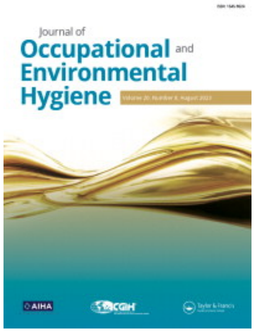

Taylor & Francis
Taylor & Francis Group

Journal of Occupational and Environmental Hygiene

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uoeh20

Causal factors of work-related chemical eye injuries reported to the Dutch Poisons Information Center

Anja P. G. Wijnands, Irma de Vries, Maxim P. Carlier, Dylan W. de Lange & Saskia J. Rietjens

To cite this article: Anja P. G. Wijnands, Irma de Vries, Maxim P. Carlier, Dylan W. de Lange & Saskia J. Rietjens (2023) Causal factors of work-related chemical eye injuries reported to the Dutch Poisons Information Center, Journal of Occupational and Environmental Hygiene, 20:8, 315-321, DOI: 10.1080/15459624.2023.2210183

To link to this article: https://doi.org/10.1080/15459624.2023.2210183

JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HYGIENE
2023, VOL. 20, NO. 8, 315–321
https://doi.org/10.1080/15459624.2023.2210183

SHORT REPORT

Causal factors of work-related chemical eye injuries reported to the Dutch Poisons Information Center

Anja P. G. Wijnands[a], Irma de Vries[a], Maxim P. Carlier[a], Dylan W. de Lange[a,b], and Saskia J. Rietjens[a]

[a]Dutch Poisons Information Center, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands; [b]Department of Intensive Care Medicine, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands

ABSTRACT
This study investigated the circumstances of chemical occupational eye exposures reported to the Dutch Poisons Information Center. During a 1-year prospective study, data were collected through a telephone survey of 132 victims of acute occupational eye exposure. Victims were often exposed to industrial products (35%) or cleaning products (27%). Most patients developed no or mild symptoms. Organizational factors (such as lack of work instructions (52%)), and personal factors (such as time pressure and fatigue (50%), and not adequately using personal protective equipment (PPE, 14%), were the main causes of occupational eye exposures. Exposure often occurred during cleaning activities (34%) and personal factors were reported more often during cleaning (67%) than during other work activities (41%). Data from Poison Control Centers are a valuable source of information, enabling the identification of risk factors for chemical occupational eye exposure. This study shows that personal factors like time pressure and fatigue play a significant role, although personal factors may be related to organizational issues such as poor communication. Therefore, risk mitigation strategies should focus on technical, organizational, and personal factors. The need to follow work instructions and proper use of PPE should also have a prominent place in the education and training of workers.

KEYWORDS
Acute intoxication; hazardous substances; occupational exposure; poison control center; preventive measures

Introduction

The Dutch Poisons Information Center (DPIC) provides 24/7 telephone and internet advice to healthcare professionals on the diagnosis and treatment of patients exposed to potentially hazardous substances. In 2019, the DPIC was consulted approximately 35,000 times by telephone on individuals exposed to a wide variety of substances. Less than 3% of these consultations involved acute occupational exposures (Nugteren-van Lonkhuyzen et al. 2019). A previous study showed that the annual number of acute occupational exposures disproportionally increased from 375 in 2015 to 871 in 2019 (Wijnands-Kleukers et al. 2022). This increase was much larger (132%) than the increase in the total number of consultations in the same period (5%). Workers were often exposed via multiple routes. Inhalation was the most common route of exposure (43%), followed by skin contact (32%), eye contact (25%), and oral contact (12%). The previous study showed that the number of occupational eye exposures almost tripled from 77 in 2015 to 224 in 2019.

Since the retrospective data (Wijnands-Kleukers et al. 2022) only provided limited information about the causes of these incidents, a prospective follow-up study was initiated to further explore the circumstances and clinical course of occupational eye exposures. As many eye exposures are preventable by wearing safety glasses, the authors were interested in learning about the underlying causes of occupational eye injuries. To provide tools to improve prevention, various causal factors in relation to business classes and types of activities were investigated, as well as technical factors (equipment failures, damaged packaging), and

CONTACT Anja P. G. Wijnands a.wijnands@umcutrecht.nl Dutch Poisons Information Center, University Medical Center Utrecht, Utrecht University, PO Box 85500, 3508 GA Utrecht, the Netherlands.

