Ocular Exposures Reported to Poison Control Centers From 2011 to 2015

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• PURPOSE: To identify and characterize the ocular exposures reported to poison control centers over a 5-year period from 2011 to 2015 in the United States.
• DESIGN: Pooled cross-sectional study.
• SUBJECTS: Callers to poison control centers.
• METHODS: We retrospectively analyzed data from 477 274 calls for ocular exposure to the National Poison Data System. Major medical outcomes, reason for exposure, location of exposure, and causative xenobiotic were evaluated.
• RESULTS: A mean volume of 95 454 calls per year were reported to poison control centers, with most exposures occurring unintentionally, at home, and predominantly in children under 5 years of age. Most serious adult exposures occurred at work owing to alkali exposures. There was an increasing incidence in exposures in those over 64 years old. The most common treatment provided was irrigation and wash for the affected eye.
• CONCLUSIONS: Children under 5 are most susceptible; they may have permanent disability owing to laundry detergent exposure; and concerted intervention is needed in this age group. Many serious adult exposures occurred at work owing to alkali exposures. (Am J Ophthalmol 2019;204:46–50. © 2019 Elsevier Inc. All rights reserved.)

CHEMICAL EXPOSURES TO THE EYE OR ADJACENT structures can cause extensive injury to the cornea, anterior segment, and ocular epithelium, resulting in significant morbidity.[1] Some of the most dangerous agents are broadly classified as acids or alkalis, with the most common being sulfuric acid, acetic acid, hydrochloric acid, ammonia, lye, lime, and potassium hydroxide. These chemicals are found in common day-to-day items of use, such as drain cleaners, bleaches, preservatives, fertilizers, gasoline, and many others.[2] Injuries caused by alkali can damage deeper eye structures like the posterior segment and retina.[3,4] Significant sequelae include lifelong visual loss, acute and chronic pain, and an increased risk for infection.[5,6]

Possible morbidities include chronic disease, loss of social structure, and decreased life-long economic activity.[5,7,8] It is estimated that eye injuries in the United States cost $300 million per year loss of production time, medical expenses, and worker compensation.[9] Initial treatments are focused on decontamination to limit the extent of injury, controlling inflammation, and promoting ocular re-epithelialization. A simple eye wash and irrigation is often sufficient in many cases; however, with extensive and penetrating chemical injuries, surgical intervention is needed for removal of necrotic debris from the corneal epithelium and the conjunctive.[1] Studies have shown that early intervention can prevent severe damage to the eye; however, it is frequently delayed or inadequate.[4]

An article published in 2016 reviewed data from the US Nationwide Emergency Department Sample and discussed demographics, ICD-9 diagnosis codes, and emergency department cost of these patients. They were also able to present convincing evidence of the higher risk to children, particularly those 1 and 2 years old. However, there is no national sample including outcomes after emergency department discharge and specific substances involved. In addition, there are many other cases that occur at home or the workplace that do not present to the emergency department. These cases may receive recommendations through poison control centers of appropriate home care or presentation to another treatment setting.[10]

The National Poison Data System (NPDS) is a large data warehouse managed by the American Association of Poison Control Centers and serves as the surveillance database in the United States for the 55 poison control centers nationwide. Poison control centers are available free of charge to anyone round-the-clock, every day of the year.[11] They receive well over 2 million human exposure calls a year and serve as an important surveillance resource. Each year, the NPDS reports the number of ocular exposures in their annual publication, but not the specific agents involved, nor the injuries that result.[11]

METHODS

ALL HUMAN OCULAR EXPOSURE CALLS REPORTED TO THE American Association of Poison Controls Centers' NPDS

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between January 1, 2011 and December 31, 2015 were retrospectively analyzed. De-identified data were received for calls made to the poison control centers during that time frame. Those cases with exposure other than the eye and skin were excluded, including any with parenteral or oral exposure, for this analysis.

