Nursing interventions to prevent corneal injury in critically ill, sedated and mechanically ventilated patients: a systematic review of interventions

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ABSTRACT

Objective: To identify the effectiveness of interventions to prevent corneal injury in critically ill, sedated, and mechanically ventilated patients. *Research methodology:* A systematic review of intervention studies was conducted in the following electronic databases: Cumulative Index to Nursing and Allied Health Literature, Cochrane Central Register of Controlled Trials, Embase, Latin American and Caribbean Literature in Health Sciences, LIVIVO, PubMed, Scopus and Web of Science, and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. Study selection and data extraction were performed by two independent reviewers. Quality assessment of the randomized and non-randomized studies was performed using the Risk of Bias (RoB 2.0) and ROBINS-I Cochrane tools, respectively, and the Newcastle-Ottawa Scale for cohort studies. The certainty of the evidence was assessed according to the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system. *Results:* 15 studies were included. Meta-analysis showed that the risk of corneal injury in the lubricants group was 66% lower (RR = 0.34; 95 %CI: 0.13–0.92) than in the eye-taping group. The risk of corneal injury in the polyethylene chamber was 68% lower than in the eye ointment group (RR = 0.32; 95 %CI 0.07–1.44). The risk of bias was low in most of the studies included and the certainty of the evidence was evaluated. *Conclusions:* The most effective interventions to prevent corneal injury in critically ill sedated mechanically ventilated, who have compromised blinking and eyelid closing mechanisms, are ocular lubrication, preferably gel or ointment, and protection of the corneas with a polyethylene chamber. *Implications for clinical practice:* Critically ill, sedated, and mechanically ventilated patients who have compromised blinking and eyelid closing mechanisms must receive interventions to prevent corneal injury. Ocular lubrication, preferably gel or ointment, and protection of the corneas with a polyethylene chamber were the most effective interventions to prevent corneal injury in critically ill, sedated, and mechanically ventilated patients. A polyethylene chamber must be made commercially available for critically ill, sedated, and mechanically ventilated patients.

Keywords: Critical care Corneal injuries Prevention and control Evidence-based nursing Systematic review

Introduction

Critically ill, sedated and mechanically ventilated patients are more prone to corneal injury due to the decline in the protective mechanisms resulting from a lowered level of consciousness, use of sedatives and muscle blocker drugs, and mechanical ventilation, among other factors. These factors can alter the blink and the eyelid closure movements that are responsible for lubricating and protecting the corneas. Therefore, interventions aiming to promote the lubrication and protection of the corneas of these patients that are usually conducted by nurses are needed (Ahmadinejad et al., 2020, Alavi et al., 2014; Alansari et al., 2015; Kalhori et al., 2015; Kam et al., 2013; Jammal et al., 2012; Herdman et al., 2021; Kocaçal Güler et al., 2018; Hartford et al., 2018; SFAr et al., 2017; Silva Carneiro E Silva et al., 2021).

The incidence of corneal injury in critically ill patients remains high in several countries (Hartford et al., 2019, Gurevitch et al., 2018; Werli- Alvarenga et al., 2011; Selvan et al., 2020). Corneal injury ranged from 21.0% to 58.5% in India (Selvan et al., 2020; Vyas et al., 2018), while the incidence of corneal injury in Iran and Jordan was 13.8% and 57.0%, respectively (Alavi et al., 2014; Jammal et al., 2012). In Brazil, the incidence of corneal injury ranged from 18.8% (state of Acre) (Silva Carneiro E Silva et al., 2021) to 59.4% (state of Minas Gerais) (Werli- Alvarenga et al., 2011). However, in both the United Kingdom and Turkey the incidence rate of corneal injury was 2.0%. Preventive nursing practice protocols have been implemented in the ICUs in both countries, where interventions aiming to prevent corneal injuries demonstrated that nurses could improve the quality of care and minimize the occurrence of this avoidable event (Selvan et al., 2020; Freitas et al., 2018; Kousha et al., 2018; Vyas et al., 2018).

Previous studies have shown that nurses' knowledge about the care and prevention of corneal injury is limited (Kocaçal Güler et al., 2018; Silva Carneiro E Silva et al., 2021; Selvan et al., 2020; Freitas et al., 2018; Kousha et al., 2018). In addition, nursing care in ICUs has more emphasis on the cardiovascular, renal, and neurological systems. Eye care is possibly neglected in ICUs because critically ill patients are unable to report discomfort or pain when their eyes are dry or irritated, increasing the risk of corneal injury. These factors along with the lack of clinical practice guidelines to prevent corneal injury among critically ill patients may contribute to the high incidence of this condition in some countries (Kocaçal Güler et al., 2018; Freitas et al., 2018; Vyas et al., 2018; Khalil et al., 2019; Momeni Mehrjardi et al., 2021).

The corneas are thin avascular structures located in the anterior part of the eyeball that act as protective barriers for the eyes. A lubricated and protected cornea provides adequate vision for the patient. However, patients with damaged corneas may experience temporary or permanent visual impairment that may impact their daily activities and self-esteem. In addition, if the corneas are damaged their transplantation may be rendered unfeasible (Kam et al., 2013; Kocaçal Güler et al., 2018, Hartford et al., 2018; Gallagher and Ramsay-Baggs, 2004).

The NANDA International (NANDA-I) Taxonomy of nursing diagnosis includes the Risk for Corneal Injury (00245) in Class 2, physical injury, of Domain 11, safety/protection (Herdman et al., 2021). The risk of corneal injury diagnosis is defined as susceptibility to infection or inflammatory lesions in corneal tissue that may affect superficial or deep layers. The risk factors for corneal injury include insufficient knowledge about modifiable factors, exposure of the eyeball, use of pharmacological agents (e.g. sedatives and muscle-blocking drugs), periorbital oedema, mechanical ventilation, low level of consciousness, prolonged hospitalization, blinking <5 times per minute, oxygen therapy, and tracheostomy (Herdman et al., 2021; Silva Carneiro E Silva et al., 2021).