Supplemental data for this article can be accessed online at https://doi.org/10.1080/15459624.2023.2210183. AIHA and ACGIH members may also access supplementary material at http://oeh.tandfonline.com.

organizational and personal factors related to the individual worker.

Methods

During a 1-year prospective study conducted from September 1, 2020 until August 31, 2021, all acute occupational eye exposures reported to the DPIC during the study period were included. When consulting the DPIC, healthcare professionals were informed on clinical effects and treatment options according to standard DPIC procedures. At this stage, the patients' personal information was unknown to the DPIC; only sex, age, and the name of the consulting healthcare professional were known. The healthcare professionals were asked to inform their patients about the study. After patient agreement, healthcare professionals provided the DPIC with patient contact information. Patients who agreed to participate in the study were interviewed by telephone within 2 weeks. Before starting the interview, informed consent was obtained by telephone (and voice recorded) after information was provided on the content, duration, and confidentiality of the interview and the anonymous processing of the data. A patient was considered lost to follow-up (LFU) when there were no contact details available, the patient was not reachable by phone, or the patient did not wish to participate in the study.

We used a standardized 15-min questionnaire with questions about the circumstances of the incident, the products exposed to, and the clinical course and treatments (as described previously (Wijnands et al. 2022b)) (for more information see Supplementary Materials Questionnaire). Causal factors were investigated at three levels: (1) technical factors (e.g., damaged packaging, defective machinery); (2) organizational factors (e.g., availability of work instructions, provision of personal protective equipment (PPE)); and (3) personal factors (e.g., fatigue, time pressure, actual use of PPE). The classification of the European Agency for Safety and Health at Work (EU-OSHA) (EU-OSHA 2023) on the hierarchy of prevention and control measures was used as the basis for the questionnaire.

Data were processed anonymously by allocating serial numbers to each questionnaire and registering the questionnaire in Castor Electronic Data Capture (EDC), a cloud-based data management platform. All identifiable data were omitted before analysis. Calculations and data analysis were performed in Excel v16.0 (Microsoft, Redmond, USA) and SPSS v26 (IBM, Armonk, USA). Descriptive statistics (percentage, median, interquartile range (IQR), full range (FR)) were used to provide an overview of patient and exposure characteristics, causes, eye effects, and treatments. Pearson's Chi-squared tests were used to test statistical differences in demographics between patients with follow-up and patients LFU.

The accredited Medical Research Ethics Committee (MREC) of the University Medical Center Utrecht determined that the Dutch Medical Research Involving Human Subjects Act did not apply to this study.

Results

From September 1, 2021 to August 31, 2021, 333 cases of occupational eye exposure were reported to the DPIC. We interviewed 132 patients (39.6%) (FU group), while 201 patients (60.4%) were considered LFU (LFU group). The most important reasons for LFU were missing contact information (46.3%), refusal to participate (25.4%), and not reachable by phone (20.9%). There were no statistically significant differences in age and gender distribution between the FU and LFU group. See Table S2.

All results in the following paragraphs relate to the interviewed patients ($n = 132$, FU group).

The interviewed patients were mainly male (75.8%). The median age was 29 years (IQR 18 years; range 16–63 years). The first phone call to the DPIC was most often made by a general practitioner (82.6%), followed by Emergency Department staff (5.3%), ophthalmologists (4.5%), ambulance staff (3.0%), and other medical professionals (4.5%). Thirty-one patients visited an Emergency Department (generally upon advice of the DPIC), and 21 were examined by an ophthalmologist. Only one patient was hospitalized.

Industries and type of activities

Industries were categorized according to the Standard Business Classification List of Statistics Netherlands (CBS) published by Kruiskamp (2021). The main business classes in which the patients worked were "industry" (30.3%), "building and installation" (13.6%), "wholesale and retail" (10.6%), and "accommodation, provision of meal and drinks" (10.6%).

Most of the incidents occurred during cleaning activities (34.1%) and production or use (22%), but incidents also happened during preparatory activities (16.7%), repair and maintenance (11.4%), and transport (2.3%). Twelve individuals (9.1%) were not working with the hazardous substance themselves but were exposed while working nearby or when walking by when a chemical was used. In the business class "accommodation, provision of meal and drinks", 50% of the incidents occurred during cleaning activities.

