Pediatric Exposures to Laundry and Dishwasher Detergents in the United States: 2013–2014

Mallory G. Davis, MPH,[a,b] Marcel J. Casavant, MD,[c,d] Henry A Spiller, MS, D.ABAT,[c,d] Thiphalak Chounthirath, MS,[a] Gary A. Smith, MD, DrPH[a,d,e]

abstract

OBJECTIVE: This study analyzes and compares pediatric exposures to packet and nonpacket forms of laundry and dishwasher detergents in the United States.

METHODS: Data from the National Poison Data System involving exposures to laundry and dishwasher detergents among children younger than 6 years old from 2013 through 2014 were analyzed.

RESULTS: There were 62 254 children younger than 6 years old exposed to laundry and dishwasher detergents from 2013 to 2014. The number of exposures to detergent increased over the study period, but the increase was greatest for laundry detergent packets (17.0%) and dishwasher detergent packets (14.0%). Eighty-five percent of children were exposed through ingestion. The odds of clinical effects (3.9–8.2), hospitalization (4.8–23.5), intubation (6.9–71.3), and serious medical outcomes (8.4–22.6) were significantly higher for laundry detergent packet exposures than for other types of detergent. There were 117 children who required intubation, and 104 of these were exposed to laundry detergent packets. There were 2 deaths, and both were associated with laundry detergent packets.

CONCLUSIONS: This national study demonstrates that pediatric laundry detergent packet exposures are more severe than laundry detergent nonpacket and dishwasher detergent (packet and nonpacket) exposures. Pediatric exposures to laundry detergent packets increased by 17% during the study period nationally and should be closely monitored to assess the effectiveness of the newly adopted voluntary safety standard; this standard should be strengthened if the number of exposures does not demonstrate a substantial decrease.

[a]*Center for Injury Research and Policy at Nationwide Children's Hospital, Columbus, Ohio;* [b]*School of Medicine, University of Washington, Seattle, Washington;* [c]*Central Ohio Poison Center, Columbus, Ohio;* [d]*Department of Pediatrics, College of Medicine, The Ohio State University, Columbus, Ohio; and* [e]*Child Injury Prevention Alliance, Columbus, Ohio*

Mrs Davis conducted the data analysis, and drafted and revised the manuscript; Drs Casavant and Spiller contributed to the conceptualization of the study, assisted in data analysis, and critically reviewed the manuscript; Mr Chounthirath assisted in data analysis and revised the manuscript; Dr Smith contributed to the conceptualization of the study, assisted in data analysis, and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

The interpretations and conclusions in this article do not necessarily represent those of the funding organizations.

DOI: 10.1542/peds.2015-4529

Accepted for publication Feb 8, 2016

WHAT'S KNOWN ON THIS SUBJECT: Previous reports have revealed that dishwasher and laundry detergents pose an important poisoning hazard to young children. A previous study conducted with data from the US National Poison Data System revealed laundry packets are particularly dangerous to children.

WHAT THIS STUDY ADDS: From 2013 to 2014, 62 254 pediatric exposures to dishwasher and laundry detergents were reported to US poison control centers. Hospitalization was observed in 0.2% of dishwasher and 3.3% of laundry detergent exposures. Laundry detergent packet exposures had more serious outcomes.

To cite: Davis MG, Casavant MJ, Spiller HA, et al. Pediatric Exposures to Laundry and Dishwasher Detergents in the United States: 2013–2014. *Pediatrics.* 2016;137(5):e20154529

Dishwasher and laundry detergents are common household products that have been used for decades. The traditional powder and liquid forms of these detergents were more commonly used until the introduction of tablets and packets. Laundry detergent packets were introduced in Europe in 2001[1] and in the United States in 2012, and their associated hazards have been described.[2,3] Consequences of powder detergent exposure include vomiting and oral and esophageal burns.[4–7] Exposure to laundry detergent packets involving young children can cause central nervous system depression, upper and lower airway injuries, corneal injury, damage to oropharyngeal mucosa, pneumonitis, respiratory depression, and death.[8–13]

Studies on laundry and dishwasher detergent exposures in the United States usually consist of case series, abstracts, or reports of national data limited to a short time period.[10,14–16] One study of National Poison Data System (NPDS) data limited to pediatric exposures to laundry detergent packets revealed serious outcomes associated with exposure to these products among young children.[13] Another study that used Texas Poison Center Network data to compare laundry detergent packets to traditional laundry detergent revealed that children exposed to laundry packets were more frequently referred to a health care facility (HCF) and experienced more serious outcomes compared with traditional laundry detergent.[14] Recent research has focused on laundry detergent packets, and several studies have examined outcomes after exposure to dishwasher nonpacket detergent[4,5,15]; however, the toxicity of dishwasher detergent packet exposures has not been evaluated in the medical literature. Moreover, research on the comparative toxicity of traditional and packet forms of laundry and dishwasher detergents has not been published. To our knowledge, this study is the first to comprehensively analyze and compare pediatric exposures to traditional and packet forms of laundry and dishwasher detergents by using a national database.

METHODS

Data Sources

We retrospectively analyzed data from the NPDS, which is maintained by the American Association of Poison Control Centers (AAPCC). The AAPCC receives data on calls to participating poison control centers (PCCs) that serve the United States and its territories. PCCs receive telephone calls through the Poison Help Line and document information about the product, route of exposure, individual exposed, exposure scenario, and other data.[16]

Case Selection Criteria

The AAPCC's generic codes (which are codes assigned to broad groups of related substances) for automatic dishwasher and laundry detergents were used to query the NPDS for all single substance exposure calls involving detergent among children younger than 6 years old during 2013 and 2014. There were 68 845 single exposures to dishwasher or laundry detergent, of which, 62 254 met study inclusion criteria, including 2 deaths. These deaths underwent secondary review by the AAPCC fatality review group and were verified to be laundry detergent packet-related deaths. Detergent types included in the study are listed in Supplemental Table 5. This study only included unintentional exposures that occurred in the 50 US states and District of Columbia, and a list of excluded cases is found in Supplemental Table 6.