Randomized clinical trials of interventions to prevent corneal injury in critically ill patients have been conducted in several countries. The findings have led to different recommendations, including the use of saline solution with gauze, manual closure of the eyelids, occlusion of the eyelids with micropore tape, use of glasses, ocular lubricant drops, ocular lubricant gel or ointment, and use of a polyethylene chamber (Alavi et al., 2014; Alansari et al., 2015; Kam et al., 2013; Kalhori et al., 2015; SFAr et al., 2017; Kocaçal Güler et al., 2018; Ahmadinejad et al., 2020; Higgins et al., 2019; Cortese et al., 1995; Ezra et al., 2008). In addition, the concomitant use of a polyethylene chamber and ocular gel lubricant have been suggested as the most effective interventions for preventing corneal injury (Mui So et al., 2008; Sfar et al., 2017; Ahmadinejad et al., 2020; ACI, 2021; Li and Zhou, 2022).

The availability of several treatment options may hamper nurses' decision-making process when selecting the most effective intervention for critically ill patients. Review papers involving studies assessing different types of interventions to prevent corneal injury in intensive care units (ICUs) have been conducted. However, these reviews may be considered outdated and their findings regarding the effectiveness of the interventions were inconclusive (Werli-Alvarenga et al., 2013; Gurevitch et al., 2018). Accordingly, this justifies the performance of a systematic review and meta-analysis aiming to synthesize evidence of the most effective intervention to prevent corneal injury in critically ill, sedated and mechanically ventilated patients (Herdman et al., 2021; Kocaçal Güler et al., 2018; Ahmadinejad et al., 2020; Gurevitch et al., 2018; Higgins et al., 2019; Page et al., 2021; Cortese et al. 1995). The aim of this research was to identify the effectiveness of interventions, to prevent corneal injury in critically ill, sedated, and mechanically ventilated patients.

Methods

This systematic review of interventions was conducted in accordance with the Cochrane Handbook for Systematic Reviews of Interventions and presented according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA 2020) (Higgins et al., 2019; Page et al., 2021).

The research question was formulated using the Population, Intervention, Comparison or Control and Outcome (PICO) strategy. Critically ill, sedated and mechanically ventilated patients were considered as the "Population", any intervention to reduce or prevent corneal injury as the "Intervention", no intervention was the "Comparison or Control", and prevention or reduction of corneal injury was the "Outcome". Therefore, the research question was: Which intervention is more effective for reducing or preventing corneal injury in critically ill, sedated and mechanically ventilated patients?

Protocol and registration

The systematic review protocol was registered in the Prospective International Register of Systematic Reviews (PROSPERO) under protocol number 253289.

Terminology definitions

The definitions of the terminology used in this systematic review are described in Table 1.

Data sources and search strategy

This systematic review was conducted in the following electronic databases: CINAHL, Cochrane CENTRAL, Embase, LILACS, LIVIVO, PubMed, Scopus, and Web of Science, in January 2022. A grey literature search was carried out in Google Scholar (Higgins et al., 2019;

Page et al., 2021). The MESH terms and Boolean operators used in all databases were: "corneal injuries" AND "prevention and control" AND "critical care". The reference lists of eligible studies were cross-checked to identify additional relevant studies. No language or year of publication restrictions were applied in the electronic search.

Eligibility criteria

The inclusion criteria were (1) adult and/or older adult sedated and mechanically ventilated patients; and (2) patients admitted to ICUs. The exclusion criteria were (1) neonatal, child, and adolescent patients; and (2) patients without sedation and/or mechanical ventilation. Any form of nursing intervention for the prevention of corneal injury in the ICU was considered as an intervention. Comparators were critically ill adult and/or older adult sedated and mechanically ventilated patients who did not receive preventive interventions for corneal injury. Outcomes measures were healthy cornea or reduction of corneal injury. The study designs included were full randomized clinical trials (RCTs), non-randomized controlled trials (NRCT), and cohort studies (Higgins et al., 2019).

Study selection and data extraction

Two reviewers independently screened the titles and abstracts of the retrieved papers for eligibility according to the inclusion criteria. A full-text assessment was conducted to select studies when the information in the title and abstract was inconclusive. The articles identified in the electronic searches were transferred to the Rayyan platform for the double-blind selection of papers by the reviewers (https://rayyan.qcri. org). Any disagreement between the reviewers in relation to the selection process was resolved through discussion. The selected articles were exported into the EndNote® reference manager program to remove duplicates and for analytical purposes (Higgins et al., 2019; Page et al., 2021).

The following data were extracted from the included studies: authors' names, year of publication, country, study design, objective, participants' characteristics (mean age, male/female ratio, and medical diagnoses), number of corneal injuries, number of patients in the control and intervention groups, types of intervention tested, and main results.

Risk of bias and quality of evidence

The methodological quality of the Randomized Clinical Trials (RCTs), non-randomized controlled trials, and cohort studies were assessed using the Cochrane risk-of-bias assessment tool for randomized trials (RoB 2), ROBINS-I and Newcastle-Ottawa Scale, respectively (Sterne et al., 2016; Sterne et al. 2019; Wells et al., 2011).

