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COVID-19 related pressure injuries in patients and personnel: A systematic review

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ABSTRACT

Background: Coronavirus disease 2019 (COVID-19) is causing a rapid and tragic health emergency worldwide. Because of the particularity of COVID-19, people are at a high risk of pressure injuries during the prevention and treatment process of COVID-19.

Objectives: This systematic review aimed to summarize the pressure injuries caused by COVID-19 and the corresponding preventive measures and treatments.

Methods: This systematic review was according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines. PubMed, Web of science and CNKI (Chinese) were searched for studies on pressure injuries caused by COVID-19 published up to August 4, 2020. The quality of included studies was assessed by the Newcastle-Ottawa Quality Assessment Scale (NOS) and the CARE guidelines.

Results: The data were extracted from 16 studies involving 7,696 participants in 7 countries. All studies were published in 2020. There are two main types of pressure injuries caused by the COVID-19: 1) Pressure injuries that caused by protective equipment (masks, goggles and face shield, etc.) in the prevention process; 2) pressure injuries caused by prolonged prone position in the therapy process.

Conclusions: In this systematic review, the included studies showed that wearing protective equipment for a long time and long-term prone positioning with mechanical ventilation will cause pressure injuries in the oppressed area. Foam dressing may need to be prioritized in the prevention of medical device related pressure injuries. The prevention of pressure injuries should be our particular attention in the course of clinical treatment and nursing.

1. Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the disease it causes, coronavirus disease 2019 (COVID-19), are causing a rapid and tragic health emergency worldwide [1,2]. More than 14 million confirmed cases of COVID-19 have been reported by the end of July 2020 [3]. Due to the high infectivity and pathogenicity of COVID-19, the clinical treatment and nursing care are extremely difficult and require high standards [4]. With the increasing use of medical protective equipment and medical devices, the number of medical staff and COVID-19 patients suffering from pressure injuries is increasing [5].

The routes of SARS-CoV-2 include direct contact (contact with the respiratory droplets and aerosols from a affected person) and indirect contact (contact with contaminated surfaces or supplies) [6]. In order to resist the invasion and infection of the SARS-CoV-2, front-line medical staff must wear a series of protective items, including medical protective masks (N95 masks and surgical masks), goggles, protective face screens, protective gowns, etc. [5,7]. Wearing the protective equipment for a long time will produce persistent pressure on the local skin, which may lead to pressure injuries [8]. Pressure injuries are local skin damage and underlying tissues caused by unrelieved pressure, shear and friction [9].

Meanwhile, prone positioning is also widely used to treat COVID-19 complicated by severe acute respiratory distress syndrome (ARDS). In cases of severe ARDS, prone positioning of patients not only control the airways to provide mechanical invasive ventilation, but also reduce the mortality of patients [10,11]. The pressure injuries caused by it has been identified as the most frequent complication [12,13].

Thus, this systematic review of the current studies on pressure injuries caused by COVID-19 was conducted for the purposes of summarizing the pressure injuries caused by COVID-19, discussing the reasons

