

Impact of the Voluntary Safety Standard for Liquid Laundry Packets on Child Injuries Treated in US Hospital Emergency Departments, 2012–2018


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Objectives. To evaluate the effect of the voluntary safety standard for liquid laundry packets on the rate of injury involving children younger than 5 years in the United States.

Methods. Semiannual national estimates of child injuries involving liquid laundry packets treated in US hospital emergency departments were developed for the July 2012 through December 2018 study period. We used a negative binomial regression model to estimate the effect of the voluntary standard on the injury rate following the standard's publication at the end of 2015. The analysis controlled for the rapid growth of laundry packet use during the study period. Results are presented as relative risks and percentage changes in the injury rate.

Results. The voluntary standard was associated with a 49.4% to 61.6% reduction in the rate of child injury.

Conclusions. The results suggest that the requirements of the voluntary standard have effectively reduced the rate of child injury involving liquid laundry packets and may have prevented 9200 to 23 000 emergency department–treated injuries during the study period. (*Am J Public Health.* 2020;110:1242–1247. doi:10.2105/AJPH.2020.305650)

 See also Smith, p. 1119.

Laundry packets are small single-use pouches containing concentrated liquid detergents in a water-soluble membrane. They were first introduced into the US market nationwide in early 2012 and rapidly gained popularity as a convenient substitute for the more traditional liquid or powder laundry detergents.

Packet-related injuries rose rapidly with increased sales. Although traditional laundry soaps and detergents have long been known to present a poisoning hazard to young children,¹ the concentrated detergents in the laundry packets have been associated with more frequent and more severe medical outcomes.^{2,3} Most injuries have resulted from oral ingestion, but ocular, dermal, and inhalation injuries also have occurred.^{2,4} Two laundry packet–related deaths involving young children were identified by the Consumer Product Safety Risk Management System, a comprehensive database containing reports of injury, potential injury, and deaths maintained by the US Consumer Product

Safety Commission (CPSC). Both deaths involved children younger than 2 years and occurred in 2013.

In October 2012, the Centers for Disease Control and Prevention warned that the injuries involving liquid laundry packets represented an emerging public health hazard.⁵ In November 2012, the CPSC issued a public safety alert, citing about 500 incidents involving the laundry packets, some requiring hospitalization for loss of consciousness, excessive vomiting, drowsiness, throat swelling, and breathing difficulties.⁶

In 2013, the CPSC requested that ASTM International, a voluntary standards development organization, initiate the development of a national consensus voluntary safety standard for liquid laundry packets (C. Church [cchurch@cpsc.gov], e-mail, March 25, 2013). The voluntary standards process began in August 2013. A final voluntary standard was published in October 2015 and updated in December 2015 as ASTM F3159–15^{6,7}.

The key requirements of the voluntary standard, which applies exclusively to household liquid laundry detergent packets, are as follows:

- Individual detergent packets must retain their contents for at least 30 seconds after being placed in water at 20°C (68°F).
- Packets must resist compression of at least 300 Newtons under standard test conditions.
- The soluble film covering the packets must contain an aversive agent that will elicit an oral repulsive behavior within 6 seconds.
- The packaging container (i.e., outer packaging that contains the individual packets) must be opaque or otherwise mask the visibility of the individual packets. The container should not be labeled with graphics that make the opaque packaging appear transparent or translucent.

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- The packaging container must be difficult for children to open. The standard gives 6 possible ways of meeting this requirement and requires that 1 or more of them be used.
- The packaging container must display prominent specified warnings and symbols on its front and side or back panels.

The standard has now been in effect for several years. Earlier studies have evaluated laundry packet exposures, as measured by reports to poison control centers.^{8–10} The purpose of this study was to evaluate the effectiveness of the laundry packet voluntary standard in preventing child injuries treated in US hospital emergency departments (EDs).

METHODS

Estimates of laundry packet injuries involving children younger than 5 years were derived from the CPSC's National Electronic Injury Surveillance System, a stratified national probability sample of US hospital EDs consisting of about 100 US hospitals that have at least 6 beds and provide 24-hour emergency service. The sample includes 4 strata based on hospital size and a fifth consisting of children's hospitals.¹¹ Each participating hospital provides the CPSC with information on all cases involving consumer products, including the age and sex of the injured, the primary injury diagnosis, the body part affected, a description of up to 2 products that were involved in the injury, and whether the injured party was hospitalized or treated and released. Each case record also includes a free-text narrative field in which the product and circumstances surrounding the injury can be described in some detail. All injuries involving laundry packets were determined by mention of laundry packet involvement in the case narratives for injuries involving soaps and detergents.