The RoB 2 is composed of 22 items grouped into five domains to assess the different types of bias, including bias arising from the randomization process, from deviations from intended interventions, from missing outcome data, from the measurement of the outcome, and from the selection of the reported result. The following response options were used: 'yes', 'probably yes', 'probably no', 'no', 'not applicable', and 'no information'. Each study was classified according to the overall risk of bias as either *Low risk of bias*: when the study was judged to have a low risk of bias for all domains of the reported result; *Some concerns*: when the study demonstrated some issues in at least one domain of the reported result, however, did not present a high risk of bias for any domain, and *High risk of bias*: when the study presented a high risk of bias in at least one domain of the reported result, or the study was judged to have some issues in multiple domains that substantially reduce the validity of the result (Sterne et al., 2019). Studies that presented a high risk of bias were excluded.

The ROBINS-I assessment of the risk of bias was used in the non-randomized studies addressing pre-intervention, during-intervention, and post-intervention moments of the study. The judgments of each study and the overall bias domains were classified as having a 'Low', 'Moderate', 'Serious' or 'Critical' risk of bias (Sterne et al., 2016).

Cohort studies were evaluated using the modified version of the Newcastle-Ottawa Scale (Wells et al., 2011). This tool evaluates studies based on 8 domains using a star system, which is divided into 3 criteria: patient selection, comparability of study groups, and outcome assessment. High-quality studies with a low risk of bias would receive the maximum of 9 stars. Studies that obtain 8, 7, or 6 stars are considered to have moderate quality, and studies with a rating of 5 stars or less are classified as low quality (Wells et al., 2011).

The certainty of the evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system (Ryan and Hill, 2016).

Data synthesis and analysis

The quantitative synthesis was performed through meta-analysis (Higgins et al., 2019; Lipsey and Wilson, 2001). The outcomes of the interventions directed toward preventing or reducing the likelihood of corneal injury were considered (Higgins et al., 2019).

Estimates from studies reporting binary outcomes (dichotomous variables) were pooled using the reported Relative Risk (RR) or Odds Ratio (OR) with a 95% confidence interval (CI). The standard mean differences were used to combine studies that measured the same outcome, however, used different methods (Higgins et al., 2019).

A meta-analysis was carried out to compare the different types of interventions for the prevention of corneal injury in critically ill patients. A forest plot was used to identify the different types of interventions compared with no treatment. The differences between the interventions were measured through head-to-head analysis.

Statistical heterogeneity was assessed through visual inspection of a forest plot, χ^2 test, or the I^2 statistic test. The interpretation of I^2 was: 0% to 40%: might not be important; 30% to 60%: moderate heterogeneity; 50% to 90%: substantial heterogeneity; 75% to 100%: considerable heterogeneity. The importance of the observed value of I2 depends on (i) the magnitude and direction of effects and (ii) the strength of evidence for heterogeneity (Higgins et al., 2019; Deeks et al., 2019; Lipsey and Wilson, 2001).

Sensitivity analysis was carried out to assess the impact of studies with a high risk of bias. The statistical analyses were performed using Cochrane's Review Manager Software (v.5.4.1) (Higgins et al., 2019).

Results

Study selection

A total of 334 studies were identified from the initial search of the databases. After removing duplicates (n = 44), the titles and abstracts of 290 studies were assessed. Of these, 23 studies were selected. No additional studies were identified through a manual search in reference lists or websites. From the 23 studies selected, 8 did not fulfill the eligibility criteria and were excluded. The final selection resulted in 15 studies (Alavi et al. 2014; Kalhori et al., 2015; Ahmadinejad et al., 2020; Kousha et al., 2018; Lenart and Garrity, 2000; Koroloff et al. 2004; Mui so et al. 2008; Werli-Alvarenga, 2013; Bendavid et al., 2017; Babamohamadi et al. 2018; Badparva et al., 2021; Kocaçal et al., 2021; Tolba et al., 2021; Salime and Sayed, 2020; Suresh et al., 2000) (Fig. 1).

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Study characteristics

Of the 15 studies included in the systematic review, 10 were RCTs (67.0%), 3 were cohort studies (20.0%) and 2 were NRCTs (13.0%). Most of the papers, 60.0% (n = 9), were published from 2015 onwards. Most studies were conducted in Iran (40.0%, n = 6), followed by the United Kingdom (UK) (13.3%, n = 2), and Egypt (13.3%, n = 2). Furthermore, Brazil, Turkey, United States, China, Australia, and Israel published one study each. The total sample of the included studies comprised 1,675 patients. The sample size of individual studies varied from 22 patients (Lenart and Garrity, 2000) to 371 patients (Kousha et al. 2018).

Several interventions for the prevention or reduction of corneal injury were tested, including Eye ointment × eyelid closure with micropore tape (Suresh et al., 2000); Eye drops × lid closure with micropore tape (Alavi et al., 2014); Eye ointment × routine (Kousha et al., 2018; (Lenart and Garrity, 2000); Polyethylene × routine (routine being considered as eye cleaning with 0.9% saline solution) (Salime and Sayed, 2020); Polyethylene × manual eyelid closure (Tolba et al., 2021); Polyethylene × eye drops (Lenart and Garrity, 2000; Koroloff et al., 2004); Polyethylene × eye ointment (Mui So et al., 2008); Polyethylene × eye ointment × eyelid closure (Ahmadinejad et al, 2020); Polyethylene × eye ointment × eye drops (Koroloff et al., 2004; Werli-Alvarenga, 2013); Vitamin A eye ointment × polyethylene (Babamohamadi et al., 2018; Badparva et al., 2021); Vitamin A eye ointment × eye ointment (Badparva et al. 2021) and Bandage contact lenses × eye drops (Bendavid et al. 2017).

As the main results, ocular lubricants, in drops or ointment, were more effective than eyelid closure with micropore tape in reducing corneal injury (Alavi et al., 2014; Suresh et al., 2000). Studies comparing polyethylene covers with cleaning routine, manual eyelid closure, and eye drops, showed that the polyethylene chamber was the most effective intervention to prevent corneal injury in critically ill patients (Kalhori et al., 2015; Ahmadinejad et al., 2020; Koroloff et al., 2004; Werli- Alvarenga, 2013; Tolba et al., 2021).

