

## Effectiveness of PPE For Prevention of Occupational Ocular Injury

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### Abstract

**Background:** The eyes are still among the organs most frequently injured in occupational accidents. It is estimated that 1.6 million people are blinded as a result of eye injuries worldwide. In general, ocular injuries at work can be preventable and attributable to non-use of protective eyewear. The purpose of this evidence-based case report was to determine the effectiveness of PPE for the prevention of occupational ocular injury.

**Method:** The literature search was conducted through PubMed, Cochrane, Science Direct, and Wiley Online. The inclusion criteria of this searching strategy were full text, humans, and published within 10 years. The exclusion criteria of this searching were children, inaccessible full text article, and non-occupational focus study. The articles were critically appraised using relevant criteria by the Oxford Center for Evidence-based Medicine.

**Result:** Two relevant and valid articles were included. A case-control study by Zakrzewski H et.al stated that eye PPE was not worn by 66.9% of the cohort, with 33.1% of the cohort sustaining an occupational eye injury despite the use of eye PPE. Its use does not preclude a significant proportion of such workers from injury. A cross-sectional study by Lombardi DA et.al (2009) stated that lack of comfort/fit, and fogging and scratching of the eyewear were suggested as the most important barriers to PPE usage. Younger age and lack of safety training were other important factors affecting use of PPE

**Conclusion:** The effectiveness of PPE usage to prevent ocular injury is still inconclusive. The advocating for both the use and appropriate selection of eye PPE in the workplace is still an important thing that should be continuously encouraged.

**Keyword:** occupational injury, ocular injury, eye injury, PPE, prevention

## Introduction

With the advancement of the technology, many fabrics are built and workers are recruited. Although the health and safety awareness are nowadays increasing in workers, the accident and work-related illness are still occurred. The eyes are among the organs most frequently injured in occupational accidents.<sup>1</sup> Around 65,000 work-related eye injuries and illnesses are occurred in United States every year and cause job absenteeism. The high risk worker group for eye are fabricators, laborers, equipment operators, repair workers, production, and precision workers. More than one half of work-related eye injuries occur in the manufacturing, service, and construction industries.<sup>2</sup> Ocular trauma remains a significant global cause of visual morbidity. It is estimated that 1.6 million people are blinded as a result of eye injuries worldwide. Moreover, population-based data suggest that up to one-third of monocular blindness may result from eye injuries, representing an additional 19 million people negatively affected by ocular trauma. Although these figures may vary depending on regional differences, ocular trauma as a cause of visual morbidity is undoubtedly a notable area of concern.<sup>3</sup>

Among the eye injuries and illness, the chemical injury is one of the most common cause. Chemical injuries to the eye represent between 11.5%-22.1% of ocular traumas. About two thirds of these injuries occur in young men. The vast majority injuries occur in the workplace as a result of industrial accidents.<sup>4</sup> In a retrospective study of 148 cases of occupational eye injuries in Germany, ocular burns (not specified as chemical or other etiology) comprised 15.5% of the total.<sup>5</sup> In another German study of 101 patients with 131 severely burned eyes, 72.3% of the injuries were work-related, 84.2% were chemical injuries, and 79.8% of these were due to alkalis.<sup>6</sup> Of 42 cases of alkali ocular burns admitted to a German eye clinic between 1985 and 1992, 73.8% involved industrial accidents.<sup>7</sup> In another study conducted in Finland in 1973, the ocular injuries contributed around 11.9% of all industrial accidents and burn contributed around 3.6%.<sup>8</sup> A 7-year retrospective Australian study of 182 industrial burns found that 5.5% were ocular burns due to chemicals, gas explosions, and electric flashes.<sup>9</sup> One study in Taiwan stated that the number of eye injury is 486 patient within 4 years, 39.9% were workrelated and the chemical ocular burns accounted for 19.6%

of these injuries.<sup>10</sup> If we discussed about the place, a significant proportion of eye injuries occurs in the workplace. The majority of these injuries are minor and are able to be managed by A&E staff. But the injuries can result in time off work, and if severe, longstanding visual sequelae.<sup>11</sup>