Variables

Dishwasher and laundry detergents were grouped into the following: packets (including all unit dose detergents) and nonpackets (including all nonunit dose detergents; Supplemental Table 5). Levels of health care facility (HCF) care received were categorized as seen at HCF, no HCF treatment, and patient refused referral/did not arrive at HCF. The category "seen at HCF" includes treated/evaluated and released (including held for less than 24 hours in observation unit), patient lost to follow-up/left against medical advice (AMA), admitted to critical care unit, and admitted to a noncritical care unit. Medical outcome was categorized as serious effect (including death and major effect), moderate effect, minor effect, no effect, not followed (judged as a nontoxic exposure), not followed (minimal clinical effects possible), and unable to follow (judged as a potentially toxic exposure). The NPDS outcome definitions are as follows: minor effect ("minimally bothersome to the patient, symptoms resolve rapidly, and usually involve skin or mucous membrane manifestations"), moderate effect ("more pronounced, more prolonged, or more of a systemic nature than minor symptoms and usually some form of treatment is or would have been indicated"), and major effect ("symptoms were life-threatening or resulted in significant residual disability or disfigurement").[17] Due to the relatively recent appearance on the market of laundry detergent packets and because their clinical effects may not have been attributed to the product early after their appearance, we analyzed all clinical effects, including those coded as related, unrelated, or unknown if related.

Additional variables analyzed included children's gender, age, month of exposure, scenario associated with the child's access to the detergent, route of exposure, and management site. Each of these categories are defined in the

TABLE 1 Characteristics of Laundry and Dishwasher Detergent Exposures Among Children Younger Than 6 Years by Detergent Type, NPDS 2013–2014

Characteristics	Dishwasher Detergent			Laundry Detergent			
	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	Overall Total, *n* (%)[a]
Gender							
Boy	6324 (52.7)	8113 (53.8)	14 437 (53.3)	7358 (56.1)	11 473 (52.0)	18 831 (53.5)	33 268 (53.4)
Girl	5653 (47.2)	6956 (46.1)	12 609 (46.6))	5749 (43.8)	10 553 (47.8)	16 302 (46.3)	28 911 (46.4)
Unknown	12 (0.1)	8 (0.1)	20 (0.1)	17 (0.1)	38 (0.2)	55 (0.2)	75 (0.1)
Child age, y							
<1	1823 (15.2)	2518 (16.7)	4341 (16.0)	1157 (8.8)	2092 (9.5)	3249 (9.2)	7590 (12.2)
1	7459 (62.2)	9857 (65.4)	17 316 (64.0)	5947 (45.3)	7697 (34.9)	13 644 (38.8)	30 960 (49.7)
2	2162 (18.0)	2258 (15.0)	4420 (16.3)	3933 (30.0)	6742 (30.6)	10 675 (30.3)	15 095 (24.2)
3	382 (3.2)	305 (2.0)	687 (2.5)	1286 (9.8)	3433 (15.6)	4719 (13.4)	5406 (8.7)
4	91 (0.8)	87 (0.6)	178 (0.7)	533 (4.1)	1439 (6.5)	1972(5.6)	2150 (3.5)
5	53 (0.4)	35 (0.2)	88 (0.3)	240 (1.8)	608 (2.8)	848(2.8)	936 (1.5)
<6[b]	19 (0.2)	17 (0.1)	36 (0.1)	28 (0.2)	53 (0.2)	81 (0.2)	117 (0.2)
Exposure site							
Residence[c]	11 960 (99.8)	15 049 (99.8)	27 009 (99.8)	13 030 (99.3)	21 837 (99.0)	34 867 (99.1)	61 876 (99.4)
Other[d]	23 (0.2)	26 (0.2)	49 (0.2)	90 (0.7)	189 (0.9)	279 (0.8)	328 (0.5)
Unknown	6 (0.1)	2 (0.0)	8 (0.0)	4 (0.0)	38 (0.2)	42 (0.1)	50 (0.1)
Route of exposure							
Single route							
Ingestion	10 738 (89.6)	14 065 (93.3)	24 803 (91.6)	10 678 (81.4)	17 464 (79.2)	28 142 (80.0)	52 945 (85.0)
Ocular	54 (0.5)	31 (0.2)	85 (0.3)	742 (5.7)	1611 (7.3)	2353 (6.7)	2438 (3.9)
Dermal	49 (0.4)	30 (0.2)	79 (0.3)	128 (1.0)	176 (0.8)	304 (0.9)	383 (0.6)
Inhalation	8 (0.1)	3 (0.0)	11 (0.0)	33 (0.3)	10 (0.0)	43 (0.1)	54 (0.1)
Aspiration	2 (0.0)	2 (0.0)	4 (0.0)	12 (0.1)	94 (0.4)	106 (0.3)	110 (0.2)
Multiple routes with ingestion	1119 (9.3)	938 (6.2)	2057 (7.6)	1389 (10.6)	2310 (10.5)	3699 (10.5)	5756 (9.2)
Other multiple routes	16 (0.1)	5 (0.0)	21 (0.1)	136 (1.0)	395 (1.8)	531 (1.5)	552 (0.9)
Other	3 (0.0)	2 (0.0)	5 (0.0)	0 (0.0)	1 (0.0)	1 (0.0)	6 (0.0)
Unknown	0 (0.0)	1 (0.0)	1 (0.0)	6 (0.0)	3 (0.0)	9 (0.0)	10 (0.0)
Total exposures (row %)[e]	11 989 (19.3)	15 077 (24.2)	27 066 (43.5)	13 124 (21.1)	22 064 (35.4)	35 188 (56.5)	62 254

[a] Column percentages were calculated by using the total number of exposures for each detergent category as the denominator and may not sum to 100.0% due to rounding error.
[b] PCCs were unable to obtain the exact age for these cases, but it was known that the child was younger than 6 y of age.
[c] Residence includes own residence and other residence.
[d] Other includes HCF, public area, restaurant/food service, school, unknown, and workplace.
[e] Percentages are totaled within the row.

NPDS manual.[17] The terms "cases," "calls," and "exposures" are used interchangeably; they represent an actual or suspected exposure to a detergent product, as reported to a PCC.

