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COMMENTARY



# Preventing occupational chemical eye injuries: important lessons from poison information centres

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**ABSTRACT**

**Background:** Occupational exposure to hazardous substances is a major public health problem. In the workplace, eye exposures are common and can be a major cause of morbidity and disability. This commentary discusses the role of poison information centres in providing valuable information on the circumstances and causes of these incidents.

**Occupational health surveillance:** As many eye exposures are easily preventable, there is a need to establish better safety practices in the workplace. Currently, both governments and labour organizations primarily employ injury statistics for the purpose of occupational health surveillance. Identifying risk factors associated with acute exposures in the workplace requires a comprehensive approach using a variety of information resources. Using information from poison information centres can provide invaluable insight into the specifics of the exposure, including the route(s) of exposure, the substances involved and the cause of the exposure.

**Circumstances of occupational eye exposures:** Exposure to hazardous substances can occur at various time points during work. A prospective study performed by the Dutch Poisons Information Centre showed that cleaning is a high-risk activity for occupational eye exposure. Patients were often exposed to chemical mixtures that frequently contained alkalis or acids.

**Chemical eye injuries:** Symptoms following eye contact with chemicals can vary greatly depending on factors such as the type and concentration of the substance(s) involved, the duration of exposure and the time and duration of irrigation (first-aid measure). Eye contact will usually cause irritation, but in more severe cases, chemical burns will result. Recent studies demonstrate that occupational eye exposures often result in only relatively mild symptoms, such as pain, redness, lacrimation or temporary loss of vision. More severe symptoms, such as corneal abrasion, were reported rarely, which may be explained by prompt eye irrigation.

**Root causes of occupational eye exposures:** To control risks to workers, a hierarchy of prevention and control measures has been established, which employers must take. If elimination or substitution of the dangerous substance is not possible, the exposure can be prevented or reduced by taking organizational (e.g., providing work instructions), technical (e.g., ventilation) and personal (e.g., wearing personal protective equipment) measures. The study performed by the Dutch Poisons Information Centre showed that organizational factors (such as lack of work instructions) and personal factors (such as time pressure and fatigue, and not (adequately) using personal protective equipment), were the main causes of occupational eye exposure.

**Conclusions:** Poison information centres provide valuable information that can be used to develop prevention strategies to reduce the number of acute occupational exposures in the future. A multidisciplinary approach is essential to ensure that these preventive measures are actually applied in practice. Therefore, all organizations involved (including governments, labour organizations, medical professionals, occupational physicians, occupational hygienists, safety experts and poison information centres) must work closely together.

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## Background

Occupational exposure to hazardous substances is a major public health problem. The World Health Organization and the International Labour Organization report that worldwide more than 650,000 deaths are caused each year by hazardous substances in the workplace [1,2]. In addition to these fatalities, there are many less serious incidents. In the United States (US), the National Safety Council reported that in 2020, occupational exposure to hazardous substances caused approximately 424,000 non-fatal injuries and illnesses

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with days away from work, resulting in significant health and socio-economic costs [3]. These data show that incidents involving hazardous substances in the workplace are common and that the number of work-related injuries and deaths is alarmingly high. It is necessary to establish better safety practices in the workplace to reduce the number of incidents.

## Occupational health surveillance

Statistics related to occupational incidents play a crucial role in laying the groundwork for effective risk management strategies. These statistics are drawn from a diverse array of data sources, encompassing insurance records, labour inspection reports and emergency department data [2]. Both governments and labour organizations primarily employ injury statistics for the purpose of public health surveillance. In numerous countries, a legal obligation exists to report workplace incidents resulting in fatalities, hospitalizations, or permanent injuries [4–6]. Consequently, this results in robust monitoring of severe work-related exposures due to hazardous substances. However, a notable limitation of this health surveillance approach lies in the potential oversight of minor injuries that require only first-aid treatment, which frequently are not reported. This leads to an underestimation of the actual number of occupational exposures. Therefore, it is imperative to investigate both major and minor incidents. Minor incidents, often perceived as insignificant, can indeed serve as precursors to major events, and insights obtained from the context of minor incidents can be invaluable for learning purposes.