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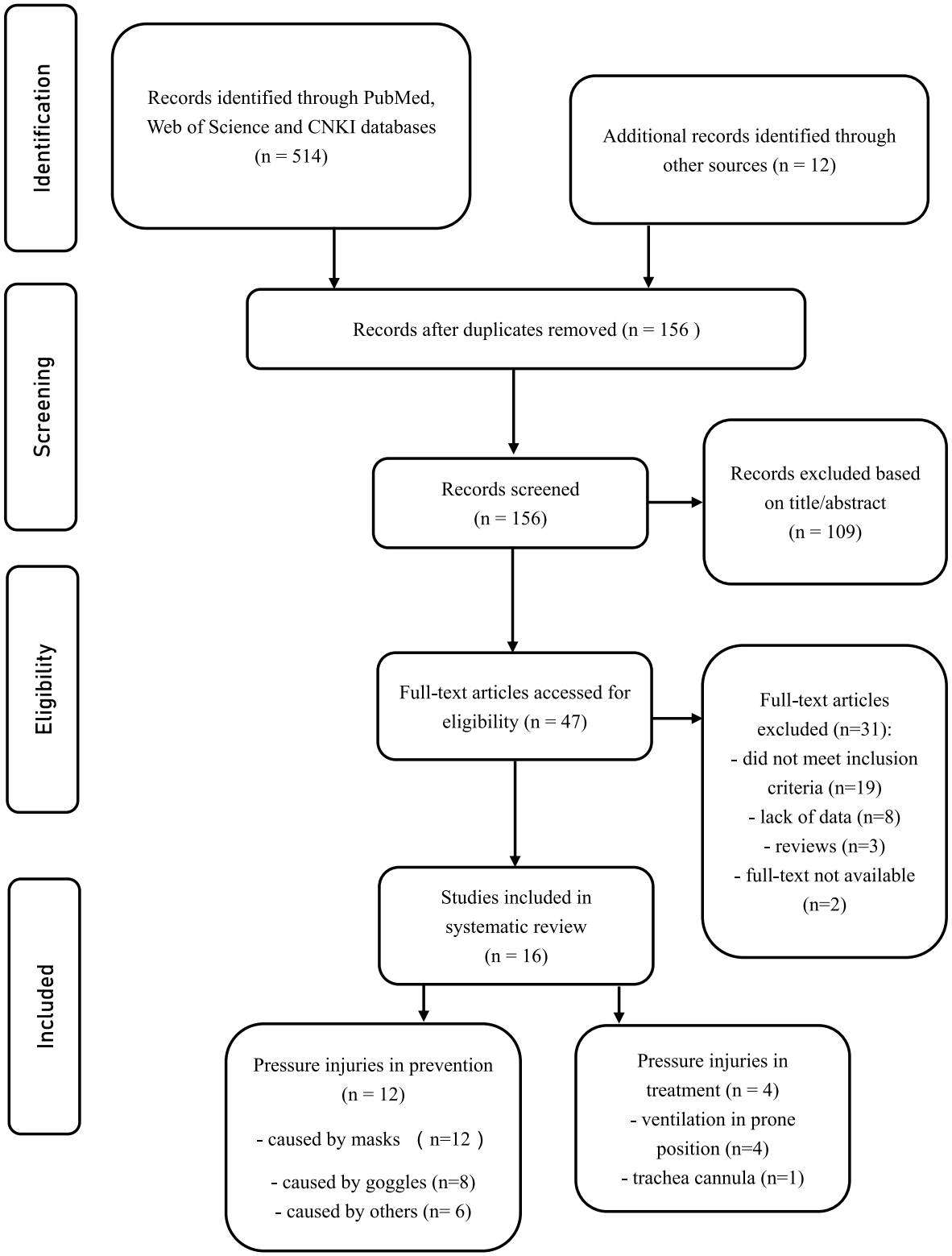

Fig. 1. Flow diagram of the study selection and exclusion process.

Table 1
The qualities of included studies (case-control study or cohort study) by Newcastle-Ottawa Quality Assessment Scale (NOS).

Study	Study design	Selection				Comparability	Outcome/Exposure			Score
		1)	2)	3)	4)	1)	1)	2)	3)	
Yun, W.	case-control study	★	★		★	★★	★	★	★	8
Jiang, Q. (a)	cohort study	★	★	★	★	★★	★	★	★	9
Tang, J.	cohort study		★	★	★	★★	★	★	★	8
Jiang, Q. (b)	cohort study	★	★	★	★	★★	★	★	★	9
Feng, C.	cohort study	★	★	★		★★	★	★	★	8
Yu, H.	cohort study	★	★		★	★★	★	★	★	8
Xia, J	cohort study		★	★		★★	★	★	★	7
Zheng, R.	cohort study	★	★	★		★★	★		★	7
Peko, L.	case-control study	★	★	★	★	★★	★	★	★	9

behind as well as the corresponding preventive measures and treatments.

