NPDS captures data from calls to regional poison control centers (PCCs) in the United States and its territories.27 Trained poison specialists record the data, which are subject to quality control measures to promote accuracy and completeness.28 July 1 population estimates from the US Census Bureau were used to calculate annual exposure rates.29

Case Selection Criteria

Single-substance and polysubstance exposures to laundry detergent packets reported to US PCCs between January 1, 2012, and December 31, 2017, were requested from the AAPCC. Because the ASTM F3159-15 voluntary safety standard covers only liquid laundry detergent packets, including liquid alone or liquid with non-liquid components (ie, granules), this study was restricted to liquid laundry detergent packet exposures only. Exposures involving liquid laundry detergent packets were identified by using the following: (1) AAPCC product codes for brand-name liquid laundry detergent packets and for the generic category “Liquid Unit Dose Laundry Detergents” or (2) AAPCC generic substance codes for “Laundry Detergents: Liquids (Unit Dose)” and “Laundry Detergents: Granules with Liquids (Unit Dose)” for exposures with a missing product code.

Exposures were excluded from the study if (1) the medical outcome was a confirmed nonexposure or an exposure probably not responsible for the observed effects, (2) age was unknown, or (3) there was a mismatched product and generic code. Additionally, among children <6 years old, nearly all exposures were “unintentional-general”; therefore, all other exposure reasons were excluded (n = 289). Of these 289 excluded cases, the majority were “unintentional-misuse” (n = 162), followed by “unintentional-environmental” (n = 43), and “unintentional-unknown” (n = 17). In addition, 5 exposures among children <6 years old in which the disposition led to admission to a psychiatric facility were excluded because of potential miscoding. Among individuals ≥6 years old, only intentional and unintentional (excluding “unintentional-therapeutic error,” “unintentional-bite/sting,” and “unintentional-food poisoning”; n = 5) exposures were included.

Study Variables

Age was grouped into <6 and ≥6 years. Medical outcome was categorized as the following: (1) major effect; (2) moderate effect; (3) minor effect; (4) no effect; (5) not managed, judged as nontoxic exposure (clinical effects not expected); (6) not managed, minimal clinical effects possible (no more than minor effect possible); (7) unable to manage, judged as a potentially toxic...
exposure); and (8) death. Per NPDS definitions, major effect is described as exposures in which individuals develop symptoms that are “life-threatening or result in significant residual disability or disfigurement.” Moderate effect is described as symptoms that are “more pronounced, more prolonged or more of a systemic nature than minor symptoms. Usually some form of treatment is or would have been indicated.” Minor effect is defined as “minimally bothersome to the patient. The symptoms resolve rapidly and often involve skin or mucous membrane manifestation.” The term “serious medical outcomes” in this study includes the outcomes of death, major effect, and moderate effect. Additional study variables included sex, year of exposure, route of exposure, management site, level of health care received, and related clinical effects.

**Statistical Analysis and Ethical Considerations**

NPDS data were analyzed with SPSS 24.0 for Windows (IBM SPSS Statistics, IBM Corporation, Armonk, NY) and SAS Enterprise Guide 7.15 (SAS Institute, Inc, Cary, NC). Single-substance and polysubstance exposures were included to calculate the frequency of general characteristics. For management site, level of care received, and medical outcome, only single-substance exposures were included to avoid potential interaction effects with other substances among the polysubstance exposures. Because the goal of the ASTM International voluntary safety standard was to limit exposures among children <6 years old, we focused our analyses on this age group. Secular trends of exposures were analyzed by using simple and piecewise linear regression models. The estimated slope from the regression model (m) was reported with the associated P value. Statistical significance was determined at P = .05. This study was judged exempt by the institutional review board at the authors’ institution.