In general, ocular injuries at work can be preventable and attributable to non-use of protective eyewear. Safety education is one of the important aspect. One study in Scotland revealed that almost half of workers do not comply with health and safety regulations.<sup>12</sup> Another study in Australia also found the same thing. Only 16% of injured workers had used safety eyewear at time of injury, with correct eye protection defined as safety goggles, hood, helmet and face shield.<sup>13</sup> Based on the above preliminary data, it is necessary to enroll a systematically searching in order to get an answer about risk factors of the ocular injury and the prevention measure.

## Case

A 45 years old male came with a chief complaint of ocular discomfort and burning sensation in his right eye. He worked as a contract laboratory staff for one of oil and gas company and just started a test using sulfuric acid solution. When he tooked the sulfuric acid bottle, the bottle slipped and broke at the table. He got some splash of the sulfuric acid solution at his right eye and his face. Suddenly he felt discomfort, foreign body sensation, burning sensation, blurred vision, and excess tearing in the right eye. He immediately went to eyeshower to do eye irrigation for about 5 minutes. Then he went to company clinic to be examined by doctor. The doctor continued the eye irrigation for about 30 minutes with normal saline. Vital signs are within normal limit. AVOD 3/60 AVOS 20/20. The right upper lid was slightly edema and they found conjungtival injection. Since there was no lacmus paper and fluorescein test, the patient was referred to eye specialist in Samarinda for further eye examination and treatment. In Samarinda, patient was examined by an ophthalmologist and it was confirmed that there was corneal abrasion due to acid solution. Patient was given antibiotic eye oinment. After one week follow up, he can be returned to work. He reported wearing only his prescription glasses at the time of the accident and he had got a safety induction training.

Based on above PICO, the clinical question for this paper is “Is PPE and safety training effective in prevention of the ocular injury in workplace?”, as seen in Table 1.

**Table 1.** Clinical Question

Based on above illustration case, the proposed PICO is as following:

P	Worker with occupational eye injury
I	PPE and Safety Training
C	Placebo
O	Decreasing ocular injury