Statistical Analysis and Ethical Considerations

NPDS data were analyzed by using SPSS 21.0 for Windows (IBM SPSS Statistics, IBM Corporation) and descriptive statistics were reported. Population data from the US Census Bureau were used to calculate exposure rates.[18] Logistic regression was used to establish an association between different types of detergents and various outcome measures, which included serious medical outcome, HCF admission, clinical effects, and intubation. Odd ratios (ORs) were calculated along with the 95% confidence interval (CI). This study was approved by the institutional review board of The Research Institute at Nationwide Children's Hospital.

RESULTS

General Characteristics

From January 2013 through December 2014, US PCCs received 62 254 calls related to dishwasher (27 066 calls) and laundry (35 188 calls) detergent exposures among children younger than 6 years old that satisfied the study inclusion criteria (Table 1). Detergent packets (24.2% dishwasher and 35.4% laundry) accounted for 59.6% of all exposures. The overall detergent rate of exposure per 10 000 US children younger than 6 years old was 13.0 (4.6 for laundry packets, 3.1 for dishwasher packets, 2.7 for laundry nonpackets, and 2.5 for dishwasher nonpackets). From 2013 to 2014, the number and rate of detergent exposures increased by 14.3% and 14.8%, respectively, with the highest increase seen among laundry packet (17.0% and 17.5%) and dishwasher packet (14.0% and 14.5%) exposures. After January 2013, the monthly number of detergent packet exposures exceeded the number of traditional detergent exposures, with laundry packets having the highest number of exposures (Fig 1).

Boys accounted for 53.4% of all detergent exposures (Table 1). The mean age of the children exposed

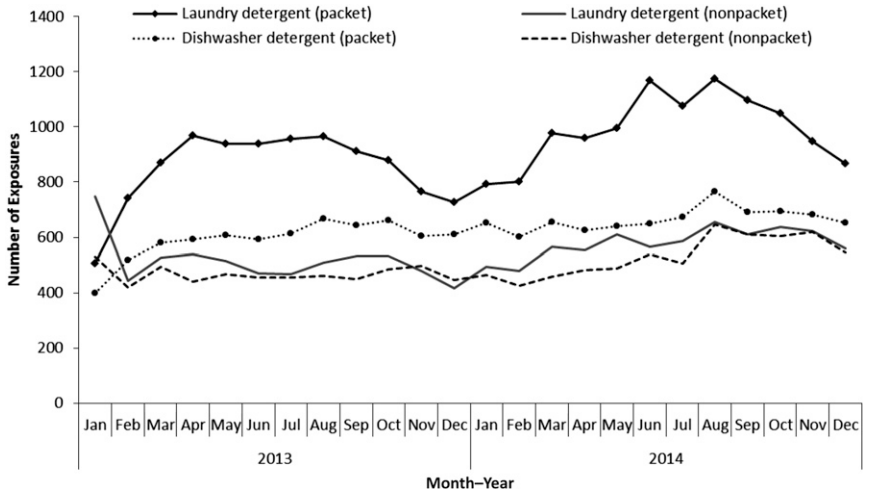

FIGURE 1

Number of laundry and dishwasher detergent exposures among children younger than 6 years by month, year, and types of detergent (NPDS 2013–2014).

to detergents was 1.7 years (SD = 0.85) with a median age of 1.5 years (interquartile range, 1.1–2.0). Children younger than 3 years of age accounted for the majority (86.2%) of cases in this study. One-year-olds accounted for a higher proportion of exposures to dishwasher detergent (64.0%) compared with laundry detergent (38.8%). Children age 2 years accounted for 16.3% of dishwasher detergent exposures and 30.3% of laundry detergent exposures. Most (99.4%) exposures occurred in a residence, and 94.3% were an ingestion alone (85.0%) or multiple routes including ingestion (9.2%). Among 3264 (5.2%) cases where the scenario of access to the detergent was reported, 34.4% involved the detergent being stored within sight of the child, 20.1% involved the detergent stored in an unlocked low cabinet in the kitchen or bathroom, and 17.0% involved the detergent being temporarily open while in use with the caregiver being momentarily distracted.

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

Among all children exposed to detergent, 76.8% were managed on site at a non-HCF, 21.3% were seen at an HCF, and 51.2% had no or minor clinical effects (Table 2). Children exposed to laundry packets had a higher proportion of being referred to a HCF by the PCC, which was 17.4% compared with 4.7% for laundry nonpacket exposures, and less than 1% for dishwasher detergent packets and nonpackets. Similarly, 29.2% of children exposed to laundry packets were already in or enroute to a HCF when the call was made to the PCC compared with 12.6% for laundry nonpackets and even less for both forms of dishwasher detergents. In addition, the proportion of children who were seen in a HCF after exposure was highest for children exposed to laundry detergent packets (44.8%) compared with those exposed to other types of detergent (16.9% for laundry nonpackets, 4.7% for dishwasher packets, and 3.9% for dishwasher nonpackets).

Among the 1.9% of all children who were admitted to a HCF, 97.5% were exposed through ingestion or aspiration. Moderate effects were observed in 3.1% of the exposures, and only 0.2% of the exposures resulted in serious medical outcomes (including 2 deaths that were associated with laundry detergent packets; Table 2). The odds of being admitted to a HCF were significantly higher for children exposed to laundry detergent packets than those exposed to laundry detergent nonpackets (OR: 4.8; 95% CI: 4.0–5.8), dishwasher detergent packets (OR: 23.5; 95% CI: 16.4–33.6), and dishwasher detergent nonpackets (OR: 21.5; 95% CI: 14.6–31.5; Table 2). Similarly, children who were exposed to laundry detergent packets also had higher odds of having serious medical outcomes compared with laundry detergent nonpackets (OR: 8.4; 95% CI: 3.9–18.2), dishwasher detergent packets (OR: 22.6; 95% CI: 7.2–71.4), and dishwasher detergent nonpackets (OR: 18.0; 95% CI: 5.7–56.8). There were no significant differences in the odds of being admitted to a HCF (OR: 1.3; 95% CI: 0.3–6.2) or having serious medical outcomes (OR: 0.8; 95% CI: 0.2–3.9) for those exposed to dishwasher detergent packets compared with those exposed to dishwasher detergent nonpackets. Among all laundry packet exposures, laundry detergent packets containing liquid components accounted for 98.3% of the exposures; children exposed to them had a 2.0 (95% CI: 1.03–3.92; $P = .038$) times higher odds of being admitted to a HCF than those exposed to laundry packets containing only granules.