Because the National Electronic Injury Surveillance System is a national probability sample of hospitals, cases were assigned a sample weight based on the adjusted inverse of the known probability of selection of hospitals in each stratum. Adjustments to these weights were made for nonresponse,

hospital mergers, and changes in the sampling frame.

We evaluated the effect of the voluntary standard on the injury rate with a log-linear negative binomial regression model designed for rate data, based on semiannual time-series data (i.e., January through June; July through December) from July 2012 through December 2018. Negative binomial models are well suited for the analysis of data that have counts as possible outcomes, such as the number of injuries during a given period. They can also be used to evaluate injury rates when the outcome data, measured in injuries, are indexed by some measure of exposure.¹² We first considered using a Poisson regression model for the count data. However, we rejected the Poisson model because the data showed greater variability than would have been expected with a Poisson distribution. The negative binomial model is the standard parametric model used to account for overdispersion.¹³

The response variable—the estimated number of injuries involving liquid laundry packets—was initially estimated as a function of 2 explanatory variables and an offset term.^{12,13} The offset term adjusts the expected value of the response variable for an indexed measure of exposure. For our initial analysis, we defined the offset term as the number of children younger than 5 years, based on census estimates of the US resident population.¹⁴

The 2 explanatory variables included a laundry packet sales variable (“Sales”), a measure of risk exposure, and estimates of conformance to the voluntary standard. Nielsen developed national laundry packet sales estimates from point-of-sale data for the total US market and reported them through Nielsen's Strategic Planner Service.¹⁵ Sales estimates were reported in 4-week increments. Because the 4-week time increments did not align perfectly with the beginning and ending of the semiannual time periods, the sales data were adjusted to account for timing discrepancies. For example, if a 4-week sales estimate ended 1 week into January of the following period, 25% of the sales during that 4-week interval were assumed to have occurred in the first week of January.

The primary explanatory variable used to quantify the effect of the voluntary standard was the estimated proportion of laundry

packets sold that conformed to the requirements of the voluntary standard. We evaluated 2 alternative measures of conformance. The first, “Conform1,” was set equal to 0 before the publication of the voluntary standard for laundry packets at the end of 2015. Voluntary standards go into effect when published, but not all industry members conform immediately. For Conform1, we treated 2016 as a transition year, during which the level of industry conformance was rising but not complete. This variable was assumed to increase gradually during the transition period, from 0.33 in the January to June 2016 period to 0.67 in July to December 2016; it was set equal to 1 beginning in 2017 when the data task group of the ASTM F15.71 subcommittee for laundry packets expected full industry conformance to the requirements.¹⁶

The second measure, “Conform2,” recognized that some early safety improvements in the packaging and labeling of the product, some of which were later incorporated into the voluntary standard, occurred before the 2015 publication of the voluntary standard and as early as mid-2013.^{17–19} This conformance measure assumes that the transition period began as early as the second half of 2013 and extended through 2016, after which conformance was complete. This extended transition period is, in fact, consistent with the transition period referenced by the ASTM F15.71 data task group.¹⁶ Consequently, Conform2 was set equal to 0 through the first half of 2013, increased gradually from 0.13 during July to December 2013, to 0.25 during January to June 2014, to 0.38 during July to December 2014, and so on, to 1 beginning in January 2017.

Model 1 contains the Conform1 and Sales covariates. However, we were unable to estimate a reliable model containing Sales with Conform2 because these 2 covariates were almost perfectly correlated ($r = 0.994$). This caused, for mathematical reasons, severe estimation problems: the model was unable to differentiate the effect of the 2 variables.²⁰

To address this extreme case of multicollinearity, we estimated 2 additional models. These models included the conformance measures as a single explanatory variable in each of the models (i.e., Conform1 in model 2 and Conform2 in model 3) and included an offset term consisting of laundry packet sales (in billions) per child, a direct

measure of the risk exposure that the voluntary standard was intended to address.