Abstracted data included case age and sex, generic and product codes (NPDS codes from Micromedex; Truven Health Analytics, Ann Arbor, Michigan, USA), exposure reason, exposure route, clinical effects, treatments given, and medical outcomes. NPDS major effect cases exhibited signs or symptoms as a result of the exposure that were life-threatening or resulted in significant residual disability or disfigurement. Moderate effect cases exhibited signs or symptoms as a result of the exposure that were more pronounced, more prolonged, or more systemic in nature than minor symptoms. Minor effect cases developed some signs or symptoms as a result of the exposure, but they were minimally bothersome and generally resolved rapidly, with no residual disability or disfigurement.

All case ages and exposure reasons were included; information and animal calls (no human exposure) were excluded on the initial data acquisition. The collected data were secured in password-protected electronic computer files with limited access. Descriptive statistics and SAS were used (SAS Institute, Cary, North Carolina). This activity was exempted by the University of Arizona institutional review board.

RESULTS

OVER THIS 5-YEAR PERIOD, FROM JANUARY 1, 2011 TO December 31, 2015, there were 477 274 calls made to the poison control centers that were associated with only ocular exposures. An average of 95 454 calls were received each year, although there was an average decline of 2.4% year over year, with maximum cases reported in 2011 (n = 101 280) and minimum cases in 2015 (n = 91 855). Both men and women had a similar likelihood of exposure, with men representing 51% of cases (n = 242 537). The median age of exposure was lower in men as compared to women (21.7 ± 19.9 years vs 26.6 ± 22.8 years, P value $< .001$). Year-over-year trend showed declining incidence of exposure in the less than 18 years and 18-64 years age cohorts; however, there was an increasing incidence for people over 64 years of age. The ocular exposures occurred most commonly in the subjects' own residence (n = 355 206 [83%]). This trend was replicated across all age groups. The second most common site of exposure varied by age group. For subjects below the age of 18 years, school was the second most common site of exposure (n = 14 463 [7%]), while for the working-age group (18-64 years), workplace was the second most common site of exposure (n = 32 066 [16%]). Most of the cases were managed onsite (n = 281 314 [66%]), although 31% (n = 134 351) of cases presented or were referred to a healthcare facility (Table 1). Age-specific incidence rates showed the highest incidence in children under 5 (n = 115 701 [24%]).

There were 709 (0.15%) reported major outcomes, suggesting a permanent significant visual disability. The most common agent resulting in a major outcome was an alkali, with 183 affected subjects. Children under the age of 10 had 25 (0.02%) major outcomes reported, all at home, 20 from laundry detergents and 5 from bleach. Working-age adults had a disproportionate number of major outcomes from alkali exposures at their place of occupation. Major outcomes occurred more commonly in men than women (n = 347 [0.35%] vs n = 229 [0.16%], $P < .001$). Men also had higher incidence of major outcomes from occupational exposure compared to women (n = 174 [0.96%]) vs n = 18 [0.20%], $P < .001$).

The most common physical examination findings in those with major outcomes were eye pain, redness, burns, corneal abrasions, blurred vision, visual defects, papilledema, and lacrimation (Table 2). Eye pain and redness were also the 2 most common symptoms for all calls received by NPDS.

Pesticides were the most common reason for exposure, affecting 4.9% (n = 23 388) of all the patients who presented. Wrong medication taken/given was the next most common reason for exposure, with 3% (n = 14 800) cases reported, followed by "Incorrect dosing route," affecting 2% (n = 10 878) of total cases (Table 3). Although pesticide exposure had an equitable distribution across age groups, "wrong medication taken/given" as a reason for exposure was higher in the geriatric population, increasing from 10% incidence in age 61-70 years, to 26% in age group 91-100 years. In the workplace, most exposures happened unintentionally, accounting for 84% of all exposures. Within this population, where the exposure was unintentional and at the workplace, the most common reason of exposure was pesticide, accounting for 54% of calls (n = 1580). Workplace injuries showed a steady decline with age, with maximum injuries occurring in the 18-21 years age group (n = 35 046 [18%]) and the lowest incidence in the 62-65 years age group (n = 6615 [3%]).