**RESULTS**

**General Characteristics**

From January 2012 to December 2017, US PCCs received 72 947 exposure calls related to liquid laundry detergent packet exposures. Most exposures involved children <6 years old (91.7%), involved a single substance (97.5%), or occurred at a residence (98.5%; Table 1). Children 7 to 17 years old accounted for 3.2% (n = 2314) of exposures, of which 11.5% (n = 266) were intentional exposures. The most common route of exposure was ingestion (73.3%) followed by multiple routes with ingestion (11.8%) and ocular exposure (10.7%). A higher percentage of ocular exposures was observed among individuals ≥6 years old (32.2%) compared with children <6 years old (8.7%).

**Management Site, Level of Health Care Received, and Medical Outcome**

Among the 65 293 single-substance exposures to liquid laundry detergent packets among children <6 years old, 55.3% of children were managed on-site and not at a health care facility (HCF), 34.6% were treated and released from an HCF, 2.2% were admitted to a noncritical care unit, and 1.4% were admitted to a critical care unit (Table 2). The majority of the exposures resulted in a minor effect (48.0%) or no effect (19.0%), and 6.4% resulted in serious medical outcomes. Compared with ingestions, a higher percentage of ocular exposures resulted in HCF use (36.8% vs 54.5%) and a serious medical outcome (5.0% vs 14.8%) but not HCF admission (4.2% vs 0.9%) among children <6 years old.

During the study period, there were 8 deaths associated with ingestion of

| TABLE 1 Characteristics of Liquid Laundry Detergent Packet Exposures by Age Group, NPDS 2012–2017 |
|------------------------------------------|-----------------|-----------------|-----------------|
| Characteristics                          | <6 y (% )       | ≥6 y (%)        | Total (%)       |
| Type of exposure                         |                 |                 |                 |
| Single substance                         | 65 293 (97.6)   | 5824 (96.4)     | 71 117 (97.5)   |
| Polysubstance                            | 1612 (2.4)      | 218 (3.6)       | 1830 (2.5)      |
| Sex                                      |                 |                 |                 |
| Male                                     | 34 908 (52.2)   | 2658 (44.0)     | 37 566 (51.3)   |
| Female                                   | 31 678 (47.8)   | 3371 (55.8)     | 35 249 (48.3)   |
| Unknown                                  | 119 (0.2)       | 13 (0.2)        | 132 (0.2)       |
| Exposure site                            |                 |                 |                 |
| Residence                                | 66 147 (98.9)   | 5707 (94.5)     | 71 854 (98.5)   |
| Other                                    | 664 (1.0)       | 321 (5.3)       | 985 (1.4)       |
| Unknown                                  | 94 (0.1)        | 14 (0.2)        | 108 (0.1)       |
| Route of exposure                        |                 |                 |                 |
| Single route                             | 57 307 (85.7)   | 5353 (88.8)     | 62 660 (85.9)   |
| Ingestion                                | 50 638 (75.7)   | 2842 (47.0)     | 53 480 (73.3)   |
| Ocular                                   | 5854 (8.7)      | 1944 (32.2)     | 7798 (10.7)     |
| Dermal                                   | 780 (1.2)       | 509 (8.4)       | 1289 (1.8)      |
| Nasal inhalation                         | 28 (<0.1)       | 46 (0.8)        | 74 (0.1)        |
| Other                                    | 7 (<0.1)        | 12 (0.2)        | 19 (<0.1)       |
| Multiple routes                          | 9581 (14.3)     | 688 (11.4)      | 10 269 (14.1)   |
| Multiple routes involving ingestion      | 8167 (12.2)     | 465 (7.7)       | 8630 (11.8)     |
| Ocular and dermal                        | 1366 (2.0)      | 215 (3.6)       | 1581 (2.2)      |
| Other multiple routes                     | 48 (0.1)        | 10 (0.2)        | 58 (0.1)        |
| Unknown                                  | 17 (<0.1)       | 1 (<0.1)        | 18 (<0.1)       |
| Total exposures                          | 66 905 (91.7)   | 6042 (8.3)      | 72 947 (100.0)  |

Percentages may not sum to 100.0% because of rounding error.