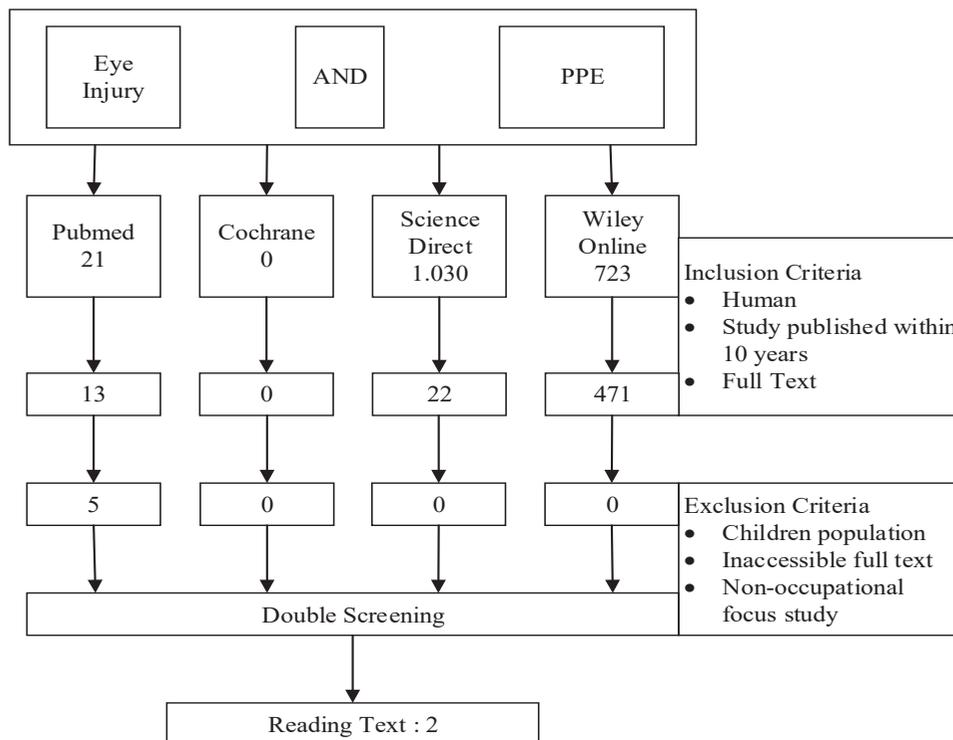
### Literature Search

The literature search was performed to answer the clinical question on the 4 major medical databases

such as PubMed, Cochrane, Science Direct, and Wiley Online. The used keywords were ‘eye injury’, and ‘PPE’ as seen in Table 2. The inclusion criteria of this searching strategy were full text, humans, and published within 10 years. The exclusion criteria of this searching were children, inaccessible full text article, and non-occupational focus study (Figure 1). The literature searching was done on January 11, 2019 at 07.30.

**Table 2.** Literature search strategy

Database	Search strategy	Hit	Selection
PubMed	((eye injury) AND PPE)	21	5
Cochrane	((eye injury) AND PPE)	0	0
Science Direct	((eye injury) AND PPE)	1,030	0
Wiley Online	((eye injury) AND PPE)	723	0



**Figure 1.** Literature searching chart

**Critical appraisal**

The selected article was critically appraised using relevant criteria by the Oxford Center for Evidence-based Medicine.<sup>14</sup>

**Result**

Based on the above literature searching, there were only two articles fit and fulfill the inclusion and exclusion criteria. The articles were a case-control study

by Zakrzweski H et.al<sup>15</sup> and a cross-sectional study by Lombardi DA et.al.<sup>3</sup> After conducting a critical appraisal, it was revealed that the articles are valid. The critical appraisal result can be seen in the Table 3 and Table 4.

A case-control study by Zakrzweski H et.al was conducted in Canada involving 169 patients. The aim of this study was to document the use of eye PPE by patients who had sustained an eye injury in the workplace and to evaluate the characteristics and outcomes of these patients.

**Table 3.** The critical appraisal of a case-control study

No	Appraisal Question	Answer
1	Did the study address a clearly focused question / issue?	Yes. The question in the study was that “Are we doing enough to promote eye safety in the workplace?” The aim of this study was to document the use of eye PPE by patients who had sustained an eye injury in the workplace and to evaluate the characteristics and outcomes of these patients
2	Is the research method (study design) appropriate for answering the research question?	Yes With case control study, we can get answering whether the PPE can be an effective effort to decrease the occupational eye injury
3	Were there enough subjects (employees, teams, divisions, organizations) in the study to establish that the findings did not occur by chance?	Yes
4	Was the selection of cases and controls based on external, objective and validated criteria?	Yes The criteria are as following: All adult patients who had sustained an eye injury in the workplace and presented to the urgent ophthalmology clinic of a tertiary care hospital from October 1, 2013, to November 30, 2014 The control is the patient without PPE worn during the injury. The case is patient with PPE worn during the injury.
5	Were both groups comparable at the start of the study?	Yes

No	Appraisal Question	Answer
6	Were objective and unbiased outcome criteria used?	Yes The outcome parameters are the usage of eye PPE at the time of the injury, disposition, duration of follow-up, and best-corrected visual acuity (BCVA) at the time of last follow-up
7	Is there data-dredging?	No
8	Are objective and validated measurement methods used to measure the outcome? If not, was the outcome assessed by someone who was unaware of the group assignment (i.e. was the assessor blinded)?	Yes The severity of injury is used as per standard ocular trauma score
9	Is the size effect practically relevant?	Yes
10	How precise is the estimate of the effect? Were confidence intervals given?	The study gave the OR and 95%CI
11	Could there be confounding factors that haven't been accounted for?	Yes. The type of eye protection worn at the injury
12	Can the results be applied to your organization?	Yes

