

TITLE PAGE

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Ocular chemical burns in the workplace: epidemiological characteristics of a Spanish cohort.

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Abbreviations

IR: Infra-Red.

PPE: Personal Protective Equipment.

UNE: *Una Norma Española*.

UV: Ultraviolet.

Introduction

The sight organ processes a great deal of the information that a person exchanges with the external environment and, as such, it directly influences quality of life. The partial or total loss of its functioning can give rise to dramatic situations, as much for the person involved as for their family. Among the causes of ocular trauma, those resulting from workplace incidents are the most common, followed by those occurring in the home and those incurred while involved in leisure pursuits (1)(2)(3)(4)(5)

Occupational Safety and Health is an essential and irrevocable aspect of today's society, particularly given that people can access more information than ever, through more and better technological means, and the existence of greater measures of protection and specific prevention programmes. Despite this, every day there are still ophthalmic incidents in the workplace, with 90% of trauma injuries to the eyes estimated to be preventable (6). The prevention of occupational ocular trauma includes measures such as Personal Protective Equipment (PPE), although its use is not the only solution, and indeed it be considered as a final step to be undertaken and only to control those risks which it has not been possible to eliminate through the implementation of the appropriate technical and organisational means (7).

Chemical and thermal burns account for approximately 15% of eye events (8) and underwent urgent emergency medical attention since if they are not treated early and appropriately the tissues and functioning of the eye may be seriously compromised (9). The noxious effect of caustication depends on the nature and type of substance involved, as well as the length of time the substance was in contact with the eye. Ischemia of the limbus is a clinical indicator of extent and severity of the damage,

perilimbic ischemia being detectable as the interruption of blood flow in the conjunctival and episcleral blood vessels (8). The use or handling of chemical products in the workplace must comply with national and international guidelines based on business-level programmes for the appropriate management of these products in the workplace (7).

Epidemiological research into who suffers these injuries, and how, where and why they occur and how they are treated can provide valuable data for future actions aimed at prevention and assistance in the case of an incident.

The objectives of this work were to collect epidemiological data on chemical burns to the eyes in the workplace and identify the key points for acting effectively. The economic costs that this type of incident incurs, both in terms of health care provision and with respect to sickness benefits, were also evaluated.

Material and Methods

Study design

A cohort study representing the Spanish population affected of ocular chemical burns during 2014 and 2015.

Patients

4762 occupational eye injuries were recorded during 2014 and 2015, needing a sickness certificate to be issued and 604 cases were diagnosed as chemical burns. These cases met the following criteria: diagnosis of chemical burn; worker seen in medical centre; workplace acquired ocular pathology leading to the issuing of a sickness certificate. No exclusion criteria were implemented.

The study was approved by the Research Committee mutual society which collaborates with the Spanish Social Security system as a service provider, with the appropriate data protection legislation and agreed with the Declaration of Helsinki for Human Research of 1974 (last modified in 2000).

Methodology

The epidemiological data was extracted from ophthalmology consultation with the authorization of mutual society based on the detailed selection of diagnoses of

ophthalmic damage resulting from chemical burn which provided the individual being issued a 'not-fit-to-work' sickness certification, and the incident also being registered as an industrial event or occupational illness.

The following variables were recorded: age, gender, job title, month in which event occurred, duration of sickness certification, diagnosis, long-term health consequences and economic cost (both health care and sickness benefit payment). The health care costs were based on the fees established by the Association of Workplace Incidents Mutual Insurance Companies for health services in the sector for initial medical consultation, follow-up consultation and nursing care in both 2014 and 2015. Observation of these chemical burns was carried out by the nursing service, by means of a patient survey or meeting with the responsible doctor to collect the relevant information for the analysis of these injuries.

Theory/Calculation

Statistical analyses were made using the SPSS 20.0[®] software for Windows (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). A descriptive study was carried out which defined quantitative variables (age, gender, month and day of week event occurred, duration of sickness certification, costs) using mean and standard deviation, while qualitative variables (gender, job, diagnosis, long-term consequence of incident) were described in terms of frequency and percentages.

Statistical inference in relation to the comparison of qualitative data was made using Chi-square tests and contingency tables, while Student's t-tests were applied for quantitative data, both sets of data showing a normal distribution in terms of a Kolmogorov-Smirnov test.

Statistical significance was demonstrated when $p < 0.05$.

Results

Over the course of the study a total of 4762 occupational eye injuries were recorded which given a sickness certificate to be issued. Of these, 604 cases (12.68%) were diagnosed as chemical burns (Figure 1).

This classification was the second most frequent behind injuries caused by foreign objects (43.42%) (Table 1). Men accounted for 68.54% of the cases of chemical burns (414) and women for 31.45% (190). Distribution data by gender is shown in Table 2 and by age in Table 3.