2. Methods

2.1. Search strategy

A systematic search was carried out by PubMed, CNKI (Chinese) and Web of Science databases. The following search terms were used: COVID-19, SARS-CoV-2, Novel coronavirus pneumonia, pressure, pressure injury, pressure sore and pressure ulcer. The search string adapted for PubMed database was ("COVID-19" [title/abstract] OR "SARS-CoV-2" [title/abstract] OR "Novel coronavirus pneumonia" [title/abstract]) AND ("pressure" [title/abstract] OR "pressure injury" [title/abstract] OR "pressure sore" [title/abstract] OR "pressure ulcer" [title/abstract] OR "decubitus" [title/abstract]). We also manually searched the references of all relevant studies to supplement our searches. There were no language restrictions, but the publication time of studies was limited from December 2019 to August 2020. This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline [14].

2.2. Study selection

Criteria for inclusion of the relevant studies are as follows: 1) types of participants: the people who developed pressure injuries due to COVID-19 must be reported; 2) the source of pressure injuries must be reported in the study; 3) measures to prevent or treat pressure injuries must be included in the study; 4) types of study design: randomized controlled trial (RCT), case report, case-control study and cohort study.

2.3. Data extraction and quality assessment

Two authors independently extracted the data into pre-designed standardized tables. The data included: 1) first author; 2) published year; 3) country; 4) study design; 5) site of pressure injuries; 6) grade of pressure injuries; 7) daily wearing time of protective equipment/prone time; 8) source of pressure injuries; 9) treatment for pressure injuries; and 10) key findings. The quality of included studies were assessed by the Newcastle-Ottawa Quality Assessment Scale (NOS) and The CARE Guidelines. Discrepant judgements of the extracted data were resolved after discussion with the third author.

3. Results

3.1. Eligible studies

A total of 514 studies were identified from databases including PubMed, Web of Science and CNKI (Chinese), we excluded 370 duplicate results. One hundred and nine studies were excluded by titles and abstracts. After assessing 47 full-text studies, we excluded 31 full-text studies due to 1) did not meet inclusion criteria (n = 19); 2) lack of data (n = 8); 3) reviews (n = 3) and 4) full-text not available. Thus, 16 studies were included in this systematic review. Fig. 1 displays the process of selection of studies. After evaluation, the quality of all included prospective cohort studies and case-control studies was assessed by the Newcastle-Ottawa Quality Assessment Scale and the scores of each study is detailed in Table 1. The quality of included case reports was assessed by CARE guideline and all of them were deemed credible.

There was a total of 7,696 participants, and the sample sizes ranged from 1 to 4,306. All included studies were published in 2020. Of the 16 studies, eight were conducted in China, two in Spain, five in UK, Australia, Italy, Malaysia and France. There were two main types of pressure injuries caused by the COVID-19: 1) Pressure injuries that caused by protective equipment (masks, goggles and face shield, etc.) in the prevention process; 2) pressure injuries caused by prolonged prone position in the therapy process. The summary of these two main types of COVID-19 related pressure injuries was provided in Table 2 and Table 3 respectively.

3.2. Pressure injuries in medical prevention of COVID-19

We identified 12 studies [1,5,7,15–22] that targeted the protective equipment related pressure injuries. The population was mainly medical staff. There were 4 case reports [1,7,15,16], 1 case-control study [22] and 7 prospective cohort studies [5,17–21,23]. Pressure injuries often occur on the bridge of the nose, cheeks, forehead and auricle (Fig. 2). The kinds of medical protective equipment include masks (N95 masks and surgical masks), goggles, protective gowns and so on. The three main measures identified as preventing pressure injuries were: 1) use of silicone foam dressings; 2) use of hydrocolloid dressings and 3) strict control on the wearing time of medical protective equipment. After comprehensive analysis, foam dressing may need to be prioritized in the prevention of medical device related pressure injuries. Meanwhile, the continuous wearing time of medical protective equipment should preferably be less than 4 h.

3.3. Pressure injuries in medical treatment of COVID-19

There were 4 studies [12,24–26] (3 case reports and 1 case-control study) identified. It was ascertained that the main sites of pressure injuries were on the forehead, chin, cheeks, lips and chest (Fig. 3). The time of the prone position across the studies was more than 12 h per day. The two main prevention measures used were: 1) use of specific softer prone positioning head cushion; 2) use of silicone gels or silicone foam dressing; 3) changing head position 2 or 3 times during a session and the position of the breathing tube should be changed between each session. The main treatment is to use the chemical debridement of necrotic tissue.