To better understand the extent of this health problem and to pinpoint the risk factors connected to acute workplace exposures, a comprehensive approach involves using various information resources and examining not only injury statistics but also exposure data. Given that numerous poison information centres routinely gather such data, using the information from these centres can provide invaluable insights into demographic aspects (such as the age and gender of the victims), specifics of the exposure (including the route(s) of exposure and substances involved) and the clinical effects.

## Circumstances of occupational eye exposures

At the workplace, victims can be exposed via multiple routes, such as inhalation, eye exposure, skin contact, high-pressure injection and ingestion. Eye exposures are common and can be a major cause of morbidity and disability. In a cross-sectional study from 2011 to 2018 on occupational illnesses and fatal injuries in the US, Hom et al. [7] described 197,160 ocular occupational injuries (including injuries of the eye, eyelids, eyelashes, lacrimal glands and optic nerve). Contact with objects was the main reason for injury in 127,530 (65%) patients, followed by exposure to harmful substances in 50,970 (26%) patients [8]. The Swedish Poisons Information Centre showed that eye exposure was the most common route of exposure at work (37% of 3,049 victims between 2010–2014) [9]. The number of occupational eye exposures reported to the Dutch Poisons Information Centre almost tripled from 77 in 2015 to 224 in 2019. Ocular exposure was the second most common route of exposure (in 40% of victims) after inhalation (62% of victims) [10].

Routinely collected poison information centre data provide only limited information on the exact cause(s) of the incident and the clinical course because this is generally not extensively collected in poison information centre databases. To further explore the circumstances, root causes and clinical course of occupational eye exposures in the Netherlands, we recently performed a prospective follow-up study. During a one-year prospective study (1 September 2020 to 31 August 2021), data were collected by a telephone survey with 132 victims of acute occupational eye exposure. The interviewed patients were mainly male (76%), with a median age of 29 years. Most eye exposures occurred in the industry and in the building and installation sector [11,12]. Kyriakaki et al. [13] also showed that construction workers are at high risk of ocular injuries. Other high-risk occupations include farmers, metalworkers and manufacturing workers. Patients were often exposed to chemical mixtures that frequently contained alkalis (24%) or acids (16%) [12]. Assad et al. [14] also showed that acids and alkalis were often involved in occupational eye exposures.

Exposure to hazardous substances can occur at various time points during work, such as during transport, preparatory activities, actual production, use, repair, maintenance and cleaning. We showed that cleaning is a risky activity for eye exposure, as 34% of the patients in this study were exposed during cleaning activities [12]. The Swedish Poisons Information Centre also found that a substantial number (24%) of occupational incidents involved cleaning products or disinfectants [15].

## Chemical eye injuries

Symptoms following eye contact with chemicals can vary greatly depending on factors such as the type and concentration of the substance(s) involved, the duration of exposure and the time and duration of irrigation (first-aid measure). Eye contact will usually cause irritation, but in more severe cases, chemical burns will result in damage to the structures of the eye; acids and alkalis commonly cause chemical burns to the eyes. Symptoms include pain, redness, loss of vision, tearing, swelling and tissue damage or ulceration. Ocular exposure to acids generally causes milder injury than exposure to alkalis. Alkalis can cause saponification of the fatty acids in the cell membrane, which can lead to disruption of the epithelial cell layer, allowing the substance to penetrate further into the tissue [16].

In our prospective study, most victims developed no (8%) or only mild eye symptoms, such as pain (56%), redness (34%), temporary loss of vision (29%) or lacrimation (6%). More severe symptoms, such as corneal abrasion, were reported in only four cases. The high percentage of patients with no or mild symptoms, and the overall lack of severe symptoms, may be explained by prompt irrigation [12].

These findings are consistent with studies performed by Assad et al. [14] and Le Roux et al. [17] that showed occupational eye exposure to potentially hazardous substances often results in relatively mild symptoms. This underlines the point made earlier that the use of injury statistics alone will lead to an underestimation of the actual number of occupational exposures to the eyes.