Clinical Effects

Of all children exposed to dishwasher or laundry detergent, 43.5% experienced 1 or more clinical effects. The most frequent clinical effects experienced by those who were exposed to any form of detergent were vomiting (29.1%), cough/choke (8.3%), ocular–irritation/pain (5.6%), red eye/conjunctivitis (3.4%), and drowsiness/lethargy (2.8%; Table 3). Children exposed to laundry detergent packets had higher odds of experiencing 1 or more clinical effects than those exposed to laundry detergent nonpackets (OR:

TABLE 2 Management Site, Level of Health Care Received, and Medical Outcome Associated With Laundry or Dishwasher Detergent Exposures Among Children Younger Than 6 Years by Types of Detergent, NPDS 2013–2014

Characteristics	Dishwasher Detergent			Laundry Detergent			Overall Total, *n* (%)[a]
	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	
Management site							
Managed on site (non-HCF)	11 361 (94.8)	14 192 (94.1)	25 553 (94.4)	10 677 (81.4)	11 552 (52.4)	22 229 (63.2)	47 782 (76.8)
Patient in (enroute to) HCF when PCC called	393 (3.3)	580 (3.8)	973 (3.6)	1657 (12.6)	6436 (29.2)	8093 (23.0)	9066 (14.6)
Patient was referred by PCC to a HCF	91 (0.8)	142 (0.9)	233 (0.9)	622 (4.7)	3837 (17.4)	4459 (12.7)	4692 (7.5)
Other	40 (0.3)	44 (0.3)	84 (0.3)	66 (0.5)	143 (0.6)	209 (0.6)	293 (0.5)
Unknown	104 (0.9)	119 (0.8)	223 (0.8)	102 (0.8)	96 (0.4)	198 (0.6)	421 (0.7)
Level of health care received							
No HCF treatment received	11 505 (96.0)	14 355 (95.2)	25 860 (95.5)	10 845 (82.6)	11.791 (53.4)	22 636 (64.3)	48 496 (77.9)
Patient refused referral/did not arrive at HCF	19 (0.2)	18 (0.1)	37 (0.1)	66 (0.5)	386 (1.7)	452 (1.3)	489 (0.8)
Seen in HCF	465 (3.9)	704 (4.7)	1169 (4.3)	2213 (16.9)	9887 (44.8)	12 100 (34.4)	13 269 (21.3)
Treated/evaluated and released	396 (3.3)	607 (4.0)	1003 (3.7)	1850 (14.1)	7975 (36.1)	9825 (27.9)	10 828 (17.4)
Patient lost to follow-up/left AMA	42 (0.4)	66 (0.4)	108 (0.4)	233 (1.8)	893 (4.0)	1126 (3.2)	1234 (2.0)
Admitted to noncritical care unit	16 (0.1)	21 (0.1)	37 (0.1)	80(0.6)	564 (2.6)	644 (1.8)	681 (1.1)
Admitted to critical care unit	11 (0.1)	10 (0.1)	21 (0.1)	50 (0.4)	455 (2.1)	505 (1.4)	526 (0.8)
Medical outcome							
Not followed, minimal clinical effects possible[b]	6299 (52.5)	7369 (48.9)	13 668 (50.5)	6228 (47.5)	3879 (17.6)	10 107 (28.7)	23 775 (38.2)
Minor effect	1556 (13.0)	2777 (18.4)	4333 (16.0)	2920 (22.2)	11 088 (50.3)	14 008 (39.8)	18 341 (29.5)
No effect	3076 (25.7)	3842 (25.5)	6918 (25.6)	2607 (19.9)	3993 (18.1)	6600 (18.8)	13 518 (21.7)
Not followed, judged as nontoxic exposure[c]	918 (7.7)	918 (6.1)	1836 (6.8)	814 (6.2)	330 (1.5)	1144 (3.3)	2980 (4.8)
Unable to follow, judged as a potentially toxic exposure	90 (0.8)	122 (0.8)	212 (0.8)	246 (1.9)	1114 (5.0)	1360 (3.9)	1572 (2.5)
Moderate effect	47 (0.4)	46 (0.3)	93 (0.3)	302 (2.3)	1561 (7.1)	1863 (5.3)	1956 (3.1)
Serious	3 (0.0)	3 (0.0)	6 (0.0)	7 (0.1)	99 (0.4)	106(0.3)	112 (0.2)
Major effect	3 (0.0)	3 (0.0)	6 (0.0)	7 (0.1)	97 (0.4)	104(0.3)	110 (0.2)
Death	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.0)	2 (0.0)	2 (0.0)
Total exposures (row %)[d]	11 989 (19.3)	15 077 (24.2)	27 066	13 124 (21.1)	22 064 (35.4)	35 188 (56.5)	62 254

[a] Column percentages were calculated by using the total number of exposures for each detergent category as the denominator and may not sum to 100.0% due to rounding error.
[b] Not followed, minimal clinical effects possible (no more than minor effect possible).
[c] Not followed, judged as nontoxic exposure (clinical effects not expected).
[d] Percentages are totaled within the row.

3.9; 95% CI: 3.7–4.1), dishwasher packets (OR: 5.6; 95% CI: 5.4–5.9), and dishwasher nonpackets (OR: 8.2; 95% CI: 7.8–8.6). Serious clinical effects observed for laundry detergent packet exposures and not for any other type of detergent exposures included the following: coma (17 cases), respiratory arrest (6 cases), pulmonary edema (4 cases), and cardiac arrest (2 cases).