The polyethylene chamber presented similar efficacy to eye ointment in the prevention of corneal injury in critically ill patients in two studies (Ahmadinejad et al., 2020; Mui So, et al 2008). However, in both, it was argued that the polyethylene chamber is easier and cheaper for routine use to prevent corneal injury in critically ill patients (Ahmadinejad et al., 2020; Mui So, et al 2008). Table 2 summarizes the descriptive characteristics of the studies included in this systematic review.

Quality assessment of the included studies

Of the 10 RCTs, one was classified as having a low risk of bias. One RCTs (Kocaçal et al., 2021) was classified as having some concerns because it presents deviations from the intended interventions (Sterne et al., 2019). Table 3 shows the Risk of Bias (RoB 2.0) assessment of the included studies.

One NRCT was classified as low risk of bias (Tolba et al., 2021); and the other NRCT has a moderate risk of bias (Salime and Sayed, 2020). Of the three cohort studies, two studies were considered to have moderate quality and one study was assessed as having excellent methodological quality. Table 4 presents the assessment and the quality of evidence of the included studies (Table 5).

Quantitative synthesis of results

The risk of developing corneal injury was assessed by comparing lubricants versus eye taping (Alavi et al., 2014; Lenart and Garrity, 2000) and polyethylene cover versus eye ointment (Ahmadinejad et al., 2020; Mui So et al., 2008; Werli-Alvarenga et al., 2013). The meta-analysis showed that the risk of occurrence of the corneal injury (outcome) in the lubricants group was 66% lower (RR = 0.34; 95 %CI: 0.13–0.92) than in the eye-taping group. The risk of corneal injury in the polyethylene chamber was 68% lower than in the eye ointment group (RR = 0.32; 95 %CI 0.07–1.44). The high heterogeneity identified in the polyethylene chamber and eye ointment studies can be explained by the small number of studies and the direction of the effects (in favor of the control group, the polyethylene chamber) (Deeks et al., 2019). In this sense, we suggest that more studies be carried out with robust samples and a follow-up time of more than 7 days.

The longer follow-up time is essential to identify the occurrence of corneal injury, which occurs more frequently after 7 days in critically ill, sedated, and mechanically ventilated patients (Werli-Alvarenga et al., 2011; Silva Carneiro E Silva et al., 2021; de Oliveira Pinheiro, 2022). Figs. 2aa and bb show Forest plots of the meta-analysis addressing interventions to prevent corneal injury.

The GRADE instrument shows that the studies were considered to have moderate certainty of evidence (Table 4).

Discussion

The findings suggest that lubricants and eye protection with a polyethylene chamber were the most effective interventions to prevent corneal injury in critically ill patients. Therefore, the recommendation for clinical practice is that sedated, mechanically ventilated patients, with reduced levels of consciousness, who have compromised blinking and closing mechanisms of the eyelids, must receive ocular lubrication, preferably with gel or ointment, and protection of the corneas with a polyethylene chamber (Mui So et al., 2008; Sfar et al., 2017; Ahmadinejad et al., 2020; ACI, 2021; Li, Tao, 2022).

Lubricants in gel or ointment formats are more effective than lubricants in drops (eye drops) possibly because they provide prolonged lubrication and eyelid closure (Kalhori et al., 2016). Adhesive or gauze tapes should not be used in critically ill patients due to the higher occurrence of corneal injury, with twice the incidence of corneal injury in patients that used adhesive tapes than those receiving eye lubricants (Alavi et al., 2014).

The polyethylene chamber has been recommended in several studies because it reduces the loss of corneal lubrication by retaining moisture in the corneas, as well as protecting them from physical and mechanical trauma. The chamber is a low-cost effective product, easy to produce and apply. In addition, the equipment is transparent, allowing the eyes to be seen, and is minimally invasive. It does not require a specialized team for handling or a medical prescription. The chamber has high durability (12 h) whereas eye drops last two hours, and eye gel and ointment last from four to six hours (Mui So et al., 2008; Werli-Alvarenga, 2013; Tolba et al., 2021; Alansari et al., 2015; Kalhori et al., 2016; Sfar et al., 2016; Koroloff et al., 2019; ACI, 2021; Li and Zhou, 2022). However, the polyethylene chamber has been produced manually and it has been improvised (Koroloff et al., 2004; Guller et al., 2011; Werli-Alvarenga, 2013; Kalhori et al., 2016; Ahmadinejad et al., 2020), which indicates the need to create a specific polyethylene cover to prevent corneal injury (Prado and Mainsh, 2022).

Some studies identified low-knowledge of nurses about eye care, thus it is imperative to provide nursing continuing education to prevent corneal injury (Kuruvilla et al., 2015; Guller et al., 2017; Freitas et al., 2018). Nursing staff must be trained and adopt an eye care

protocol that includes the Risk for corneal injury nursing diagnosis, which must be carried out using eye ointment lubrication and polyethylene chamber in critically ill patients (Ezra et al., 2008; Kuruvilla et al., 2015; Guller et al., 2017; Kousha et al., 2018; Freitas et al., 2018; Vyas et al., 2018; Khalil et al., 2019; Momeni Mehrjardi et al., 2021; Herdman et al., 2021). In addition to the eye care previously mentioned, patients in the prone position, such as those with COVID-19, should receive anti-pressure pads on their head and constant evaluation of eyelid closure to avoid complications, such as bleeding conjunctival, and compression of retinal nerves and vessels (Avilar et al., 2022).