* Excluding ingestion.
liquid laundry detergent packets as single-substance exposures. Two of these deaths involved children aged 7 and 16 months old and have previously been reported.15,16,30 Six deaths were among adults 43 years of age and older.31,32 All adult fatalities involved individuals with a history of dementia, Alzheimer’s disease, or developmental disability.

Secular Trends of Exposures

The annual number of single-substance and polysubstance exposures involving liquid laundry detergent packets among children <6 years old increased significantly by 110.4% (m = 2327.5; P = .015) from 2012 (6343 exposures) to 2015 (13 347 exposures) before decreasing by 18.0% (m = −1550; P = .113) from 2015 to 2017 (10 943 exposures). This corresponded to a 111.9% increase (m = 97.9; P = .015) in the annual exposure rate per 1 million children <6 years old from 263.1 in 2012 to 557.7 in 2015 followed by an 18.0% decrease (m = −65.3; P = .113) to 457.1 in 2017 (Fig 1). In comparison, the annual number and rate of exposures among individuals ≥6 years old increased by 292.7% (m = 229.8; P < .001) and 277.2% (m = 0.74; P < .001) from 2012 (423 exposures; 15 exposures per 1 million) to 2017 (1661 exposures; 5.5 exposures per 1 million), respectively.

Among all single-substance and polysubstance exposures with single routes of exposure, the annual number of ingestions of liquid laundry detergent packets among children <6 years old increased significantly by 106.2% (m = 1746.6; P = .022) from 2012 (5017 exposures) to 2015 (10 344 exposures) before decreasing by 28.9% (m = −1833.6; P = .056) from 2015 to 2017 (7355 exposures) (Fig 2). Annual ocular exposures in this age group increased significantly by 198.9% (m = 218; P < .001) during the study period, from 451 exposures in 2012 to 1348 exposures in 2017. Among individuals ≥6 years old, the annual number of ingestions increased by 203.2% (m = 81.5; P = .001), and the number of ocular exposures increased by 306.9% (m = 74.7; P < .001) during the study period.

Secular Trends in Health Care Use and HCF Admission

Among single-substance exposures, the annual number of children <6 years old who used an HCF increased significantly by 104.8% (m = 863.8; P = .025) from 2012 (2480 exposures) to 2015 (5080 exposures) before declining by 29.6%...
(m = −954.6; P = .055) from 2015 to 2017 (3574 exposures) (Fig 3).

Among individuals ≥6 years old, the annual number of individuals who used an HCF increased by 193.1% (m = 54.3; P < .001) from 144 exposures in 2012 to 422 exposures in 2017. The percentage of children <6 years old who used an HCF decreased significantly from 41.0% (2480 of 6053 exposures) in 2012 to 33.1% (3574 of 10791 exposures) in 2017 (m = −1.6; P = .069) (Fig 4).

The annual number of hospital admissions for single-substance exposures among children <6 years old increased by 63.4% (m = 61.3; P = .198) from 2012 (290 exposures) to 2015 (474 exposures), with a peak in 2014 (579 exposures), and declined by 55.5% (m = −173.1; P = .054) from 2015 to 2017 (211 exposures) (Fig 3). Annual hospital admissions among individuals ≥6 years old increased from 13 exposures in 2012 to 40 exposures in 2017, an increase of 207.7% (m = 4.9; P = .002). The percentage of children <6 years old admitted to an HCF decreased significantly from 4.8% (290 of 6053 exposures) in 2012 to 2.0% (211 of 10791 exposures) in 2017 (m = −0.59; P = .009), and a similar trend (from 3.3% to 2.5%) was observed for individuals ≥6 years old (m = −0.17; P = .072) (Fig 4).