Exposure characteristics

Patients were either exposed to liquids (75.8%), vapors or aerosols (11.4%), solids, powders or pastes (10.6%), or gasses (2.3%). Most patients were exposed to industrial products ($n = 46$, 34.8%), cleaning products ($n = 35$, 26.5%), construction products ($n = 21$, 15.9%), or disinfectants ($n = 15$, 11.4%). Industrial products were diverse and ranged from corrosive acids and alkalis to irritants like acetone and ethylene glycol. Cleaning products often involved were chlorine bleach, sanitary cleaners, and oven cleaners, which often contain corrosive substances like sodium hydroxide, potassium hydroxide, or acids. Most reported construction products were cements and epoxy resins, while detergents or hand gels containing ethanol, were the most reported disinfectants. Table 1 provides an overview of the most frequently involved compounds.

Causal factors of occupational eye exposure

Three categories of possible causal factors were distinguished, namely technical factors, organizational factors, and personal factors. Table 2 lists the most important causes. In Table S3, more detailed information on the causes in relation to specific business classes is given.

Technical factors mainly involved damaged packaging and defective apparatus. In 107 cases, the patient used a product that was (initially) packaged. Damage to the packaging, such as holes, ruptures, or cracks, caused 32 incidents. Fifty-six patients used a tool or machine. In nine incidents, an equipment failure occurred, such as leakage, clogging, or detachment of a hose. When comparing different business classes, damaged packaging as the cause of the incident was mentioned relatively often in the business class "Transport and storage" (71.4%). See Table S3.

Lack of work instruction (51.5% of incidents) and poor communication and/or planning (18.9%) were important organizational factors. Twenty-eight incidents

Table 1. Most frequently involved compounds in occupational eye exposures reported by interviewed patients ($n = 132$).

Group	Compound*	Number of patients exposed
Alkalis		31
	Sodium hydroxide	14
	Potassium hydroxide	7
Acids		21
	Nitric acid	3
	Hydrofluoric acid	3
	Phosphoric acid	2
	(per)acetic acid	2
Alcohols and phenols		11
	Ethanol	6
	Isopropyl alcohol	2
Adhesives and sealants		10
	Epoxy resin	7
	Acrylate	2
Medicines and vaccines		8
	Vaccine[a]	3
	Pentobarbital/Thiopental[b]	4
Glycols		7
	Ethylene glycol	3
	Propylene glycol	1
Aldehydes and ketones		6
	Formaldehyde	2
	Acetone	2
Chlorine compounds		6
	Chlorine gas/vapor[c]	2
	Sodium hypochlorite	3
Metals and metal salts		6
Gases		5
	Propane/butane	3
Fuels (gasoline, diesel, etc.)		5
Lubricants (hydraulic oil, etc.)		5
Cyclic hydrocarbons		4

*Most patients were exposed to a mixture of compounds.
[a]Three incidents of COVID-19 vaccine (during vaccine preparation).
[b]Three incidents during euthanizing animals with pentobarbital.
[c]In two incidents, chlorine gas was formed due to inappropriate mixture of chemicals.

Table 2. Most important causes of occupational eye exposures reported by interviewed patients ($n = 132$).

Causes*		Number	%
Technical	Damaged packaging	32	24.2%
	Defective apparatus	9	6.8%
Organizational	No work instructions available	68	51.5%
	Poor communication, planning	25	18.9%
Personal	Inaccuracy[a], hastiness[b], time pressure, fatigue, etc.	66	50.0%
	PPE (face protection) obligatory, but not used	18	13.6%

*Patients could indicate more than one cause.
[a]Inaccuracy, i.e., nonchalance, carelessness, or inattention.
[b]Hastiness, i.e., working hastily or rushed.
PPE: Personal Protective Equipment.

(21.2%) were caused by a colleague instead of the patient.