The inclusion criteria are all adult patients who had sustained an eye injury in the workplace and presented to the urgent ophthalmology clinic of a tertiary care hospital from October 1, 2013, to November 30, 2014. Medical records were reviewed to obtain occupational eye injury data, including etiology, type, and severity of injury as per the Ocular Trauma Score. Use of eye PPE at the time of injury was recorded. Outcome data, including disposition, duration of follow-up, and return to baseline best-corrected visual acuity, were also recorded. One hundred sixty-nine patients were included in this study.<sup>4</sup>

The median age of the cohort was 31 years (range, 17–68 years), and 92.9% were male. Chemical exposure (31.4%), grinding (17.9%), and injuries sustained by a sharp-object, metal, or nail (13.1%) were overall the most common etiologies of injury. Eye PPE was not worn by 66.9% of the cohort, with 33.1% of the cohort sustaining an occupational eye injury despite the use of eye PPE. The conclusion of this study is the usage of eye PPE among workers who sustain an eye

injury in the workplace remains low. Its use does not preclude a significant proportion of such workers from injury. Increasingly advocating for both the use and appropriate selection of eye PPE in the workplace is an important public health initiative that should therefore be encouraged.<sup>3</sup>

A cross-sectional study by Lombardi DA et.al (2009) is conducted in USA involving 51 participants. The aim of the study is to identify and describe the array of factors that influence workers' decision to wear personal protective eyewear (PPE) and the barriers that exist in preventing their use. A series of focus groups enrolled workers and supervisors primarily from manufacturing, construction, or service/retail industries that had potential exposure to eye injury hazards in their job tasks. Focus group sessions were facilitated to collect qualitative and quantitative data in two categories, "sought information" and "emergent themes", related to the factors influencing use of PPE. The study conducted a series of 7 groups with 51 participants, 36 (71%) males and 15 (29%) females ranging in age from 19 to

**Table 4.** The critical appraisal of a cross-sectional study

No	Appraisal Question	Answer
1	Did the study address a clearly focused question / issue?	Yes. To identify and describe the array of factors that influence a workers' decision to wear PPE and the barriers that exist in preventing their use
2	Is the research method (study design) appropriate for answering the research question?	Yes The study use cross sectional study to describe the factors.
3	Is the method of selection of the subjects (employees, teams, divisions, organizations) clearly described?	Yes The subjects are workers (non-management) employed in manufacturing, construction, service, and retail industries in Massachusetts, USA who reported having potential exposure to eye injury hazards either in their specific job, tasks or workplace who met following criterias: 18–70 years of age. Work in manufacturing, construction, service/retail or related industries. Employed for at least 6 months in the past year. Potential exposure to occupational eye injury hazards. Fluent in English Industries were selected (excluding mining and agriculture) that reportedly have the highest incidence of work-related eye injuries based on the previous study (Lombardi et al., 2005; Islam et al., 2000).
4	Could the way the sample was obtained introduce (selection) bias?	No. Potential participants were recruited using local newspaper advertisements.
5	Was the sample of subjects representative with regard to the population to which the findings will be referred?	Yes
6	Was the sample size based on pre-study considerations of statistical power?	No
7	Was a satisfactory response rate achieved?	Yes
8	Are the measurements (questionnaires) likely to be valid and reliable?	Yes
9	Was the statistical significance assessed?	No

10	Are confidence intervals given for the main results?	No
11	Could there be confounding factors that haven't been accounted for?	No
12	Can the results be applied to your organization?	Yes

64 years old, from a variety of occupations including construction (24%), production (22%), installation, repair and maintenance (14%), and healthcare (10%). Most were highly experienced in their occupation (>10 years); males (86%) and females (53%), and had received some safety training in the past (82%). The majority of workers in this study were required to wear PPE on their worksite (78%), however only 55% had a dedicated safety officer.