The most common treatment was dilute/irrigate/wash, done in 93% (n = 445 750) of cases; 7% (n = 33 409) received nonspecific "Other" treatment, followed by antibiotics, which were administered to 4% (n = 19 384) of the total patients.

DISCUSSION

OCULAR XENOBIOTIC EXPOSURE IS A PREVENTABLE OCCURRENCE that seriously impacts the US population, causing 91 207 calls to poison control centers in 2016.[11] This study confirms the findings of Haring and associates[10] that the age

TABLE 1. Demographics and Details of Ocular Exposures Reported to Poison Control Centers

	Age Group[a]		
	<18 Years N (%)	18-64 Years N (%)	≥65 Years N (%)
Sex			
Male	113 092 (55.3%)	99 071 (50.1%)	9260 (36.2%)
Female	91 235 (44.7%)	98 862 (49.9%)	16 326 (63.8%)
Year of call			
2011	44 043 (21.5%)	41 849 (21.1%)	4725 (18.5%)
2012	42 943 (21.0%)	40 179 (20.3%)	4941 (19.3%)
2013	40 052 (19.6%)	39 111 (19.7%)	5171 (20.2%)
2014	38 997 (19.1%)	38 453 (19.4%)	5250 (20.5%)
2015	38 651 (18.9%)	38 661 (19.5%)	5507 (21.5%)
Site of exposure			
Own residence	176 801 (86.4%)	154 482 (77.9%)	23 923 (93.0%)
Workplace	753 (0.4%)	32 066 (16.2%)	524 (2.0%)
School	14 463 (7.1%)	1055 (0.5%)	10 (0.0%)
Other residence	5277 (2.6%)	3152 (1.6%)	352 (1.4%)
Public area	4447 (2.2%)	3281 (1.7%)	244 (0.9%)
Other	1954 (1.0%)	1959 (1.0%)	304 (1.2%)
Unknown	562 (0.3%)	1685 (0.8%)	92 (0.4%)
HCF	328 (0.2%)	463 (0.2%)	137 (0.5%)
Restaurant / food service	101 (0.0%)	110 (0.1%)	137 (0.5%)
Management site			
Managed on site	152 554 (74.5%)	113 074 (57.0%)	15 686 (61.3%)
Other	6371 (3.1%)	3024 (1.5%)	624 (2.4%)
Patient already in HCF	29 490 (14.4%)	55 592 (28.0%)	6244 (24.4%)
Patient was referred by PCC to HCF	14 990 (7.3%)	25 157 (12.7%)	2878 (11.2%)
Unknown	1281 (0.6%)	1406 (0.7%)	162 (0.6%)

HCF = healthcare facility; PCC = poison control center.
[a]A total of 48 741 caller records did not have age recorded

TABLE 2. Physical Exam Findings Reported to Poison Control

Symptoms	Number of Calls With Major Outcomes N (%)
Ocular-Irritation/pain	531 (74.9%)
Red eye/conjunctivitis	349 (49.2%)
Burns	198 (27.9%)
Corneal abrasion	190 (26.8%)
Blurred vision	137 (19.3%)
Visual defect	116 (16.4%)
Papilledema	115 (16.2%)
Lacrimation	108 (15.2%)
Dermal-Irritation/pain	98 (13.8%)
Other	97 (13.7%)

TABLE 3. Exposure Types by Age Demographic

	Age Group			
Exposure Type	<18 Years N (%)	18-64 Years N (%)	>64 Years N (%)	Total[a] N (%)
Pesticide exposure	8883 (4.3%)	9820 (4.9%)	1812 (7.1%)	23 388 (4.9%)
Wrong medication taken/given	3171 (1.6%)	6207 (3.1%)	3563 (13.92%)	14 800 (3.1%)
Incorrect dosing route	2825 (1.4%)	4283 (2.2%)	2273 (8.9%)	10 878 (2.3%)

[a]Includes 48 741 records with missing age.