Personal circumstances that were often reported were inaccuracy (i.e., nonchalance, carelessness, or inattention) ($n = 38$, 28.8%), hastiness (i.e., working hastily or rushed) ($n = 22$, 16.7%), time pressure ($n = 15$, 11.4%), and fatigue ($n = 5$, 3.8%). In total, 66 patients (50%) mentioned that one or more of these personal circumstances played an important role in the incident. Personal circumstances were reported relatively often in the business class "Accommodation, provision of meals and drinks" (78.6%) and "Industry" (62.5%). See Table S3. Personal circumstances as a cause of incidents were reported more often during cleaning activities (66.7%) than during other activities (41.4%).

Another personal factor was that work instructions and/or the obligatory use of PPE were sometimes disregarded. Fifty workers reported that work instructions were available, but 17 workers reported that they did not follow these instructions. Forty-three patients (32.6%) reported that wearing eye protection (safety goggles, $n = 39$) or some type of facial protection (face mask, $n = 4$) was obligatory. However, 18 of these patients did not wear any form of eye or facial protection or only wore their own regular glasses ($n = 3$).

Clinical effects and treatment

Next to eye exposure, some patients were simultaneously exposed through other routes (i.e., dermal exposure ($n = 19$), inhalation ($n = 12$), dermal and oral exposure ($n = 5$), and dermal exposure and inhalation ($n = 4$)). In this study, the authors focused on eye exposure. Table 3 provides a summary of the most frequently reported eye symptoms, treatments, and use of health care services.

Pain in the eyes was the most frequently reported symptom (56.1%), followed by eye irritation (55.0%), redness of the eyes (34.1%), and temporary loss of vision (28.8%). Corneal abrasion, diagnosed by a medical professional, was reported four times. Ten patients reported no symptoms.

Irrigation of the eye(s) is the most important first-aid treatment after eye contact. Eye irrigation was performed in 111 patients with either tap water, an eye-shower, or a rinse bottle, mostly by the patient him/herself ($n = 108$) promptly after exposure ($n = 96$). The median duration of eye irrigation was 15 min. In 60 cases, an eye shower was available. Sixteen patients did not use the available eye shower, half of which rinsed with tap water because it was quicker or more comfortable. Thirty-one patients visited an Emergency Department, and 21 were examined by an ophthalmologist. One patient was admitted to hospital after exposure to 10–25% hydrofluoric acid. He was released after 24 hr without further complications.

Most patients with symptoms recovered quickly (31.1% within 1 day and 44.7% within 2 days). Absenteeism was reported by 23 patients (17.4%). Eight patients were absent from work for 1 day, six for 2 days, four for 3 days, and five for 4 days or longer.

Discussion

In this study, most patients developed no (8%) or only mild eye symptoms after eye exposure to hazardous substances at the workplace, such as pain (56%), redness (34%), temporary loss of vision (29%), or lacrimation (6%). These findings are consistent with other studies that show that occupational eye exposure to potentially hazardous substances often results in relatively mild symptoms. Assad et al. (2020) and Le Roux et al. (2020) reported that 72–74% of patients developed no or minor symptoms (such as mild irritation, conjunctivitis, and lacrimation), whereas 26–28% of patients developed moderate or severe symptoms (such as intense irritation, keratitis, ulceration, corneal perforation, and scarring). In this study, 45% of symptomatic patients recovered within 2 days. The high percentage of patients with no or mild symptoms, and the overall lack of severe

Table 3. Eye symptoms, duration of symptoms, treatments, and use of health care services, reported by interviewed patients ($n = 132$).

Symptoms	Number of patients N	(%)	Duration (hrs) Median (IQR, Full Range)
No eye symptoms	10	(7.6)	
Pain in the eyes	74	(56.1)	20 (IQR: 2-72, FR: 0.02-312)
Eye irritation	66	(50.0)	24 (IQR: 4-72, FR: 0.1-216)
Redness	45	(34.1)	31 (IQR: 12-72, FR: 0.1-144)
Temporary loss of vision	38	(28.8)	24 (IQR: 11-72, FR: 0.3-144)
Edema (eye lid, conjunctiva)	12	(9.1)	48 (IQR: 10-72, FR: 1.0-96)
Lacrimation	8	(6.1)	3 (IQR: 1-24, FR: 0.7-24)
Corneal abrasion	4	(3.0)	42 (IQR: 28-54, FR: 3-72)[a]
Treatment/use of health care services			
Eye irrigation[b,c]	111	(84.1)	
Eye examination	75[d]	(56.8)	
Treatment with ointments and/or eye drops	65	(49.2)	
Emergency Department visit	31	(23.5)	
Hospitalization	1	(0.8)	