Secular Trends in Serious Medical Outcomes

Among single-substance exposures, the annual number of children <6 years old who experienced a serious medical outcome increased by 78.5% (m = 104.6; P = .164) from 2012 (452 exposures) to 2017 (807 exposures), with a peak in 2014 (877 exposures), and declined by 32.9% (m = −186.9; P = .119) from 2015 to 2017 (541 exposures) (Fig 3). Among individuals ≥6 years old, annual exposures classified as a serious medical outcome increased by 168.4% (m = 17.3; P = .003) from 2012 (57 exposures) to 2017 (153 exposures). The percentage of children <6 years old experiencing a serious medical outcome decreased significantly from 7.5% (452 of 6053 exposures) in 2012 to 5.0% (541 of 10791 exposures) in 2017 (m = −0.62; P = .005), and a similar trend (from 14.6% to 9.5%) was observed for individuals ≥6 years old (m = −0.92; P = .061) (Fig 4).
DISCUSSION

In 2012, the year that laundry detergent packets entered the US market, the US Consumer Product Safety Commission issued a consumer safety alert about the hazards associated with the product.33 During the following year, extensive media coverage occurred after the death of an infant who ingested contents from a packet.30 Beginning in the spring and summer of 2013, the leading US manufacturer of laundry detergent packets began implementing a series of changes to the product, including opaque packaging, container latches, and warning labels, to reduce child exposures.34,35 In September 2015, ASTM International published voluntary safety standard F3159-15 for liquid laundry detergent packets, which included specifications for child-resistant containers, opaque packaging, the addition of an aversive (bittering) agent to the packet film, a minimum packet burst strength, warning labeling, and other provisions.25 Legislation was also introduced that year in the US Congress that proposed creating a mandatory safety standard.26 The leading US laundry detergent packet manufacturer introduced a new child-resistant closure (CRC) for its product bags in April 2016, along with a nationwide ad campaign.24,36 It later announced new child-resistant lids on its product tubs in August 2017.37 The American Academy of Pediatrics, Prevent Child Injury, and other child-safety and advocacy organizations have conducted public awareness campaigns about the hazards of laundry detergent packets for young children.38,39

It is likely that the voluntary safety standard and the accompanying product changes and ongoing public awareness efforts contributed to the observed decrease in liquid laundry detergent packet exposures among children <6 years old starting in 2015. This conclusion is strengthened by the observation that this decrease was seen in the age group targeted by the safety standard and by public awareness efforts, whereas the number and rate of exposures continued to increase among older individuals. Unlike ingestion, ocular exposures among children <6 years old continued to increase throughout the study period, which reveals that current prevention strategies are particularly ineffective in addressing this route of exposure.

The percentage of exposures resulting in health care use, hospital admission, serious medical outcomes, and at least 1 clinical effect decreased during the study period among individuals of all ages. This suggests...
that prevention efforts may have decreased the severity of exposures; however, health care use and hospital admission are also affected by health care provider and PCC clinical decision-making, which may have changed with increasing clinical familiarity with this product during the study period. It is also unknown whether formulation changes to reduce product toxicity were made during the study period because this information is proprietary.

Despite the modest decline in the number and rate of exposures among children <6 years old since 2015, liquid laundry detergent packet exposures remain high. The decrease in exposures after adoption of the ASTM F3159-15 safety standard is less than that seen after passage of the landmark Poison Prevention Packaging Act (PPPA) of 1970, which required CRCs for selected toxic products. The PPPA was a cornerstone of child-poisoning prevention and was associated with a decrease in ingestion of baby aspirin and other regulated non–baby aspirin products, including household chemicals, by 40% to 55%. This decrease was rapid, occurring during the first 2 to 3 years after changes in CRCs. We should expect at least as rapid a response to the laundry detergent packet standard because a container of aspirin or other medication may take years to completely consume, but a package of laundry detergent would typically be used within weeks to months, which would eliminate the older, less child-resistant packaging from households more quickly. The weak response to the ASTM standard was not because there was not enough time for a decline to occur: Furthermore, several elements of the standard, including opaque packaging, child-resistant packaging changes, and improved labeling were first implemented during the spring and summer of 2013 by the leading US manufacturer of laundry detergent packets, which was >2 years before the final adoption of the standard, and exposures continued to increase during this period. However, not all of these elements were implemented by all manufacturers during this time period.