Therapies

For all children exposed to dishwasher or laundry detergent, the most commonly used therapies were dilute/irrigate/wash (76.5%) and food/snack (10.7%; Table 4). Intubation was performed in 4 cases of dishwasher detergent (3 nonpackets and 1 packet) exposure and 113 cases of laundry detergent (9 nonpackets and 104 packets) exposure. The odds of being intubated were significantly higher for children exposed to laundry detergent packets than those exposed to laundry detergent nonpackets (OR: 6.9; 95% CI: 3.5–13.6), dishwasher packets (OR: 71.3; 95% CI: 10.0–511.7), and dishwasher nonpackets (OR: 18.9; 95% CI: 6.0–59.6). Vasopressors were used only for laundry detergent exposures (1 nonpacket and 7 packets), and cardiopulmonary resuscitation (CPR; 3 cases) and cardioversion (1 case) were used only for laundry packet exposures.

DISCUSSION

In 2013 and 2014, 62 254 exposures associated with laundry and dishwasher detergent were reported to US PCCs, and almost 60% of those involved detergent packets. After January 2013, the monthly number of detergent packet exposures exceeded that of traditional detergent exposures, with laundry packets having the highest number of exposures. The increase in laundry packet exposures is likely due to the increase in their use and presence in homes.[13]

Children younger than 3 years of age accounted for the majority (86.2%) of cases in this study, which agrees with findings by others.[13,19] The high

TABLE 3 Selected Clinical Effects Associate With Laundry or Dishwasher Detergent Exposures Among Children Younger Than 6 Years by Types of Detergent, NPDS 2013–2014

Clinical Effects	Dishwasher			Laundry			Clinical Effects Total, *n* (%)[a]
	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	
Cardiac effects							
Tachycardia	8 (0.1)	1 (0.0)	9 (0.0)	19 (0.1)	144 (0.7)	163 (0.5)	172 (0.3)
Chest pain (including noncardiac)	—	—	—	1 (0.0)	6 (0.0)	7 (0.0)	7 (0.0)
Bradycardia	—	—	—	—	4 (0.0)	4 (0.0)	4 (0.0)
Cardiac arrest	—	—	—	—	2 (0.0)	2 (0.0)	2 (0.0)
Dysrhythmia (other)	—	—	—	—	1 (0.0)	1 (0.0)	1 (0.0)
Dermal effects							
Erythema/flushed	51 (0.4)	50 (0.3)	101 (0.4)	129 (1.0)	371 (1.7)	500 (1.4)	601 (1.0)
Edema	10 (0.1)	11 (0.1)	21 (0.1)	118 (0.9)	363 (1.6)	481 (1.4)	502 (0.8)
Rash	36 (0.3)	22 (0.1)	58 (0.2)	79 (0.6)	280 (1.3)	359 (1.0)	417 (0.7)
Dermal—irritation/pain	27 (0.2)	42 (0.3)	69 (0.3)	86 (0.7)	243 (1.1)	329 (0.9)	398 (0.6)
Burns second—third degree	1 (0.0)	—	1 (0.0)	3 (0.0)	9 (0.0)	12 (0.0)	13 (0.0)
Burns (superficial)	4 (0.0)	7 (0.0)	11 (0.0)	10 (0.1)	55 (0.2)	65 (0.2)	76 (0.1)
Gastrointestinal effects							
Vomiting	1725 (14.4)	3184 (21.1)	4909 (18.1)	2704 (20.6)	10 504 (47.6)	13 208 (37.5)	18 117 (29.1)
Nausea	120 (1.0)	158 (1.0)	278 (1.0)	223 (1.7)	874 (4.0)	1097 (3.1)	1375 (2.2)
Oral irritation	243 (2.0)	281 (1.9)	524 (1.9)	240 (1.8)	611 (2.8)	851 (2.4)	1375 (2.2)
Throat irritation	29 (0.2)	29 (0.2)	58 (0.2)	108 (0.8)	424 (1.9)	532 (1.5)	590 (0.9)
Diarrhea	28 (0.2)	30 (0.2)	58 (0.2)	74 (0.6)	367 (1.7)	441 (1.3)	499 (0.8)
Abdominal pain	24 (0.2)	19 (0.1)	43 (0.2)	55 (0.4)	160 (0.7)	215 (0.6)	258 (0.4)
Oral burns (including lips)	3 (0.0)	5 (0.0)	8 (0.0)	6 (0.0)	40 (0.2)	46 (0.1)	54 (0.1)
Dysphagia	3 (0.0)	2 (0.0)	5 (0.0)	8 (0.1)	39 (0.2)	47 (0.1)	52 (0.1)
Oropharyngeal edema	3 (0.0)	1 (0.0)	4 (0.0)	9 (0.1)	31 (0.1)	40 (0.1)	44 (0.1)
Esophageal injury	2 (0.0)	1 (0.0)	3 (0.0)	2 (0.0)	33 (0.1)	35 (0.1)	38 (0.1)
Hematemesis	3 (0.0)	1 (0.0)	4 (0.0)	5 (0.0)	16 (0.1)	21 (0.1)	25 (0.0)
Esophageal stricture	1 (0.0)	—	1 (0.0)	—	1 (0.0)	1 (0.0)	2 (0.0)
Melena	—	2 (0.0)	2 (0.0)	—	—	—	2 (0.0)
Hematologic/hepatic effects							
Other coagulopathy	—	—	—	—	3 (0.0)	3 (0.0)	3 (0.0)
Other LFT abnormality	—	—	—	—	3 (0.0)	3 (0.0)	3 (0.0)
Miscellaneous effects							
Excess secretions	18 (0.2)	28 (0.2)	46 (0.2)	40 (0.3)	325 (1.5)	365 (1.0)	411 (0.7)
Fever/hyperthermia	9 (0.1)	17 (0.1)	26 (0.1)	23 (0.2)	114 (0.5)	137 (0.4)	163 (0.3)
Acidosis	—	1 (0.0)	1 (0.0)	6 (0.0)	51 (0.2)	57 (0.2)	58 (0.1)
Bleeding (other)	7 (0.1)	7 (0.0)	14 (0.1)	6 (0.0)	8 (0.0)	14 (0.0)	28 (0.0)
Pain (not dermal, GI, ocular)	2 (0.0)	1 (0.0)	3 (0.0)	11 (0.1)	9 (0.0)	20 (0.1)	23 (0.0)
Neurologic effects							
Drowsiness/lethargy	21 (0.2)	28 (0.2)	49 (0.2)	211 (1.6)	1504 (6.8)	1715 (4.9)	1764 (2.8)
Agitated/irritable	28 (0.2)	32 (0.2)	60 (0.2)	53 (0.4)	220 (1.0)	273 (0.8)	333 (0.5)
Ataxia	—	—	—	3 (0.0)	16 (0.1)	19 (0.1)	19 (0.0)
Coma	—	—	—	—	17 (0.1)	17 (0.0)	17 (0.0)
Seizure (single)	1 (0.0)	—	1 (0.0)	4 (0.0)	11 (0.0)	15 (0.0)	16 (0.0)
Syncope	—	—	—	—	3 (0.0)	3 (0.0)	3 (0.0)
Ocular effects							
Ocular—irritation/pain	77 (0.6)	71 (0.5)	148 (0.5)	895 (6.8)	2437 (11.0)	3332 (9.5)	3480 (5.6)
Red eye/conjunctivitis	41 (0.3)	29 (0.2)	70 (0.3)	521 (4.0)	1547 (7.0)	2068 (5.9)	2138 (3.4)
Lacrimation	13 (0.1)	10 (0.1)	23 (0.1)	107 (0.8)	311 (1.4)	418 (1.2)	441 (0.7)
Corneal abrasion	2 (0.0)	5 (0.0)	7 (0.0)	77 (0.6)	293 (1.3)	370 (1.1)	377 (0.6)
Burns	—	—	—	15 (0.1)	80 (0.4)	95 (0.3)	95 (0.2)
Photophobia	1 (0.0)	—	1 (0.0)	10 (0.1)	49 (0.2)	59 (0.2)	60 (0.1)
Papilledema	1 (0.0)	—	1 (0.0)	1 (0.0)	8 (0.0)	9 (0.0)	10 (0.0)
Respiratory effects							
Cough/choke	488 (4.1)	891 (5.9)	1379 (5.1)	770 (5.9)	3004 (13.6)	3774 (10.7)	5153 (8.3)
Dyspnea	11 (0.1)	7 (0.0)	18 (0.1)	33 (0.3)	245 (1.1)	278 (0.8)	296 (0.5)
Bronchospasm	3 (0.0)	2 (0.0)	5 (0.0)	15 (0.1)	153 (0.7)	168 (0.5)	173 (0.3)
Radiograph findings (+)	—	2 (0.0)	2 (0.0)	13 (0.1)	131 (0.6)	144 (0.4)	146 (0.2)
Hyperventilation/tachypnea	3 (0.0)	—	3 (0.0)	9 (0.1)	95 (0.4)	104 (0.3)	107 (0.2)
Respiratory depression	—	—	—	5 (0.0)	67 (0.3)	72 (0.2)	72 (0.1)
Pneumonitis	1 (0.0)	—	1 (0.0)	3 (0.0)	32 (0.1)	35 (0.1)	36 (0.1)