Our results are presented as relative risks, with accompanying 95% confidence intervals, and the estimated percentage change in injury rates indicated by the relative risks. We estimated SEs with Huber/White robust estimators.²¹

RESULTS

Table 1 provides a description of the liquid laundry packet injuries involving children younger than 5 years during the study period. ED injuries rose after the introduction of laundry packets in the US market in 2012,

peaked in 2014 and 2015 with about 5700 ED injuries annually, and began declining in 2016 following the publication of the voluntary standard. By 2018, injuries declined to about 3340, a reduction of about 42% from their peak.

About 55% of the injured children were boys; 48% were aged 1 year or younger, and 28% were aged 2 years. The great majority of injuries resulted from oral ingestion (73%) or involved ocular (25%) or dermal (2%) contact. About 88% were treated and released from the ED, 8% were hospitalized, and 2% were held for observation.

Laundry packet sales (i.e., sales of the individual packets) estimates rose throughout the study period (Figure 1), increasing

from about 985 million in the second half of 2012 to about 2.5 billion in the second half of 2018.

Relative Risks

The regression results for the 3 models are presented in Table 2. In general, the specified models appear to fit the data reasonably well. This is indicated by the ratio of the deviance to the degrees of freedom in each model (as well as the ratio of the Pearson χ^2 to the degrees of freedom), which was not appreciably different from the value 1, and suggests that data evaluated do not have greater variability than would be expected from the statistical model used.¹²

The relative risk for Conform1 in model 1 suggests a reduction of about 49.4% (95% confidence interval [CI] = 28.7%, 64.2%) in the ED injury rate. The model also shows the expected positive relationship between injuries and laundry packet sales, suggesting that an increase in sales of 1 billion laundry packets results in a 51.2% (95% CI = 14.7%, 99.3%) increase in the injury rate. The relative risk for Conform1 in model 2 indicates a reduction of about 56.5% (95% CI = 44.9%, 65.7%); the relative risk for Conform2 in model 3 indicates a reduction of 61.6% (95% CI = 47.2%, 72.0%).

The reduction in the laundry packet injury rate is illustrated in Figure 2, which is based on the model 1 results: it shows (1) the predicted (i.e., fitted) rate of liquid packet injuries per million children, (2) what the model's predicted rate would have been in the absence of the voluntary standard, and (3) the observed injury rate. The vertical distance between the 2 rate functions beginning in 2017, when all laundry packets were assumed to conform to the voluntary standard, represents the estimated injury rate reduction associated with the voluntary standard.

Sensitivity Analysis

We conducted several analyses to evaluate the sensitivity of the statistical findings to variations in the specification of the regression model. For example, our analysis assumed that injuries occurring during a specified period were related to laundry packet sales during that same period. However, because packages of laundry packets may be used over a period of several months, some injuries

TABLE 1—Characteristics of Laundry Packet Emergency Department Injuries Involving Children Younger Than 5 Years: United States, July 2012–December 2018

Characteristic	National Injury Estimate ^a (%)	Sample Size, No.
Total	29 521 (100.0)	1 119
Year of injury		
2012 (half year)	2 293 (7.8)	82
2013	3 714 (12.6)	165
2014	5 755 (19.5)	187
2015	5 698 (19.3)	199
2016	4 782 (16.2)	180
2017	3 939 (13.3)	161
2018	3 339 (11.3)	145
Age, y		
< 1	3 619 (12.3)	130
1	10 633 (36.0)	401
2	8 265 (28.0)	321
3	5 167 (17.5)	190
4	1 836 (6.2)	77
Sex		
Male	16 215 (54.9)	280
Female	13 306 (45.1)	539
Treatment level		
Treated and released	26 035 (88.2)	933
Hospitalized	2 261 (7.7)	117
Held for observation	673 (2.3) ^b	51
Left without being seen by physician	552 (1.9) ^b	18
Route of injury		
Ingestion	21 626 (73.3)	709
Ocular	7 284 (24.7)	302
Dermal	507 (1.7) ^b	25
Inhalation, other	103 (0.3) ^b	3

^aEstimates may not sum to totals because of rounding.

^bNational estimates are potentially unreliable when the number of records used is less than 20 or the national estimate is less than 1200.