[a]Duration of symptoms reported by the patients, but not confirmed by an eye examination performed by a medical professional.
[b]Ninety-six patients irrigated the eye(s) immediately after exposure.
[c]In 60 cases, an eye shower was available. Sixteen patients did not use the eye shower: 8 patients used tap water, 4 used an eye bottle, and 4 did not irrigate (2 had no symptoms, 1 could not find the eye shower, and 1 sought medical attention without rinsing first).
[d]Eye examination was performed by a general practitioner ($n = 37$), ophthalmologist ($n = 21$), or other medical professional ($n = 17$).

symptoms, may be explained by the fact that eye irrigation was often carried out promptly after exposure. In this study, 111 patients irrigated their eyes, 96 of whom irrigated their eyes immediately after exposure.

Most eye exposures in this study occurred in industry (such as the chemical, food, and pharmaceutical industry) and the building and installation sector. Other European studies (Assad et al. 2020; Martin-Prieto et al. 2020; Quesada et al. 2020) described that occupational eye exposures often occur in industry and construction workers as well.

Cleaning was shown to have a higher potential for eye exposure, as 34% of our patients were exposed during cleaning activities and 33% were exposed to either a cleaning agent or a disinfectant. The Swedish Poisons Control Center also found that a substantial part (24%) of occupational incidents involved cleaning agents or disinfectants (in the Swedish study 60% of incidents involved eye exposures, and the other 40% involved other routes of exposure) (Schenk et al. 2020). This study showed that people working in the service sector, especially in the business class "accommodation, provision of meal and drinks", were often involved in cleaning incidents. This finding was consistent with the findings of Quesada et al. (2020) and Schenk et al. (2020).

In this study, patients were often exposed to mixtures that frequently contained alkalis (reported in 24% of the exposures) or acids (16%). Similar to our study, other Poisons Control Center studies showed that acids and alkalis are often involved in occupational exposure (Downs et al. 2021; Schenk et al. 2018; Schenk and Oberg 2018; Woolf et al. 2001). In a study performed by the French Poisons Control Center, alkalis and acids were involved in occupational eye exposures in 32% and 17% of incidents, respectively (Assad et al. 2020).

European worker protection legislation establishes a hierarchy of measures that employers are required to take to control risks to workers from dangerous substances. Total elimination of the use of the dangerous substance is the preferred option, followed by substitution with less hazardous compounds. If elimination or substitution is not possible, the exposure can be prevented or reduced by taking organizational (e.g., providing work instructions and training), technical (e.g., ventilation), and personal (e.g., wearing PPE) measures (EU-OSHA 2022).

When looking at the causes of occupational eye exposure, improper work instructions are an important factor that increases the risk of exposure to hazardous substances. In this study, almost half of the patients reported a lack of work instruction(s). Workers that are unaware of potential chemical hazards in the work environment are more vulnerable to exposure and injury (EU-OSHA 2023; US-OSHA 2022).

In this study, damaged packaging (24%), and to a lesser extent defective apparatus (7%), were the most important technical factors that caused eye exposure at work. Schenk et al. (2020) found that occupational eye exposure is often caused by equipment failures (such as the detachment of a hose or broken spray applicator), illustrating that proper maintenance of machinery is important. Instructing employees to carefully handle packaging and encouraging manufacturers to improve the design of packages can lead to a further reduction in the number of occupational incidents (Meulenbelt and de Vries 1997).

Personal circumstances such as inaccuracy, hastiness, time pressure, and/or fatigue, play a significant role, especially in the business classes "Accommodation, provision of meals and drinks" and "Industry". Remarkably, personal circumstances were often mentioned as a cause of eye exposure during cleaning activities. Half of all patients (79% in the business classes "Accommodation, provision of meals and drinks" and 63% in "Industry") mentioned one or more personal circumstances as a possible causative factor for the incident. Another important personal factor is the use of PPE. In this study, 16% of patients did not use the obligatory facial protection or assumed that wearing regular glasses would offer appropriate protection.