One reason for the less-than-expected decline in exposures is likely because the ASTM F3159-15 safety standard permits manufacturers to meet the requirement for child-resistant containers in 6 different ways rather than requiring them to conform to the PPPA standard. Requiring that all liquid laundry detergent packet packaging be PPPA-compliant would be an important next step in reducing child access to these products.

“Layers of protection” is a fundamental concept in injury prevention. In cases in which product packaging does not prevent a child from gaining access to an individual laundry detergent packet, a secondary layer of protection can help prevent potential harm. The use of an aversive agent in the packet film and increasing the burst strength of the film are examples of this approach. An additional strategy would be to individually wrap each laundry packet with a child-resistant packaging, which would mitigate risk of exposure should a laundry packet container be left open or packets be removed from their container. Unit packaging currently exists for at least 1 brand of dishwasher detergent packets, which dispels the argument that this is too costly and inconvenient to be acceptable to consumers. The current ASTM standard should be revised to include child-resistant packaging of individual laundry detergent packets.

Liquid laundry detergent packets are more toxic than traditional liquid and powder laundry detergents. The reasons for this increased toxicity are not completely understood, and further research is needed to determine how to make packet contents less toxic. Constituent reformulation has been successful in decreasing the toxicity and adverse health effects of other products, including fabric cleaners, in which benzene was replaced with aliphatic chlorinated hydrocarbons. Such reformulation, although perhaps difficult, could reduce the severity of exposures to liquid laundry detergent packets.

Pediatricians and other health care providers should continue to counsel patients and their families about the potential hazards of laundry detergent packet exposures and the importance of safe storage practices. Specific recommendations have been discussed in previous studies and are also available as public service announcements by industry. Most fatalities involved older adults with developmental delay or degenerative brain diseases, making injury prevention efforts relevant to this age group as well as to children.

This study has several limitations. NPDS data underestimate the number of exposures associated with liquid laundry detergent packets because not all exposures are reported to PCCs. Several manufacturers publish phone numbers of contract poison centers on their product labels, and cases reported to these contract centers may not be reported to the NPDS. The NPDS relies on self-reports, and the accuracy of the reported information cannot be completely verified by the PCCs or the AAPCC. Exposures do not necessarily represent a poisoning or overdose. Data miscoding by PCC personnel or product misidentification by callers to a PCC are other potential limitations; however, strict data quality control procedures are used. Despite these limitations, the NPDS is the most comprehensive database available for investigating liquid laundry detergent packet exposures in the US population.
CONCLUSIONS

The number, rate, and severity of liquid laundry detergent packet exposures have begun to decrease in recent years among children <6 years old, likely attributable, in part, to the ASTM voluntary safety standard and increased public awareness about the hazards of laundry detergent packets. However, the observed overall decrease has been modest, ocular injuries continue to climb, and exposures among older children and adults are increasing. Opportunities exist to strengthen the current ASTM safety standard to further reduce liquid laundry detergent packet exposures.

ACKNOWLEDGMENTS

We acknowledge Sandhya Kistamgari, MPH, for her assistance in data analysis during the revision of the article.

REFERENCES


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

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

ABBREVIATIONS

AAPCC: American Association of Poison Control Centers
ASTM: American Society for Testing and Materials
CRC: child-resistant closure
HCF: health care facility
NPDS: National Poison Data System
PCC: poison control center
PPPA: Poison Prevention Packaging Act
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Pediatrics 2019;144;
DOI: 10.1542/peds.2018-3117 originally published online June 3, 2019;

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/144/1/e20183117