The following recommendations emerged from this systematic review. Future studies should follow up patients for at least seven days because that was the minimum period interval identified with the highest occurrence of corneal injury in critically ill patients (Werli-Alvarenga, et al., 2011; Silva Carneiro E Silva et al., 2021; de Oliveira Pinheiro et al. al., 2022). In addition, future research should investigate the medical diagnosis and comorbidities of the participants, such as diabetes, hypertension, and dyslipidemia. This is because diabetic patients, patients with heart diseases and those with vascular diseases have 80%, 50% and 60% greater risk of developing corneal injury, respectively. There are also clinical and surgical differences between patients that should be investigated when assessing the intervention to prevent corneal injury among critically ill, sedated and mechanically ventilated patients (Lenart and Garrity, 2000; Werli-Alvarenga, 2014; Tolba et al., 2021; Silva Carneiro E Silva et al., 2021).

Strengths and limitations

This systematic review evaluated the effectiveness of the main interventions to prevent corneal injury. The search was comprehensive, including relevant electronic databases, with specific inclusion criteria (sedated and ventilated critically ill adult patients). The findings produced important recommendations for the clinical practice involving patients in ICUs. The included studies were considered to have a low risk of bias and certainty of evidence it was evaluated. However, some limitations should be acknowledged. First, studies using different research designs (e.g., RCT, NRCT, and cohort studies) were included. Consequently, direct comparisons between their findings were not conducted. Second, the sample size of some studies was small, which affected the precision of the estimates of individual studies. Third, the follow-period was quite distinct across studies. Finally, the meta-analysis was not large due to the diversity of interventions among the studies. Thus, further comparisons were not possible, which can explain the high heterogeneity across metanalysis in polyethylene chamber studies. Future studies investigating the effectiveness of interventions to prevent corneal injury should use robust sample sizes and patient's follow-up within seven days should be observed.

Conclusion

This Systematic review of interventions supports the recommendation of ocular lubrication, preferably with gel or ointment, and protection of the corneas with a polyethylene chamber for the clinical practice in sedated, mechanically ventilated, critically ill patients in ICUs, who have compromised blinking and closing mechanisms of the eyelids. As a recommendation, we suggest that nurses follow an eye care protocol including eye gel lubrication, for 4 or 6 hours, and a polyethylene chamber, for 12 hours, for sedated, mechanically ventilated, critically ill patients. In addition, a polyethylene chamber must be made commercially available for sedated and mechanically ventilated, critically ill patients to prevent corneal injuries.

Ethical approval and consent to participate
Patients and/or the public were not involved in the design, conduct, reporting, or dissemination of this study.

Consent for publication
In accordance with PRISMA-2020 Guidelines, the review protocol was submitted to PROSPERO. The results of this study will be submitted to peer-reviewed journals. In addition, it is intended that the abstract will be presented at a national and/or international conference.

Availability of supporting data
Upon completion of the study, the datasets generated and/or analyzed during the current study will be available to investigators upon request to the corresponding author by E-mail: patriciarezende@usp.br

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Authors' contributions
PRP, FREGS, RCCPS, MVV, MF, and GLV developed the systematic review that contributed to the development of the data selection criteria, assessed the risk of bias, performed the extraction and analysis of the data, developed the search strategy, and read, reviewed, and approved the final version.

Declaration of Competing Interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1 – Terminology definitions of the systematic review of interventions.

Terminology	Definitions
Cornea	An anterior structure of the eye where light first enters the eye, providing refractive power that helps focus light rays on the retina (Kam et al., 2013; Gallager et al., 2004; Grixti et al., 2012).
Corneal injury	Characterized by an alteration of the corneal epithelium and may be of inflammatory (keratitis or corneal ulcer), microbial or traumatic origin (Grixti et al., 2012).
Lacri-Lube	An eye lubricant ointment consisting of white paraffin, mineral oil, non-ionic lanolin derivatives, and chlorbutol (0.5%). It is retained in the tear film longer than other eye solutions, preventing corneal dryness (Ezra et al. 2009).
Geliperm	A transparent, non-allergenic, polyacrylamide hydrogel substance. Its high water content prevents desiccation of the ocular surface and its non-adherent properties facilitate eye care management. It also acts as a mechanical barrier to bacterial infections and provides gentle pressure to maintain eyelid closure (Ezra et al. 2009).
Polyethylene cover/chamber	The polyethylene chamber creates a moisture chamber around the cornea, providing a barrier against tear film evaporation, and assisting in maintaining eyelid closure, thus preventing corneal injury. Its transparency, simplicity of application, easy maintenance, and lower cost favour its use (Ahmadinejad et al., 2020; Corte et al. 1995; Tao and Zhou, 2022).