A conceptual model that summarizes the “sought information” and “emergent themes” is presented that depicts the decision-making process for the factors influencing use of PPE and consists of three primary branches; perceptions of hazards and risks, “barriers” to PPE usage, and enforcement and reinforcement. Lack of comfort/fit, and fogging and scratching of the eyewear was suggested as the most important barriers to PPE usage. Younger age and lack of safety training were other important factors affecting use of PPE. As the conclusion of this study is that several potentially modifiable factors identified would lead to an increase in workers’ PPE use and encourage supervisors to provide ongoing positive feedback on the continuous use of PPE by workers at risk for an eye injury.<sup>15</sup>

## Discussion

The eyes are still among the organs most frequently injured in occupational accidents.<sup>1</sup> Around 65,000 work-related eye injuries and illnesses are occurred in United States every year and cause job absenteeism. The high risk worker group for eye are fabricators, laborers, equipment operators, repair workers, production, and precision workers. More than one half of work-related eye injuries occur in the manufacturing, service, and construction industries.<sup>2</sup> It is estimated that 1.6 million people are blinded as a result of eye injuries worldwide.

Although these figures may vary depending on regional differences, ocular trauma as a cause of visual morbidity is undoubtedly a notable area of concern.<sup>3</sup>

In general, ocular injuries at work can be preventable and attributable to non-use of protective eyewear. Safety education is one of the important aspect. The study in Scotland revealed that almost half of workers do not comply with health and safety regulations.<sup>12</sup> Another study in Australia also found the same thing. Only 16% of injured workers had used safety eyewear at time of injury, with correct eye protection defined as safety goggles, hood, helmet and face shield.<sup>13</sup>

A case-control study by Zakrzewski H et.al also showed that eye PPE was not worn by 66.9% of the cohort, with 33.1% of the cohort sustaining an occupational eye injury despite the use of eye PPE. The mean age of those not wearing eye PPE (33.4years) was not found to be significantly different from the mean age of those wearing eye PPE (34.1 years,  $p > 0.05$ ). The proportion of those wearing eye PPE who had sustained a previous ocular trauma (55.2%) was found to be significantly greater than the proportion of those wearing eye protection who had not sustained an ocular trauma (22.8%,  $p = 0.009$ ).<sup>3</sup> The history of a previous ocular trama is one of factor driven workers to use eye PPE. A study done by Blackburn also found the same findings. Most respondents (66%) indicated they were more likely to use eye protection since their injuries. Workers not using eye protection at the time of injury were more likely to use eye protection in the future.<sup>16</sup> Most likely workers who had previous eye injury had better compliance to use eye PPE compare to non-injured workers.

This study also revealed that there was no significant association between wearing eye PPE and final BCVA (OR = 0.81, 95% CI 0.42–1.57). Of those patients who returned to baseline BCVA, the proportion of patients who were wearing eye PPE (43.4%) was not

found to be significantly different from the proportion of patients who were not wearing eye PPE (49.1%,  $p > 0.05$ ). Unfortunately, the study did not collect the date regarding the type of eye protection worn. Data regarding rates of appropriate eye PPE usage also was not collected. There is possibility that the worn eye PPE worker group did not use the appropriate PPE so it does not give adequate protection to eye injury. Thus, there is a need to do further research which also included the type of eye protection and rate of appropriate eye PPE.