TABLE 3 Continued

Clinical Effects	Dishwasher			Laundry			Clinical Effects Total, *n* (%)[a]
	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	Nonpacket, *n* (%)[a]	Packet, *n* (%)[a]	Total, *n* (%)[a]	
Cyanosis	—	3 (0.0)	3 (0.0)	1 (0.0)	17 (0.1)	18 (0.1)	21 (0.0)
Respiratory arrest	—	—	—	—	6 (0.0)	6 (0.0)	6 (0.0)
Pulmonary edema	—	—	—	—	4 (0.0)	4 (0.0)	4 (0.0)
Total exposures (row %)[b]	11 989 (19.3)	15 077 (24.2)	27 066 (43.5)	13 124 (21.1)	22 064 (35.4)	35 188 (56.5)	62 254 (100.0)

GI, gastrointestinal; LFT, liver function test; —, no clinical effect.

[a] Column percentages were calculated by using the total number of exposures for each detergent category as the denominator. Percentages will not sum to 100.0% because an exposed child may or may not experience 1 or more clinical effects.

[b] Row percentages.

TABLE 4 Therapies Performed on Children Younger Than 6 Years Exposed to Laundry or Dishwasher Detergent by Types of Detergent, NPDS 2013–2014

Therapies[a]	Dishwasher Detergent			Laundry Detergent			Total Therapies Performed, *n* (%)[b]
	Nonpacket, *n* (%)[b]	Packet, *n* (%)[b]	Total, *n* (%)[b]	Nonpacket, *n* (%)[b]	Packet, *n* (%)[b]	Total, *n* (%)[b]	
Dilute/irrigate/wash	9352 (78.0)	12 079 (80.1)	21 431 (83.2)	9836 (74.9)	16 336 (74.0)	26 172 (75.5)	47 603 (76.5)
Food/snack	1260 (10.5)	1804 (12.0)	3064 (11.9)	1330 (10.1)	2293 (10.4)	3623 (10.4)	6687 (10.7)
Intubation	3 (0.0)	1 (0.0)	4 (0.0)	9 (0.1)	104 (0.5)	113 (0.3)	117 (0.2)
Vasopressors	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	7 (0.0)	8 (0.0)	8 (0.0)
CPR	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (0.0)	3 (0.0)	3 (0.0)
Cardioversion	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.0)	1 (0.0)	1 (0.0)
Other	562 (4.7)	682 (4.5)	1244 (4.8)	916 (7.0)	3731 (16.9)	4647 (13.4)	5889 (9.5)
Total exposures (row %)[c]	11 989 (19.3)	15 077 (24.2)	27 066 (43.5)	13 124 (21.1)	22 064 (35.4)	35 188 (56.5)	62 254 (100.0)

[a] Only therapies used in more than 9% of exposures or those that were used to treat children with serious outcomes (ie, intubation, vasopressors, CPR, and cardioversion) were included.

[b] Column percentages. Percentages will not sum to 100.0% because some therapies were excluded, whereas none or at least 1 therapy may have been used.

[c] Row percentages.

proportion of exposures among this age group is most likely due to the large amount of time they spend in the home, their newfound mobility, and their curiosity leading to exploratory and mouthing behavior.