## Root causes of occupational eye exposures

Controlling exposures to hazards in the workplace is vital to protecting workers. The "hierarchy of controls" is a way of determining which actions will best control exposures. The hierarchy of controls has five levels of actions to reduce or remove hazards (elimination, substitution, engineering controls, administrative controls and personal protective equipment (PPE)). Total elimination of the use of the dangerous substance is, obviously, 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 [4]. The application of these control measures can lower worker exposure and reduce the risk of illness or injury [18]. In order to control the risks of workers to dangerous substances, the hierarchy of measures has been embedded in the worker protection legislation of many countries, including the Netherlands [4–6].

The hierarchy of prevention and control measures [4,5,18] was used as the basis for classifying the root causes of work-related eye exposures in our prospective study [11,12]. This study showed that lack of work instructions (51,5%) is an important organizational factor that increases the risk of eye exposure to hazardous substances [12]. Workers who are unaware of the potential hazards of chemicals in their work environment are more vulnerable to exposure and subsequent injury [4,5]. In our study, damaged packaging (24%) and, to a lesser extent, defective apparatus (7%) were the most important technical factors [12]. The Swedish Poisons Information Centre also showed that occupational eye exposures are often caused by equipment failure [15]. This illustrates that proper maintenance of machinery is important. Instructing employees to handle packaging carefully and paying more attention to the design of packages can probably lead to a further reduction in the number of occupational incidents [19].

Personal circumstances, such as inaccuracy, hastiness, time pressure and/or fatigue, play a significant role in occupational eye exposures. Half of all patients in our study mentioned one or more personal circumstances as possible causative factors for the incident [12]. Another important personal factor is the use of PPE. In our study, 16% of patients did not use the obligatory face or eye protection or assumed that wearing regular glasses would offer appropriate protection [12]. Nowrouzi-Kia et al. [20] performed a systematic review and concluded that "most ocular injuries could be prevented by using suitable protective eye devices and strict employee compliance with the safety rules". However, appropriate protection is a more complex process than it appears at first glance. Failure to use safety glasses can be due to either the unavailability of the correct PPE or the worker's incorrect decision not to wear it [13]. There are a variety of reasons for not using PPE, such as discomfort when using (e.g., because of weather conditions), cultural determinants, ignorance, lack of training and lower educational level (e.g., difficulties to read or understand PPE regulations in the workplace) [13].

Discerning causal factors can often be challenging due to the intricate web of interconnections that frequently exist. There often is an interplay between personal and organizational elements. The behaviour of workers may be influenced when there is understaffing, and they have to work under strict time limits. Trying to ensure an appropriate workload is key, as previous studies also showed that pressure increases the risk of incidents [5,15]. Another example of interrelated factors is the relation between the responsibility of the employer with regard to providing work instructions and appropriate PPE (organizational factors) towards employee compliance to following the safety rules (personal factors). Simply providing work instructions and PPE is not enough. It is important that during employee training, attention is paid to both the need to follow work instructions and the correct use of PPE when required [12].

## Future perspectives

Our study showed that poison information centres can provide valuable information on circumstances, root causes and health effects of acute occupational exposures to hazardous substances [11,12]. In order to get a more complete picture of the circumstances and root causes of the incident, future studies should preferably also include interviews with company representatives, as patients often give a one-sided view of the incident and may be inclined to falsely attribute the aetiology of the incident to certain factors. Further improvement can be achieved by also interviewing medical professionals. Using data from medical professionals has the advantage of collecting objective information with respect to the clinical course and treatment of patients.

## Conclusions

Poison information centres are crucial to achieving progress in chemical safety-related strategies [1], as they can provide valuable information that can be used to develop poisoning prevention strategies to reduce the number of acute occupational exposures in the future. In order to formulate the most effective preventive measures and to ensure that these preventive measures are actually applied in practice, a multidisciplinary approach is essential, and all organizations involved (such as governments, labour organizations, insurance companies, medical professionals, company doctors, occupational hygienists, safety experts, poison information centres) have to collaborate closely.

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