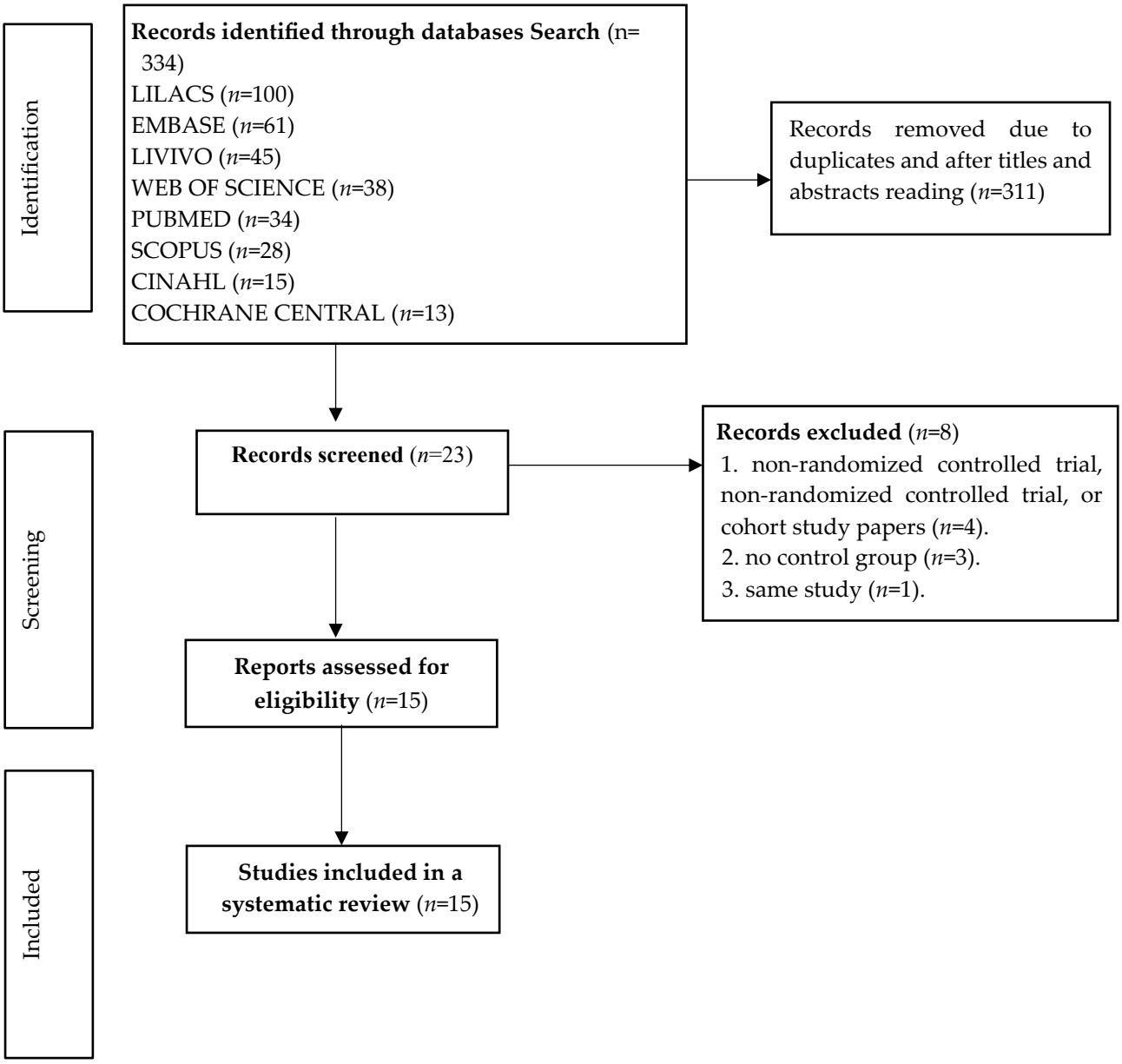

Fig. 1. Flowchart of the selection process of primary studies included in the systematic review of interventions.

Table 2 - Characteristics of the included studies in the Systematic Review of Interventions.

Author	Year	Country	Study Design	Objective	Total Sample	Intervention Group	Control Group	Participants characteristics		Conclusions
								Demographics	Medical Diagnosis	
Lenart and Garrity	2000	United States of America	RCT	To determine whether applying artificial eye ointment in paralyzed or heavily sedated patients receiving mechanical ventilation decreases the prevalence of corneal injury more than passive closure of the eyelid.	50	50	50	Mean age: 55 Ratio M/F: 1.5	54.0% surgical 46.0% clinical disorder.	Eye care with a lubricating ointment with a regular, set schedule can effectively reduce the prevalence of corneal injuries in paralyzed or heavily sedated patients and can help prevent serious complications, such as corneal injury and visual loss.
Koroloff et al.	2004	Australia	RCT	To compare the efficacy of two forms of eye care: hypromellose and Lacri-Lube eye lubricants versus polyethylene covers for critically ill patients.	110	60	50	Mean age: 50.1 Ratio M/F: 2.0	16.4 % surgical. 15.0% clinical disorder.	The results of this study have been incorporated into the clinical practice with polyethylene covers now the standard preventative intervention for all unconscious patients.
Mui So et al.	2008	China	RCT	To compare the effectiveness of polyethylene covers (GladwrapTM) with lanolin (Duratears1) eye ointment in the prevention of corneal abrasions in critically ill patients.	116	57	59	Mean age: 59.4 Ratio M/F: 1.45	45% septic shock.	The use of a polyethylene cover and lanolin eye ointment was equally effective in the prevention of corneal injury. Polyethylene film has the additional benefit of being cost-effective, easy to apply, and can be applied early. After this study, the unit adopted the polyethylene cover as the standard preventive eye care