Children exposed to laundry detergent packets were referred to a HCF by a PCC specialist and were treated at a HCF more frequently than those exposed to other types of detergent. This is due to the known toxicity associated with these products.[13] Children exposed to laundry detergent packets had 3.9 to 8.2 times higher odds of developing 1 or more clinical effects compared with those exposed to other types of detergent. This may also explain why almost 30% of the children exposed to laundry packets were already in or enroute to a HCF when the call was made to the PCC compared with smaller proportions for other types of detergent.

In this study, children exposed to laundry detergent packets had significantly higher odds of being admitted to a HCF (4.8–23.5) or having a serious medical outcome (8.4–22.6) than those exposed to other types of detergent. Furthermore, serious clinical effects, such as coma, respiratory arrest, pulmonary edema, cardiac arrest, and death were only observed among children exposed to laundry detergent packets and not for those exposed to other types of detergents. The odds of being intubated were significantly higher for children exposed to laundry detergent packets than those exposed to other types of detergent. CPR and cardioversion were only used in laundry detergent packet exposures. These findings corroborate those in a previous study.[13] It is unknown why more severe clinical effects and medical outcomes are observed among laundry packet exposures than among traditional laundry detergent and dishwasher detergent (packets and nonpackets) exposures.[20] Differences in chemical composition and concentration between laundry detergent packets and other types of detergents may account for the higher toxicity observed for laundry detergent packets.[13] The possible contribution to clinical effects of the water-soluble membrane that surrounds laundry detergent packets remains unknown. There were no significant differences in the odds of having serious medical outcomes or being hospitalized between dishwasher detergent packet and nonpacket exposures. In addition, children exposed to laundry detergent packets containing liquid components experienced an odds of being admitted to a HCF that was twice that of those exposed to laundry packets containing only granules. These observations support the focus on liquid laundry detergent packets, rather than all detergent packets, in the recently adopted ASTM International F3159-15 voluntary safety standard for liquid laundry packets.[21]

Perhaps because dishwasher detergents have become safer, or, more likely, because laundry detergent products have become more toxic, our findings reveal that the old knowledge found in medical and toxicology textbooks that (mostly cationic) dishwasher detergents are more dangerous than (mostly anionic or nonionic) laundry detergents is no longer correct.[22,23] Further, our findings demonstrate that laundry detergent packets are more toxic than other types of detergents. Exposure to these detergent packets can lead to serious clinical effects, including death, which corroborates findings of other studies.[10,13,14] The Consumers Union has recommended that this product not be used, which is only the second time in its history that it has made such a strong statement.[24] The industry has recognized the risk associated with pediatric laundry packet exposures and has taken steps in the right direction to help prevent these exposures. The ASTM F3159-15 safety standard has been adopted; however, this standard has a number of weaknesses that could potentially limit its effectiveness. It permits the industry to meet the requirement for a child resistant container in 6 different ways rather than use the proven-effective Poison Prevention Packaging Act performance standard.[25] The standard also does not require that packets be individually wrapped in a child-resistant enclosure, which would add layers of protection and help address the scenarios when a packet is accessed after it is removed from the container or when the container is momentarily left open. Some dishwasher detergent packets currently on the market already come individually wrapped, which refutes the argument that the public would find this too inconvenient. The standard also does not address the possibility that the design, color, or fragrance of the packets may attract young children, which is an area requiring further research.

In addition, changing the chemical composition of the packets to reduce their toxicity remains unaddressed. Pediatric exposures to laundry detergent packets should be closely monitored nationally to assess the effectiveness of the newly adopted voluntary safety standard. House Bill 1139, the Detergent Poisoning and Child Safety Act of 2015, was introduced into the US Congress in February 2015.[26] This bill would allow the US Consumer Product Safety Commission to create a mandatory safety standard for liquid laundry detergent packets if a voluntary standard does not adequately address the safety issues.

In addition to changing the packaging and chemical composition of packets, educational efforts and public awareness may help prevent detergent exposures. The most frequently reported scenario of access among all exposures was "stored within sight of child," followed by "stored in unlocked low cabinet in kitchen or bathroom," and "product temporarily open." Detergents should be stored up and out of sight of children and in a locked cabinet to help prevent exposures. When detergents are in use, parents and child caregivers should not leave the product accessible to children. Health care providers should counsel parents and caregivers about the dangers associated with detergent exposure and recommend safe storage and use of these products. Households with children younger than 6 years of age should be encouraged to use traditional laundry detergent rather than laundry detergent packets.

This study has a number of limitations. The number of pediatric exposures to detergent is underestimated because not all exposures are reported to PCCs. Data coding errors, including miscoding of detergent type, may have occurred. The NPDS relies on self-reports from parents, caregivers, and health care professionals, which cannot be completely verified by PCCs or the AAPCC. Reported exposures do not necessarily represent a poisoning or overdose. Additionally, some reporting fields are optional, such as the scenario associated with the child's access to the detergent, which may limit interpretation. Also, PCC specialists may be more likely to record a detailed account of the exposure if the outcome is more severe; therefore, more information may be available for serious cases than less serious ones. Despite these limitations, data in the NPDS national database are entered by highly qualified poison experts by using strict quality controls and case follow-up methods. The NPDS offers the most inclusive and comprehensive database available for research on detergent exposures among US children.

CONCLUSIONS

This national study demonstrates that pediatric laundry detergent packet exposures are more severe than laundry detergent nonpacket and dishwasher detergent (packet and nonpacket) exposures. Pediatric exposures to laundry detergent packets increased by 17% from 2013 to 2014 nationally; exposures should be closely monitored to assess the effectiveness of the newly adopted voluntary safety standard, and this standard should be strengthened if the number of exposures does not demonstrate a substantial decrease.

ABBREVIATIONS

AAPCC: American Association of Poison Control Centers
AMA: against medical advice
CI: confidence interval
CPR: cardiopulmonary resuscitation
HCF: health care facility
NPDS: National Poison Data System
OR: odds ratio
PCC: poison control center

Address correspondence to Gary A. Smith, MD, DrPH, Director, Center for Injury Research and Policy; The Research Institute at Nationwide Children's Hospital; 700 Children's Dr, Columbus, OH 43205. E-mail: gary.smith@nationwidechildrens.org

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

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

FUNDING: Mrs Davis received a research stipend from the National Student Injury Research Training Program at Nationwide Children's Hospital, funded by the Centers for Disease Control and Prevention (grant 1R49CE002106), and the Child Injury Prevention Alliance while she worked on this study.