In terms of distribution by professional sector, the service sector accounted for the highest proportion of cases (62.1%) (Table 4).

Tables 5, 6 and 7 shows the data related to when the event occurred: time of day, day of the week and month of the year, respectively. In around 75% of cases, the sickness certificate issued, corresponding to time off work, was for less than 7 days (Table 8), and in 96% of cases the individual received medical treatment (eyedrops or other medication) (Table 9).

Six of the patients suffered permanent partial disability (3 from the construction sector, 2 from the industrial sector and 1 from the service sector/kitchen staff) and another 2 patients suffered total permanent disability (1 from the service sector and 1 from construction).

For both years an initial emergency consultation was costed at 49.53€, follow up consultations at 17.25€ and nursing appointments at 11.43€. These costs also included consultations with the mutual society's ophthalmologist, medical transport and medication and treatment costs. The economic cost of sickness benefits, health care costs and total cost across the study period are shown in Table 10.

Discussion

Chemical burns to the skin and eyes occur with similar frequency, and the workplace is the environment which presents the greatest risk of such injuries (10).

The data of this study proves, like other recent works, the need to reinforce the efforts to teach workers the use of PPE, given that it's use can be improved. In this way the adequate selection of use of PPE can develop into an important public health initiative that should be applied with greater frequency (1).

Employees such as solderers, with a high risk of injury to eyes, skin and hearing, usually work without formal prevention training, and they are not aware of the existing safety protocols (11). In this work, solderers have been included in the industrial sector,

without precise data, but it is demonstrated that they are at high occupational risk of eye injury. This is similar to the findings of Alexander et al (11). They can be considered a target group for enforcing the future use of PPE.

It is important to know the economic effect to the worker involved who suffered these injuries, including loss of productivity, absence from work, health care costs, administrative costs and long-term health consequences. There are several studies of eye injuries across the world (1)(2)(3)(4)(11), but the current work is ground-breaking in that it collects together epidemiological data from the workplace and the economic costs generated by industrial eye events, data which warrants in-depth study due to the consequences that may result from this type of ophthalmic damage.

Approximately 55% of workplace incidences with chemical products impact on the eye, and 53% of them include cleaners, workers and technicians (12). Alkalis can cause irreversible damage to the eye, in between 5-15 minutes, (Figure 2) and many are considered the most common cause of ocular chemical burns (13)(14)(15). This aspect can be seen in this study, even though it doesn't appear in the clinical history, details of the harmful etiological agent. Because of this it is necessary to improve the rigour of completing of all clinical documents by the healthcare professionals.

We showed in this work an elevated incidence of events involving chemical burns to the eyes in women compared to the rate for eye injuries in general (31.5% and 12.4% respectively).

The service sector accounts for the largest proportion of chemical eye injuries and it also employs most women in cleaning and kitchen jobs. In these work areas, splashing and spraying of the liquids used in the pursuance of these jobs are very common (16). In Europe cleaning personnel are predominantly female (around 77%) and many have very little training, and the sector also employs high numbers of immigrant workers. The reasons for the high representation of women in this sector include "tradition" and the frequently part-time nature of contracts which enable women to balance work and home responsibilities/childcare. In contrast, only 24% of management positions in this sector are filled by women (17). The necessity to provide high quality early assistance indicates the importance of strengthening the use of protocols and clinical guides which assist the management of these situations by the healthcare professionals (18)(19)(20)(21). This will create clear criteria to assign a patient to an ophthalmologist,

especially in rural areas or developing countries (22)(23). This could help to reduce the costs and the levels of absenteeism, thus improving productivity and profitability of the business (24).

Give the international protocols considered key to the immediate washing of the ocular cavity and the eyelid conjunctiva, areas that can harbour traces of chemical agents or other aggressive materials such as cement or lime (25)(26). Workers must be informed about first aid necessary at the moment of the accident. Washing the eye must not be delayed until the injury is examined by a professional (27).

It is reasonable to demand equipment specifically for eye-washing in workplaces where there is potential risk, and this preferably include solutions which help to re-establish physiological pH (28), although there are no specific irrigation products for immediate use (isotonic, ringer lactate or ph neutralizers), water can and may be used as the first alternative (29). However, more studies are needed to recommend a reference irrigation fluid, something that can be considered an unresolved problem nowadays and that future studies can provide clear evidence in this regard.

The incidence of events is highest in the 31-50 age group, a life stage which coincides, for women, with the management and care of children together with other domestic responsibilities. Despite substantial improvement in terms of equality, this type of responsibility continues to fall mostly on women, which may sometimes result in lapses in concentration and errors in the management of dangerous products (30). To the future, labour and family conciliation policies may be powered that please more secure behaviours in the work.