Another cross-sectional study conducted by Lombardi DA et.al (2009) used focus group approach to collect qualitative and quantitative data in two categories, “sought information” and “emergent themes”, related to the factors influencing use of PPE. If a PPE was not required as a condition of employment and left up to the worker to decide on daily use, the participant expressed that the decision was based on their perception of the hazards and risks involved in a particular job. Task duration was also an important factor. The risk of a task in some cases is perceived as low because the duration of the task is only short period. One worker commented that “The last time I didn’t wear them is just because it was a short task, I just had to grind a piece of metal down really quick and I said, I don’t need glasses, it’s only going to take 10 seconds.”<sup>15</sup> The comment was also stated by the injured person in the illustration case as stated in chapter 2. He did not wear eye protection because the duration of the task was only in short period. Even the work duration is short, if the the job requires PPE, the worker must use PPE to prevent the occupational injury. The need to give awareness should be enforced by company.

Age is also considered as one of the influencing factors. Participants in Lombardi study generally agreed that in their experience, older and more experienced workers, are more likely to wear PPE than younger or less experienced workers. Older workers expressed a belief that younger workers feel invincible or did not have enough work experience to know what can happen to them if they do not wear PPE. Safety culture is also an important aspect in encouraging PPE usage, even if it is optional. Workers indicated that proper training in addition to supervisor and coworker influence were some of the key components in creating a safe work environment culture. Many workers agreed that it is best that new employees receive training and regular refresher

sessions. Coworker influence and peer pressure were also often noted even when PPE was not required. Supervisor support and encouragement in the use of PPE is a supporting factor. Lack of support by management in supporting its own culture of safety was also a source of worker frustration.<sup>15</sup>

The Lombardi study also did quantitative polling results for factors related to the use of PPE. They identified and categorized three main themes that include issues related to protective eyewear, vision-related issues, and other emerging issues. With respect to issues related to protective eyewear, all 7 groups (100%) raised the issue of comfort and/or fit as important factor (average rank of 1.7), 6 out of 7 groups (85.7%) suggested accessibility/ availability were issues (average rank of 3.8), and 4 groups (57.1%) suggested that style/ choice were important factors (average rank of 4.8). Regarding the vision-related issues, all 7 groups (100%) considered fogging to be a significant factor (average rank of 2.9). When given the option to raise other issues; lack of enforcement or low management priority is the main issue besides cheap quality of PPE, rushing around, laziness to put them on, invincibility, and lack of awareness of hazards. The study also discussed the issue of how to increase the use of PPE eyewear. All groups (100%) suggested two issues, comfort/fit and the use of training and videos to encourage use to increase the PPE usage. The use of enforcement or reinforcement can also be considered as the other contributing factor to increase the usage of PPE.<sup>15</sup>

Based on the above evidence, the use of PPE among workers was poor. And the effectiveness of PPE usage to prevent ocular injury is still inconclusive since its use does not statistically preclude a significant proportion of such workers from injury. Although this study cannot prove the significant association, the advocating for both the use and appropriate selection of eye PPE in the workplace is an important thing that should be continuously encouraged. The appropriate selection of PPE should consider the comfort of the PPE and non-fogging lens capability. Enforcement from management for the mandatory use of PPE and the safety training using video can be a factor to increase the use of PPE. Further studies or research focusing PPE effectiveness in prevention of ocular injury is still needed to be done with additional aspect the type of eye protection and rate of appropriate eye PPE.

## Conclusion

The effectiveness of PPE usage to prevent ocular injury is still inconclusive since its use does not statically preclude a significant proportion of such workers from injury. The effort for both the use and appropriate selection of eye PPE in the workplace is an important thing that should be continuously encouraged. The appropriate selection of PPE should consider the comfort of the PPE and non-fogging lens capability Enforcement from management for the mandatory use of PPE and the safety training using video can be a factor to increase the use of PPE

## Recommendation

The advocating for both the use and appropriate selection of eye PPE in the workplace is an important thing that should be continuously encouraged. Further studies or research focusing PPE effectiveness in prevention of ocular injury is still needed to be done with additional aspect the type of eye protection and rate of appropriate eye PPE.

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