group at the highest risk, and probably the most fruitful area for intervention, is that of 1- and 2-year-old children. However, Haring and associates did not review the trends over time. We noted a decreasing number of exposures to young people during these 5 years. This study does not provide a reason for this trend, but improving education and child-resistant container use may have decreased these exposures. Properly keeping dangerous substances up and out of reach or locked up may significantly reduce the incidence of these exposures. Protective packaging decreased the rates of child exposures by 40%, and should be considered in high-risk substances.[12,13] In addition, education of first responders and emergency personnel by ophthalmologists may impact the morbidity in those exposed.[14] We also found the number of major outcomes from laundry detergent remarkable. While there has been a public health effort leading to making laundry pods less appetizing and placed into protective packaging, the hazard of eye exposure to laundry detergents may not be fully appreciated by parents, leading to easier access by young children.

An observation missing on extensive literature search was the increasing incidence of ocular chemical injuries in the geriatric age group, where we saw a year-over-year increase in number of calls made to the poison control center. In this cohort, the results showed increasing incidence of "wrong medication taken/given" as reason for ocular injury. This parallels other studies in geriatric populations indicating issues with polypharmacy, polymorbidity, and inadequate geriatric assessment.[15] Some studies have cited elderly abuse as a potential cause.[16,17] Extra precautions are warranted in this population owing to frailty and longer path of recovery.

Workplace safety has been an area of focus, discussion, and continuous improvement to prevent accidents and injuries. Multiple studies have been conducted to identify root causes for gaps in workplace safety. Research has shown that safety knowledge, safety motivation, group safety climate, and cognitive failure have been shown to correlate with lower workplace accidents and injuries.[18–21] A study done in the state of California in 1996 showed that approximately 14.3% of all admissions for ocular trauma admitted to the emergency room were work related, and occurred most commonly in men and between the age group of 20-24 years.[22] This finding is similar to the results we found in our study, where 16% (n = 32 066) of exposures in the working age group (18-64 years) happened at the workplace, with 0.67% (n = 215) leading to a major outcome. However, our study showed that with increasing age, the incidence of exposures gradually decreased, with maximum injuries occurring in 18-21 years age group and minimum in the 62-65 years age group. Other epidemiologic studies done on ocular trauma showed similar incidence and identified lack of eye protection as the single largest reason.[23–26] As such, it is advised that mandatory eye protection at the workplace should be strongly enforced through company policies and safety motivation. Continued safety education should be routinely provided at the workplace, especially in the younger age group.

Several agents were identified to be most commonly associated with major outcomes after exposure, particularly alkali agents. Continued development of safer containers and education of risks might be indicated to mitigate this population risk.

In the majority of the cases, the poison control centers are able to effectively advise first aid, immediate irrigation, and treatment, which prevents an unnecessary visit to the emergency room or to the doctor's office, leading to a savings of millions of dollars in healthcare costs. In our study, 66% of cases were managed outside of a healthcare setting, probably representing a cost savings. A joint project of ophthalmologists and poison control centers should be to increase parental and workplace knowledge of appropriate first aid and poison control contact information.

The strengths of this dataset includes multiple call settings, wide population coverage, and the ability to examine temporal trends. There were several limitations involved in this work. The retrospective review of calls received by US poison control centers introduced selection and reporting bias. It is assumed that not all ocular exposure cases, particularly those with minimal or no clinical effects, were reported to a poison center. Fatalities, if they occur, are not always reported to poison control centers.

In summary, there were a mean number of 95 454 calls per year to poison control centers for ocular exposures, with most occurring unintentionally, at home, and predominantly in children under 5 years of age. Many serious adult exposures occurred at work owing to alkali exposures. There was an increasing incidence of ocular injury in those over 64 years old over these 5 years. The most common treatment provided was irrigation and wash for the affected eye. Children under 5 are most susceptible and may have permanent disability owing to laundry detergent exposure, and concerted intervention is needed in this age group.