Looking at the data relating to age, the most affected age group is neither the youngest, even though they might be considered less expert, nor the oldest group, those over 51 years who might be thought to have more physical limitations, but rather the 31-50 age group (63.40%). This underlines the need for continuous training and information with respect to risk prevention for the 31 to 50 age group rather than concentrating on those just entering the profession.

The time of day when the incidence of events is highest suggests that improvement plans consider more flexibility in staffing levels in order to respond to the demands of the job, i.e. increasing the workforce at peak times, while reducing it at others, to meet

the true requirements of the work and thus avoid overstretching the workforce, and creating situations where staff are pressurised to work faster and with, potentially, less care for their safety.

Several works have identified the peak time of events as being the morning, between 08.00 a.m. to 16.00 p.m. [45], 09.00 a.m. to 13.00 p.m. [30], 08.00 a.m. to 12.00 p.m. (31) and throughout the morning [48], data similar to those presented in this work, showing in the time slot of 9.00 a.m. to 13:00 p.m., 295 events (48.84%). One work analyses the influence of sleep cycles and sleep quality on the concentration of workers and the “lunch effect”, sometimes including consumption of alcohol, which can explain the spike in events between 15.00 p.m. to 17.00 p.m., including more serious incidents (32). Information campaigns towards target professional groups, around the influence that alcohol intake or substance use can have on concentrate ability and the increased risk in accidents, can be positive for prevention, as well as the possible taking of sanctions against the detection of behaviours not recommended in this regard.

Around 62% of chemical events occurred from Monday to Friday, June and July were the months with the highest incidence of events, when lifeguards and swimming pool and health spa staff are affected by splashing when handling water chlorination products (33)(34). In the service sector, extra staff contracted during the high season characteristically have temporary contracts (35)(36). In the future, employment of staff at risk of chemical burns, should be trained in all first aid procedures and made aware of the relevant risk prevention protocols.

In around 75% of cases in this study, the sickness certificate issued was for 7 days or less, and 25% of cases where treatment extends beyond a week, indicating that the eye incidents were not severe and processes that have lasted less than a week have been non-serious injuries and what should be worked on for the future is to alleviate potential training gaps in care services to reduce that duration of more than a week, through guides clear criteria for early referral to the specialist.

However, in 6 cases there were partial permanent effects of the incident, and in a further 2 cases, the consequences were total permanent disability, which, in both situations, impacting dramatically on the patient and their families. All 8 of these cases were male, and 50% worked in the construction industry, 25% in the service sector and 25% in the industrial sector.

The average total costs by process/year, which can be broken down as costs of benefits, health costs and total cost, demonstrate that there is a statistically significant difference ($p=0.036$) in the costs for 2014 compared to 2015. We wanted to know the origin and direction of this difference in order to understand why it happened. There was no difference in the number of days for which sickness certification was issued. Furthermore, in the service sector data there was no difference in costs of sickness benefits between the two years, hence this cannot account for the difference in average total cost between years. In contrast, though, comparing the benefits paid out in terms of the consequences of the injury (partial or total permanent disability) showed a significant difference between years, which explains the overall difference in benefits costs for the two years. It is important to note that in 2015 the cases where there were long-term effects of the workplace incident all related to men who worked in the construction industry, indicating that this sector poses a high risk of workplace chemical burns to the eye, and that both prevention measures and training in the same are imperative in the sector.

This work has some limitations; it is a cohort study compiled from 2014 and 2015, such that some bias in the data can be assumed due to the exclusion of certain interesting variables. A prospective controlled study will be carried out to confirm and corroborate these results showed, with epidemiological data on persons suffering this type of injury, as well as details of how, where and why the event happened and what treatment was received, as this can provide useful data for future preventative and treatment actions.

Conclusions

The service sector had the highest frequency of chemical burns to the eye, and cleaning and kitchen staff, where women are highly represented, were those most affected. The most serious events, however, related to men working in the construction sector.

The idea that workers take responsibility for their own protection needs to be strengthened, and employers need to comply with their obligations to provide preventative materials and detect situations of risk in order to correct them. Despite efforts and initiatives put in place over the last decades, direct interventions using PPE should be considered part of occupational health programs. Efforts also be directed towards the study of the consequences of the growing use and handling of nanomaterials.

The appropriate and early management of the care to the patient involved in such workplace incidents is essential. The drawing up and distribution of clinical guidelines could optimise and standardise the care such patients receive, thereby compensating for deficiencies in the training of emergency health care professionals.

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Authorship

Jesús Moreno-Arrones Quesada made a substantial contribution to the concept, design and acquisition of data, revising critically for intellectual content, approved the version to be published.

David Varillas Delgado made a substantial contribution to analysis and interpretation of data and revised the article critically for important intellectual content.

Jesús Merayo Lloves revised the article critically for important intellectual content, approved the version to be published.

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