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

REFERENCES

1. Mathew RG, Kennedy K, Corbett MC. Eyes and alkalis. Wave of paediatric eye injuries from liquid detergent capsules. *BMJ*. 2010;340:c1186
2. Mowry JB, Spyker DA, Cantilena LR Jr, Bailey JE, Ford M. 2012 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 30th Annual Report. *Clin Toxicol (Phila)*. 2013;51(10):949–1229
3. Stromberg PE, Burt MH, Rose SR, Cumpston KL, Emswiler MP, Wills BK. Airway compromise in children exposed to single-use laundry detergent pods: a poison center observational case series. *Am J Emerg Med*. 2015;33(3):349–351
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. Kynaston JA, Patrick MK, Shepherd RW, Raivadera PV, Cleghorn GI. The hazards of automatic-dishwasher detergent. *Med J Aust*. 1989;151(1):5–7
6. Wason S. The emergency management of caustic ingestions. *J Emerg Med*. 1985;2(3):175–182
7. Bautista Casasnovas A, Estevez Martinez E, Varela Cives R, Villanueva Jeremias A, Tojo Sierra R, Cadranel S. A retrospective analysis of ingestion of caustic substances by children. Ten-year statistics in Galicia. *Eur J Pediatr*. 1997;156(5):410–414
8. Gray ME, West CE. Corneal injuries from liquid detergent pods. *J AAPOS*. 2014;18(5):494–495
9. Williams H, Jones S, Wood K, et al. Reported toxicity in 1486 liquid detergent capsule exposures to the UK National Poisons Information Service 2009–2012, including their ophthalmic and CNS effects. *Clin Toxicol (Phila)*. 2014;52(2):136–140
10. Centers for Disease Control and Prevention (CDC). Health hazards associated with laundry detergent pods - United States, May-June 2012. *MMWR Morb Mortal Wkly Rep*. 2012;61(41):825–829
11. Schneir AB, Rentmeester L, Clark RF, Cantrell FL. Toxicity following laundry detergent pod ingestion. *Pediatr Emerg Care*. 2013;29(6):741–742
12. Beuhler MC, Gala PK, Wolfe HA, Meaney PA, Henretig FM. Laundry detergent "pod" ingestions: a case series and discussion of recent literature. *Pediatr Emerg Care*. 2013;29(6):743–747
13. Valdez AL, Casavant MJ, Spiller HA, Chounthirath T, Xiang H, Smith GA. Pediatric exposure to laundry detergent pods. *Pediatrics*. 2014;134(6):1127–1135
14. Forrester MB. Comparison of pediatric exposures to concentrated "pack" and traditional laundry detergents. *Pediatr Emerg Care*. 2013;29(4):482–486
15. Bramuzzo M, Amaddeo A, Facchina G, Neri E, Martelossi S, Barbi E. Liquid detergent capsule ingestion: a new pediatric epidemic? *Pediatr Emerg Care*. 2013;29(3):410–411
16. Mowry JB, Spyker DA, Cantilena LR Jr, McMillan N, Ford M. 2013 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 31st Annual Report. *Clin Toxicol (Phila)*. 2014;52(10):1032–1283
17. American Association of Poison Control Centers. *National Poison Data System (NPDS): NPDS System Manual (May 2009)*. Alexandria, VA: American Association of Poison Control Centers; 2009
18. US Census Bureau. Annual estimates of the resident population by single year of age and sex for the United States: April 1, 2010 to July 1, 2014. Available at: https://www.census.gov/popest/data/national/asrh/2014/index.html. Accessed February 23, 2016
19. Forrester MB. Referral of pediatric laundry detergent pack exposure reported to poison centers. *J Emerg Med*. 2014;47(5):532–538
20. Ng S. Dangers behind laundry pods stump poison-control experts. Available at: www.wsj.com/articles/laundry-pod-dangers-stump-medical-experts-1435702614. Accessed August 24, 2015
21. ASTM International. ASTM F3159-15: Standard safety specification for liquid laundry packets. . Available at: http://www.astm.org/DATABASE.CART/HISTORICAL/F3159-15.htm. Accessed December 7, 2015
22. Walsh MJ. Detergents. In: Olson KR, ed. *Poisoning and Drug Overdose*, 6th ed. San Francisco, CA: McGraw Hill Medical; 2012:192–193
23. Wax PM, Young A. Caustics. In: Marx JA, Hockberger RS, Walls RM, eds. *Rosen's Emergency Medicine*, 8th ed. Philadelphia, PA: Elsevier/Saunders; 2014:1994–1998
24. Consumer Reports. Consumer reports will no longer recommend liquid laundry detergent pods. 2015. Consumer Reports. Available at: http://pressroom.consumerreports.org/pressroom/2015/07/

yonkers-ny-consumer-reports-today-announced-that-it-would-no-longer-recommend-liquid-laundry-detergent-pods-because-of-t.html. Accessed December 7, 2015

25. Public Law 91-601, 84 Stat. 1670, December 30, 1970, as amended. Poison Prevention Packaging Act. Available at: www.cpsc.gov//Global/PDF/Statues/pppa.pdf. Accessed August 24, 2015

26. US Congress. H.R. 1139 - Detergent PACS Act of 20. Available at: https://www.congress.gov/bill/114th-congress/house-bill/1139/text. Accessed August 24, 2015

Pediatric Exposures to Laundry and Dishwasher Detergents in the United States: 2013–2014

Mallory G. Davis, Marcel J. Casavant, Henry A Spiller, Thiphalak Chounthirath and Gary A. Smith

Pediatrics 2016;137;
DOI: 10.1542/peds.2015-4529 originally published online April 25, 2016;

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Pediatric Exposures to Laundry and Dishwasher Detergents in the United States: 2013–2014

Mallory G. Davis, Marcel J. Casavant, Henry A Spiller, Thiphalak Chounthirath and Gary A. Smith

Pediatrics 2016;137;
DOI: 10.1542/peds.2015-4529 originally published online April 25, 2016;