Personal factors may well be related to organizational issues. When understaffed, employees may have to work under strict time limits and feelings of time pressure can arise, which may influence the behavior of workers. For employers, it is important to assess and mitigate such factors that can have potentially dangerous consequences. Trying to ensure an appropriate workload is key, as previous studies also showed that time pressure increases the risk of accidents (Schenk et al. 2020; US-OSHA 2022). Both employers and workers should be made aware that cleaning activities, either as regular work processes or as activities for maintenance and repair, have more potential for accidents than usually perceived. The need to follow work instructions and proper use of PPE when obligatory should have a prominent place in the education and training of workers.

In most countries, there is a legal obligation to report incidents at work that cause hospitalization, permanent injury, or a fatality (Arbeidsomstandighedenwet 2022; EU-OSHA 2023; US-OSHA 2022). Minor injuries are often not reported to governmental authorities. Many epidemiological studies on occupational eye injuries focus on Emergency Department patients (Hong et al. 2010; Gobba et al. 2017; Quesada et al. 2020). This study shows that Poisons Center data on relatively mild incidents can reveal meaningful information on the causes of accidents. Combined with the existing national statistics data on work-related accidents, these data also provide more insight into the pattern of occupational (eye) exposures in the Netherlands.

Limitations

This study has a few limitations. First, data is based on voluntary reports of healthcare professionals to the DPIC, which may have resulted in an underestimation of the total number of occupational eye exposures in the Netherlands. Second, in this study, the number of cases LFU was relatively high. However, as the sex and age distribution of the FU group and LFU group are comparable, the interviewed patients are likely a fair representation of all patients with occupational exposures reported to the DPIC. Third, we only interviewed patients (employees) and not employer representatives. This may have resulted in bias because patients have a personal perception of the incident. The causes of the incidents were not confirmed by an occupational hygienist or other employer representative. Therefore, interviewing only patients resulted in the presentation of a one-sided view of the incident. In addition, from this study, it was difficult to evaluate whether factors such as time pressure were solely personal factors or in some way related to organizational factors.

Conclusions

This study shows that personal circumstances such as inaccuracy, hastiness, time pressure, and/or fatigue play a major role in eye exposures, although personal factors may be related to organizational issues such as poor communication. Eye exposure occurred during all phases of the working process, especially during cleaning activities. Poisoning prevention strategies should therefore focus on technical, organizational, and personal factors. In addition, this study shows that Poisons Control Centers can collect valuable data regarding the identification of risk factors in acute occupational eye exposures. These data can be used to improve risk mitigation strategies at the workplace, which begins with raising awareness of risk factors among employers and employees and implementing this knowledge in education and training programs.

Acknowledgments

All authors whose names appear on the submission made substantial contributions to the conception or design of the work. All authors critically revised the manuscript and approved the final version. The authors would like to thank Agnes van Velzen for her assistance in editing the manuscript.

Disclosure statement

There were no disclosures or potential conflicts of interest for any of the contributing authors.

Ethics approval and consent

Informed consent was obtained by telephone (and voice recorded) after information was provided on the content, duration, and confidentiality of the interview and the anonymous processing of the data.

The accredited Medical Research Ethics Committee (MREC) of the University Medical Center Utrecht determined that the Dutch Medical Research Involving Human Subjects Act did not apply to this study.

Funding

All authors declare no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work; no other relationships or activities that could appear to have influenced the submitted work. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Research data are not shared.

References

Arbeidsomstandighedenwet. 2022. https://wetten.overheid.nl/BWBR00103.

Assad S, Legeay M, Meyer G, Descatha A, Goyer P, Le Roux G. 2020. EXP3OP study: occupational eye exposures reported to a western France poison center. Clin Toxicol. 58(6):585.

Downs JW, Wills BK, Cumpston KL, Rutherfoord Rose S. 2021. Descriptive epidemiology of clinically significant occupational poisonings, United States, 2008-2018. Clin Toxicol. 59(12):1259–1263. doi:10.1080/15563650.2021.1892717.

European Occupational Safety and Health Association (EU-OSHA). 2023. European Agency for Safety and Health at Work. https://oshwiki.osha.europa.eu/en/themes/hierarchy-prevention-and-control-measures.