										for all unconscious patients with impaired or no blink reflex.
Werli-Alvarenga	2013	Brazil	RCT	To evaluate the effect of nursing interventions: eye cleaning (control), eye gel, eye drops, and polyethylene cover for the prevention of corneal injury in critically ill patients.	360	90	270	Mean age: 56.7 Ratio M/F: 1.64	45.0% heart; 41.1% vascular; 40.6% respiratory 22.8% metabolic disorder.	Polyethylene was the most effective intervention for preventing corneal injury in these critically ill patients.
Tolba et al.	2015	Egypt	NRCT	To evaluate the impact of polyethylene cover versus eyelid closure in preventing corneal injuries among critically ill patients at Assiut University Hospital.	60	30	30	Mean age: 33.18. Ratio M/F: 14.	76.7% trauma; 20% respiratory disorder.	Polyethylene covers was more effective, easier, and saved more time in preventing corneal injury in critically ill patients.
Kalhori et al.	2016	Iran	RCT	To compare the effect of three eye care interventions: polyethylene cover, liposic ointment, and artificial tear drops to prevent corneal injury in critically ill patients of Kermanshah.	96	32	64	Mean age: 60.87 Ratio M/F: 0.81	10.4% surgical; 32.3% clinical; 57.3% neuronal disorder.	Results of the study suggest the use of polyethylene cover as a non-aggressive and non-pharmaceutical nursing intervention for the prevention of corneal injury in critically ill patients.
Bendavid et al.	2017	Israel	RCT	To compare the effectiveness of bandage contact lenses and punctual plugs with ocular lubricants for preventing corneal injury in mechanically ventilated and sedated, critically ill patients.	104	38	66	Mean age: 62.4 Ratio M/F: 1.53	35.6%: clinical; 43.3%: surgical; 19.2%: trauma disorder.	Compared with ocular lubrication, bandage contact lenses and punctal plugs were more effective in limiting corneal injury, and their use, particularly that of bandage contact lenses, was associated with significant healing of existing corneal injuries.

Babamohamadi et al.	2018	Iran	RCT	To determine the effectiveness of vitamin A eye ointment and moist chamber in preventing cornel injuries in critically ill patients.	38	38	38	Mean age: 69.8 Ratio M/F: 0.9	89.5%: clinical; 10.5%: surgical disorder.	The Vitamin A eye ointment through increasing the excretion of tears. Therefore, it can be more effective than a moisture chamber in preventing corneal injury in critically ill patients.
Ahmadinejad et al.	2020	Iran	RCT	To compare polyethylene cover, eye ointment, and routine with eye taping to prevent corneal injuries in critically ill patients.	152	124	28	Mean age: 44.0 Ratio M/F: 3.31	Trauma disorder. Young patients.	This study recommends simple eye ointment and polyethylene cover methods for preventing corneal injuries in critically ill patients.
Kocaçal et al.	2020	Turkey	RCT	To compare the effect of carbomer eye drops when used alone and in combination with polyethylene covers in the healing of the corneal injury in critically ill patients.	43 corneas	22	21	Mean age: 57 Ratio M/F: 7	50% neuro; 16.7% respiratory 8.3% metabolic disorder.	Carbomer eye drops used in combination with polyethylene covers were more effective in preventing a corneal injury than the eye drops method in critically ill patients.
Salime and Sayed	2020	Egypt	NRCT	To evaluate the effect of ocular hygiene with 0.9% saline solution versus lubrication with chloramphenicol antibiotic ointment and polyethylene cover as treatment or as prescribed after swab culture is taken if signs of eye infection in critically ill patients.	60	30	30	Mean age: 45.75 Ratio M/F: 2.0	30.0% respiratory disorder. 63.3% hypertension 40.0% diabetes.	Regular screening with chloramphenicol antibiotic and polyethylene cover is necessary to prevent corneal injury and subsequent eye complications in critically ill patients.
Badparva et al.	2021	Iran	RCT	To compare the effectiveness of Lubratex ointment and vitamin A eye ointment in preventing corneal injuries in critically ill patients.	38	38	38	Mean age: 57.6 Ratio M/F: 2	38.9% trauma disorder.	Lubratex ointment was more effective than vitamin A ointment in preventing corneal injuries in critically ill patients.

Suresh et al.	2000	United Kindgom	Cohort	To evaluate the effectiveness of Horizontal lid taping using Micropore tape and eye lubricants, 4 hourly, versus cleaning eyelids with gauze and saline solution to prevent corneal injury in critically ill patients.	30	30	30	Mean age: 53.16 Ratio M/F: 1.14	26.7% respiratory disorder.	Adhesive tape and eye drops were more effective in the prevention of corneal injury in critically ill patients. Incidence in the intervention group was 8.7% versus 42.0% in the control group.
Alavi et al.	2014	Iran	Cohort	To determine the incidence of eye dryness and corneal abrasion, on day 5 after admission, in critically ill patients using adhesive tapes and eye drops.	87	29	58	Mean age: 57.6 Ratio M/F: 2.95	15.9% heart disorder.	Patients receiving adhesive tape, as an eye injury prevention intervention, presented twice the number of corneal injuries. Therefore, this method is not recommended to prevent corneal injury in critically ill patients.
Kousha et al.	2018	United Kingdom	Cohort	To determine the rate of corneal injury in critically ill patients before and after an eye care protocol with eye ointment versus routine of cleaning with gauze and saline solution.	371	257	114	Mean age: 63.0 Ratio M/F: 1.17	No information	Lacri-Lube eye ointment was more effective in preventing a corneal injury than cleaning with gauze and saline solution in critically ill patients.

RCT: Randomized Controlled Trial; M/F: Male/Female; NRCT: Non-Randomized Controlled Trial.

Table 3 – The Risk of Bias (RoB 2.0) assessment of the included studies.

Studies of review	D1	D2	D3	D4	D5	Overall Risk of Bias
Lenart and Garrity, 2000	+	+	+	+	+	+
Koroloff et al., 2004	+	+	+	+	+	+
Mui So et al., 2008	+	+	+	+	+	+
Werli-Alvarenga, 2014	+	+	+	+	+	+
Kalhori et al., 2016	+	+	+	+	+	+
Bendavid et al., 2017	+	+	+	+	+	+
Babamohamadi et al., 2018	+	+	+	+	+	+
Ahmadinejad et al., 2020	+	+	+	+	+	+
Badparva et al., 2021	+	+	+	+	+	+
Kocaçal et al., 2020	+	!	+	+	+	!

+ low risk of bias; ! Some concerns; - High risk of bias.