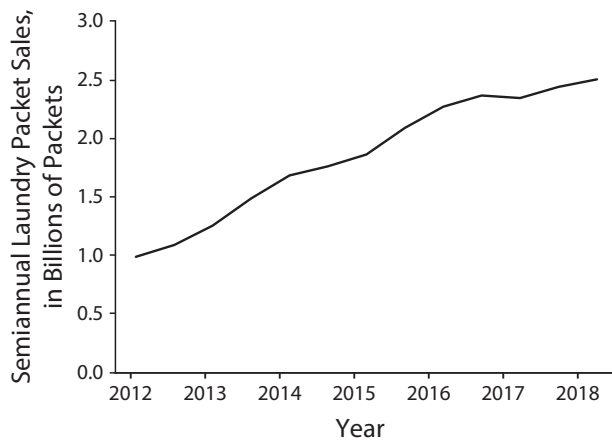


FIGURE 1—Semiannual Sales of Liquid Laundry Packets: United States, July 2012–December 2018

likely involved laundry packets sold during the preceding period. To evaluate the potential effect of this possibility, we lagged the sales estimate so that injuries were assumed to be related to sales during the preceding period. When the lagged sales estimates were used, the regression models suggested a somewhat greater injury rate reduction than in our base analysis: models 1 and 3 suggested injury rate reductions of 52.7% (95% CI = 28.2%, 68.8%) and 64.5% (95% CI = 45.3%, 77.0%), respectively.

Although our main analysis evaluated the effect of the voluntary standard on the rate of injury in children younger than 5 years, the age group of interest designated in the Poison Prevention Packaging Act,²² some analysts have focused on rates in children younger than 6 years.^{9,10} When injuries involving children younger than 6 years were included, the total estimated number of ED-treated

injuries during the study period rose from about 29 521 to 30 308. When these injuries were included in the analysis, models 1 and 3 suggested an injury rate reduction of 45.6% (95% CI = 26.8%, 59.5%) and 60.4% (95% CI = 47.3%, 70.3%), respectively.

DISCUSSION

This analysis indicates that the voluntary standard for liquid laundry packets has effectively reduced the rate of child injury. Our statistical results suggest that the voluntary standard may have reduced the child injury rate by about 49.4% to 61.6% from levels that would have been projected in the absence of the voluntary standard and that the standard may have prevented 9200 to 23 000 ED injuries in the United States during the 2012 through 2018 study period. The estimated

reduction of 9200 ED injuries corresponds to the model 1 results (as represented in Figure 2), which assumed that the injury rate reduction began in the transition year of 2016, just after the voluntary standard was published. The estimated reduction of 23 000 ED injuries corresponds to the model 3 results, which assumed a longer transition period and indicated a somewhat higher injury rate reduction.

Although the conformance variables were designed to measure the effect of the voluntary standard, they may have also implicitly captured a reduction in injuries resulting from increased safety efforts on the part of parents that may have occurred as a response to the media coverage of the laundry packet hazard,^{23–27} as well as hazard warnings from governmental agencies,^{6,28} the American Academy of Pediatrics,²⁹ and advocacy groups.³⁰ The effect of such increased safety efforts on the injury rate cannot be quantified with available data but could be consequential, especially in the model 3 results that allowed for some injury reduction as early as 2013 when the public was first warned about laundry packet hazards.

The voluntary standard requires that packaging containers be difficult for children to open and that children should be unable to open the packaging by brute force. It lays out 6 different methods by which manufacturers can conform to this requirement. One method is compliance with the child-resistant packaging requirements under the Poison Prevention Packaging Act, which is administered by the CPSC and requires a formal testing regimen to demonstrate child resistance.³¹ Some of the alternatives may be less stringent than requirements under the Poison Prevention Packaging Act, as suggested by some commenters.¹⁰ Nevertheless, our results suggesting a 49.4% to 61.6% reduction in laundry packet injury rate compare favorably with the effect of CPSC's child-resistant packaging requirements. Formal studies of child-resistant packaging for aspirin and oral prescription drugs have found injury and fatality rate reductions of about 35% to 45%.^{32–34}

Although current requirements appear to have effectively reduced the injury rate, further reductions can be achieved. Child-resistant packaging testing requirements, for example, might be made more stringent by

TABLE 2—Relative Risks (RRs) for the Child Injury Rate Involving Liquid Laundry Packets: United States, July 2012–December 2018

Variable	Model 1, ^a RR (95% CI)	Model 2, ^b RR (95% CI)	Model 3, ^c RR (95% CI)
Conform1	0.506 (0.358, 0.713)	0.435 (0.343, 0.551)	...
Conform2	0.384 (0.280, 0.528)
Sales (in billions)	1.512 (1.147, 1.993)

Note. CI = confidence interval. The RR – 1 represents the percentage change in the injury rate associated with a 1-unit increase in the predictor variable.