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REFERENCES

1. Wagoner MD. Chemical injuries of the eye: current concepts in pathophysiology and therapy. *Surv Ophthalmol* 1997;41:275–313.
2. Singh P, et al. Ocular chemical injuries and their management. *Oman J Ophthalmol* 2013;6:83.
3. Schrage NF, Langefeld S, Zschocke J, et al. Eye burns: an emergency and continuing problem. *Burns* 2000;26:689–699.
4. Paschalis EI, et al. Mechanisms of retinal damage after ocular alkali burns. *Am J Pathol* 2017;187:1327–1342.
5. Eslani M, Baradaran-Rafii A, Movahedan A, Djalilian AR. The ocular surface chemical burns. *J Ophthalmol* 2014;2014:196827.

6. Pfister RR. Chemical corneal burns. *Int Ophthalmol Clin* 1984; 24(2):157–168.
7. Court H, McLean G, Guthrie B, Mercer SW, Smith DJ. Visual impairment is associated with physical and mental comorbidities in older adults: a cross-sectional study. *BMC Med* 2014;12:181.
8. Green D, Ducorroy G, McElnea E, et al. The cost of blindness in the Republic of Ireland 2010-2020. *J Ophthalmol* 2016; 2016:4691276.
9. United States Department of Labor. Eye injuries report. Available at: https://www.osha.gov/SLTC/eyefaceprotection/. Accessed August 29, 2018.
10. Haring RS, Sheffield ID, Channa R, Canner JK, Schneider EB. Epidemiologic trends of chemical ocular burns in the United States. *JAMA Ophthalmol* 2016;134:1119–1124.
11. Gummin DD, Mowry JB, Spyker DA, Brooks DE, Fraser MO, Banner W. 2016 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 34th Annual Report. *Clin Toxicol* 2017;55:1072–1254.
12. Walton WW. An evaluation of the Poison Prevention Packaging Act. *Pediatrics* 1982;69:363–370.
13. Rodgers GB. The safety effects of child-resistant packaging for oral prescription drugs: two decades of experience. *JAMA* 1996;275:1661–1665.
14. Al-Moujahed A, Chodosh J. Outcomes of an algorithmic approach to treating mild ocular alkali burns. *JAMA Ophthalmol* 2015;133:1214–1216.
15. Fialová D, Onder G. Medication errors in elderly people: contributing factors and future perspectives. *Br J Clin Pharmacol* 2009;67(6):641–645.
16. Jones J, et al. Emergency department protocol for the diagnosis and evaluation of geriatric abuse. *Ann Emerg Med* 1988;17:1006–1015.
17. Lachs MS, Pillemer K. Abuse and neglect of elderly persons. *N Engl J Med* 1995;332:437–443.
18. Christian MS, et al. Workplace safety: a meta-analysis of the roles of person and situation factors. *J Appl Psychol* 2009;94: 1103.
19. Hayes BE, et al. Measuring perceptions of workplace safety: development and validation of the work safety scale. *J Safety Res* 1998;29:145–161.
20. Wallace JC, Vodanovich SJ. Workplace safety performance: conscientiousness, cognitive failure, and their interaction. *J Occup Health Psychol* 2003;8:316.
21. Kaminski M. Unintended consequences: organizational practices and their impact on workplace safety and productivity. *J Occup Health Psychol* 2001;6:127.
22. Baker RS, et al. Demographic factors in a population-based survey of hospitalized, work-related, ocular injury. *Am J Ophthalmol* 1996;122:213–219.
23. May DR, et al. The epidemiology of serious eye injuries from the United States Eye Injury Registry. *Graefes Arch Clin Exp Ophthalmol* 2000;238:153–157.
24. Dannenberg AL, et al. Penetrating eye injuries in the workplace: the National Eye Trauma System Registry. *Arch Ophthalmol* 1992;110:843–848.
25. Fong LP, Taouk Y. The role of eye protection in work-related eye injuries. *Aust N Z J Ophthalmol* 1995;23:101–106.
26. Griffith GAP, Jones NP. Eye injury and eye protection: a survey of the chemical industry. *Occup Med* 1994;44:37–40.