D1: Domain 1 – Risk of bias arising from the randomization process; D2: Domain 2 - Risk of bias due to deviations from the intended interventions; D3: Domain 3 - Risk of bias due to missing outcome data; D4: Risk of bias in the measurement of the outcome; D5: Domain 5 – Risk of bias in the selection of the reported result. *Risk of Bias II.

Table 4 – Assessment and risk of bias of the included studies.

Study	Method	RoB 2	Robbins - I	Newcastle	GRADE
Lenart and Garrity, 2000	RCT	Low	-	-	High
Koroloff et al., 2004	RCT	Low	-	-	High
Mui So et al., 2008	RCT	Low	-	-	Moderate
Werli-Alvarenga, 2014	RCT	Low	-	-	High
Kalhori et al., 2016	RCT	Low	-	-	High
Bendavid et al., 2017	RCT	Low	-	-	High
Babamohamadi al., 2018	RCT	Low	-	-	High
Ahmadinejad et al., 2020	RCT	Low	-	-	High
Badparva et al., 2021	RCT	Low	-	-	High
Kocaçal et al., 2020	RCT	Some concerns	-	-	High
Tolba et al., 2015	NRCT	-	Low	-	Low
Salime and Sayed, 2020	NRCT	-	Moderate	-	Low
Kousha et al., 2020	Cohort	-	-	High	Low
Suresh et al., 2000	Cohort	-	-	Moderate	Low
Alavi et al., 2014	Cohort	-		Moderate	Low

RCT: Randomized Controlled Trial; NRCT: Non-Randomized Controlled Trial; RoB2: Risk of Bias of RCT; GRADE: Grading of Recommendations Assessment, Development, and Evaluation.

Table 5: Grading of Recommendation, Assessment, Development, and Evaluation (GRADE) instrument.

Certainty assessment							# patients		Effect		Certainty
# of studies	Study design	Risk of bias	Inconsistency	Indirect evidence	Imprecision	Other considerations	Intervention	Control	Relative (95% CI)	Absolute (95% CI)	
Lubricants x Eye taping											
2	Randomized clinical trial	None	Not serious	Not serious	Not serious	None	8/108 (7.4%)	17/79 (21.5%)	RR: 0.34 (0.13 - 0.92)	142 / 1.000	⊕⊕⊕⊕ High
Polyethylene cover x Lubricants											
3	Randomized clinical trial	None	Not serious	Not serious	Not serious	None	9/231 (3.9%)	36/230 (15.7%)	RR: 0.32 (0.07 - 1.44)	106 / 1.000	⊕⊕⊕ Moderate

CI: Confidence interval; RR: Risk ratio; RCT: randomised clinical trials. Explanations: a Wide range of confidence interval crossing the line of null effect. b Presence of statistical heterogeneity ($I^2 = 72\%$). There is no overlap of all CI.

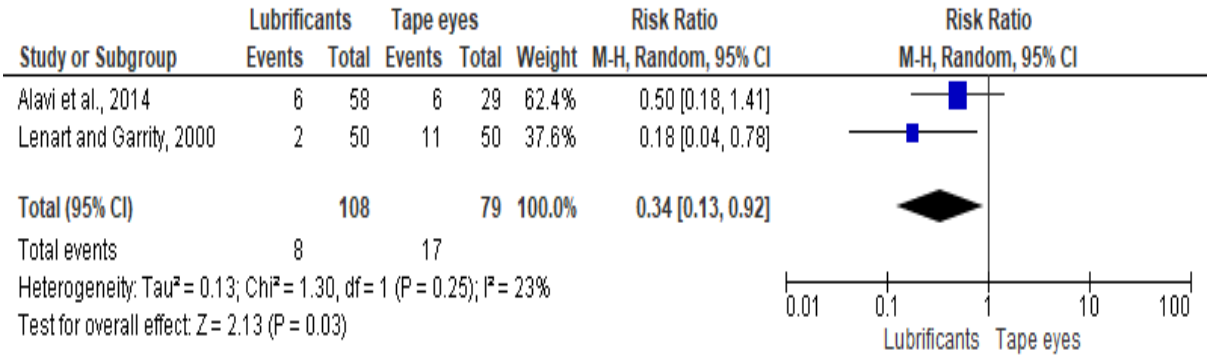

Figure 3a: Forest plot of the lubricants versus eye taping to prevent corneal injury.

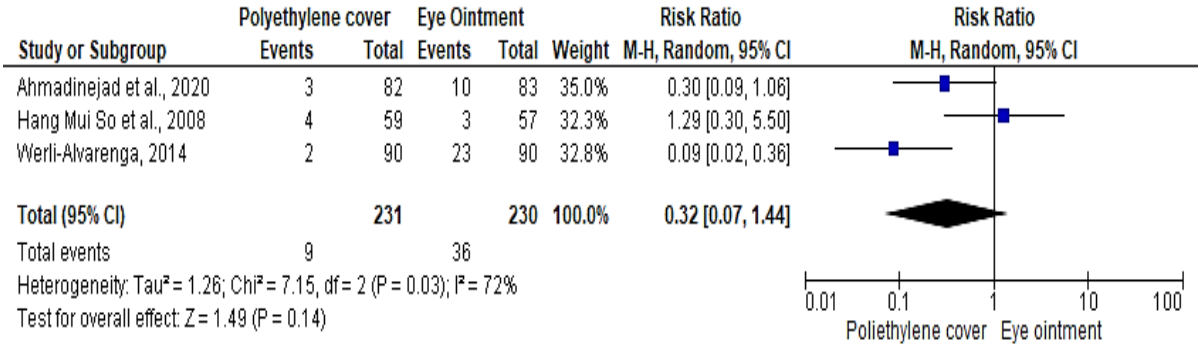

Figure 3b: Forest plot of the polyethylene cover versus eye ointment to prevent corneal injury.