Gobba F, Dall'Olio E, Modenese A, De Maria M, Campi L, Cavallini GM. 2017. Work-related eye injuries: A relevant health problem. Main epidemiological data from a highly-industrialized area of Northern Italy. IJERPH. 14(6):604. doi:10.3390/ijerph14060604.

Hong J, Qiu T, Wei A, Sun X, Xu J. 2010. Clinical characteristics in visual outcome of severe ocular chemical injuries in Shanghai. Ophthalmology. 117(12):2268–2272. doi:10.1016/j.ophtha.2010.03.050.

Kruiskamp P. 2021. Statistics Netherlands. SBI 2008 - Standard Business Classification 2008. Version 2021; [accessed 2023]. https://www.cbs.nl/nl-nl/onze-diensten/methoden/classificaties/activiteiten/sbi-2008-standaard-bedrijfsindeling-2008?msclkid=53499c78b1af11eca97617c87f393a66.

Le Roux G, Buisset A, Leruez S, Puskarczyk E, Gohier P, Descatha A. 2020. Agents involved and severity of acute ocular exposure reported at a Poison Control Center. Ophthalmic Epidemiol. 27(6):468–476. doi:10.1080/09286586.2020.1773871

Martin-Prieto S, Álvarez-Peregrina C, Thuissard-Vasallo I, Catalina-Romero C, Calvo-Bonacho E, Villa-Collar C, Sánchez-Tena MA. 2020. Description of the epidemiological characteristics of work-related eye injuries in Spain: a retrospective study. BMJ Open. 10(10):e035696. doi:10.1136/bmjopen-2019-035696.

Meulenbelt J, de Vries I. 1997. Acute work-related poisoning by pesticides in the Netherlands; a one year follow-up study. Medical Review (Przeglad Lekarski). 54(10):665–670.

Nugteren-van Lonkhuyzen JJ, Kan AA, Mulder-Spijkerboer HN, van Velzen AG, Visser CC, de Lange DW, van Riel AJHP, de Vries I. 2019. Dutch Poisons Information Centre. Annual report 2019: acute human and animal poisonings. https://nvic.umcutrecht.nl/nl/jaaroverzichten.

Quesada JM-A, Lloves JM, Delgado DV. 2020. Ocular chemical burns in the workplace: epidemiological characteristics. Burns. 46(5):1212–1218. doi:10.1016/j.burns.2019.11.007.

Schenk L, Feychting K, Annas A, Oberg M. 2018. Records from the Swedish poisons information centre as a means for surveillance of occupational accidents and incidents with chemicals. Saf. Sci. 104:269–275. doi:10.1016/j.ssci.2017.10.021

Schenk L, Feychting K, Annas A, Oberg M. 2020. Calls made to the Poisons Information Centre reveal need for improved risk management of cleaning agents in the workplace. Int J Occup Saf Ergon. 26(1):140–148.

Schenk L, Oberg M. 2018. Comparing data from the Poisons Information Centre with employers' accident reports reveal under-recognized hazards at the workplace. Ann Work Expo Health. 62(5):517–529. doi:10.1093/annweh/wxy009

United States Occupational Safety and Health Administration (US-OSHA). 2022. United states department of labor. https://www.osha.gov/chemical-hazards.

Wijnands APG, de Vries I, Verbruggen T, Carlier MP, de Lange DW, Rietjens SJ. 2022. Acute occupational exposures reported to the Dutch Poisons Information Center: a prospective study on the root causes of incidents at the workplace. J Occup Med Toxicol. 17(1):19. doi:10.1186/s12995-022-00360-4.

Wijnands-Kleukers APG, Rietjens SJ, Verkooijen RBT, de Lange DW, de Vries I. 2022. Verontrustende toename van arbeidsongevallen met gevaarlijke stoffen. NVIC ziet verdubbeling van aantallen. TBV - Tijdschr Bedrijfs- en Verzekeringsgeneeskd. 30(1-2):54–60. doi:10.1007/s12498-021-1464-5

Woolf A, Alpert HR, Garg A, Lesko S. 2001. Adolescent occupational exposures. Arch Pediatr Adolesc Med. 155(6):704–710. doi:10.1001/archpedi.155.6.704