^aFor model 1, $n = 13$, $df = 10$; deviance = 13.06; Pearson $\chi^2 = 13.36$.

^bFor model 2, $n = 13$, $df = 11$; deviance = 13.07; Pearson $\chi^2 = 14.00$.

^cFor model 3, $n = 13$, $df = 11$; deviance = 13.08; Pearson $\chi^2 = 12.42$.

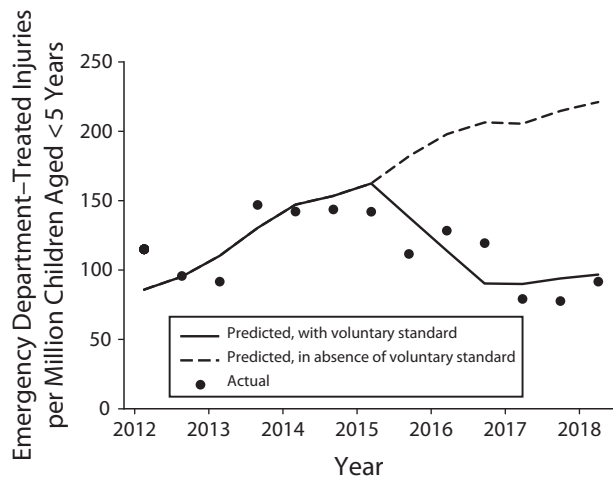


FIGURE 2—Fitted Model Showing the Effects of the Voluntary Safety Standard for Liquid Laundry Packets on Child Injury Rates, Based on Semiannual Data: United States, July 2012–December 2018

adopting the existing Poison Prevention Packaging Act testing requirements. Health care providers should continue to counsel parents to adopt safe storage practices. Some parents of young children also might be encouraged to use the more traditional and potentially less hazardous powder or liquid laundry detergents. Additionally, changes in product formulation, to make the detergent in the packets less toxic, could lessen the severity of the injury hazard. The ASTM subcommittee on laundry packets is still active and is evaluating possible new strategies to further reduce injuries. CPSC staff is a full participant in the process and continues to encourage further safety improvements in the voluntary standard.

Limitations

We identified liquid laundry packet cases by examining the National Electronic Injury Surveillance System narratives for language referring to laundry packets. Because the narratives are collected from medical records and include only information recorded by medical personnel, in some cases, these personnel may have omitted that the detergent involved was in packet form.

Because the 4-week increments of sales data from Nielsen did not align perfectly with the semiannual time increments used in our analysis, sales estimates cannot be considered

precise. However, because possible discrepancies would have occurred only at the beginning and end of the semiannual time periods, they are likely to have been small and to have had little effect on our results.

The conformance variables used in this analysis were assumed to rise smoothly during the transition periods. Although more precise estimates are not available, it seems unlikely that small changes in estimated conformance during transition periods would have materially affected our results.

Injuries treated in hospital EDs do not include medically attended injuries treated in other settings, such as physicians' offices, clinics, and ambulatory surgery centers. Although, in a strict sense, inferences were limited to laundry packet injuries treated in US hospital EDs, no evidence suggests that injuries treated in alternative medical settings also would not have declined following the implementation of the voluntary standard.

Finally, we note that the analysis did not evaluate the voluntary standard's effect on older children or adults who may be subject to injury patterns that differ substantially from those of children younger than 5 years.¹⁰

Conclusions

This analysis suggests that the voluntary standard may have reduced the child injury rate by 49.4% to 61.6% from levels that would

have been expected in the absence of the voluntary standard and that the standard may have prevented 9200 to 23 000 ED injuries during the 2012 through 2018 study period. Notwithstanding its apparent effect, the annual rate of laundry packet injuries remains at about 170 ED injuries per million children younger than 5 years, a rate that should be further reduced. **AJPH**

CONTRIBUTORS

S.J. Hanway collected the injury data, conducted a preliminary analysis of the data, and edited and approved the final article. G. B. Rodgers conducted the regression analysis, prepared the initial draft of the article, and edited and approved the final article.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to disclose.

HUMAN PARTICIPANT PROTECTION

No protocol approval was needed because no human participants were involved.

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