Table 2
Summary of the studies on pressure injuries in personnel using preventive measures against COVID-19.

Author, year, country	Source of PI	Sample size **Gender (M/F)**	**Age (years)**	Study design	Site of PI	PI grade	DWT	measures	Key findings
Lam, U. N. 2020, Malaysia	①	5 (0/5)	Median age 32.5 (29–36)	Case report	Bridge of nose	I, n = 4 III, n = 1	3 h, n = 1 4–5 h, n = 2 >6 h, n = 2	1) foam dressing 2) hydrocolloid dressing (DuoDERM EXTRA THIN)	1) HCW's are advised use both hands to bend the nose piece to fit the N95 respirator snugly rather than push the respirator against the nose and face. 2) HCW's are advised to use barrier dressings as prophylaxis. 3) HCW's are advised to relive the pressure of N95 respirators every 2 h.
Del Castillo, J. L., 2020, Spain	①②③	NR	NR	Case report	Nasal dorsum, cheeks and forehead	NR	Upwards of 4–5 h	hydrocolloid dressing	1) Hydrocolloid is semi permeable material that is present as a layer within a film or foam pad which adheres to the skin, usually used for wound healing. 2) The use of face masks and goggles for hours results in greater sweating, which is aggravated by the large number of patients being treated and the stressful situation of possible contagion.
Field, M. H., 2020, UK	①	NR	NR	Case report	Bridge of nose	NR	NR	Hydrocolloid dressing	Cut hydrocolloid dressing into thin strips, which are positioned directly beneath the mask on the bridge of the nose and can provide both pain and pressure relief.
Yun, W, 2020, China	①②③	60 (0/60)	Median age EG: 27.5 (23–32) CG: 28.5 (24–33)	Case-control study	Nose, forehead, cheeks, auricle	EG: I, n = 3 II, n = 1 CG: I, n = 12 II, n = 8 III, n = 1	8 h	Foam dressing	1) Foam dressing reverse adhesive can effectively prevent PI and improve the degree of comfort of nurses wearing protective equipment. 2) Reverse adhesive can also avoid skin laceration caused by repeated removal of foam dressing.
Jiang, Q., 2020, China	①②④	4306 (516/3790)	<35, n = 2903; ≥35,n = 1403	Prospective cohort study	Bridge of nose, cheeks, auricle, forehead, others (mandible, groin, neck and so on)	I, n = 2866 II, n = 551 III, n = 17 DTI, 23	>4 h, n = 3632 ≥4 h, n = 674	1) hydrocolloid dressing 2) silicone foam dressing	1) The prevalence of device-related PI among medical staff wearing personal protective equipment (PPE) was significantly higher than that of patients. 2) The common anatomical locations of PI among medical staff wearing PPE were on the nose bridge, cheeks, ears, and forehead. 3) Four risk factors associated with device-related PI among medical staff wearing PPE were sweating, male, level 3 PPE, and longer wearing time.
Tang, J., 2020, China	①②③	102 (42/59)	Median age 31 (25–55)	Prospective cohort study	Nasal bridge, zygomatic arch, auricles	I, n = 51 II and above, n = 11	Median time 6 h (0–17 h)	1) reduce bearing time 2) hydrocolloid dressing	1) Working in the COVID unit was confirmed to have a strong correlation with PI. 2) PPE may induce a detrimental combination of pressure, friction, shearing forces, and moisture. 3) Prolonged N95 use increased the chance of suffering PI.
Jiang, Q., 2020, China	①②④	2901 (214/2687)	Average age (31.9 ± 7.1)	Prospective cohort study	Bridge of nose, cheeks, ears, forehead and others	I, n = 667 II, n = 98 III, n = 1 DTI, N = 5	≤4 h, n = 326 5–8 h, n = 2140 ≥9 h, n = 471	1) foam dressing 2) hydrocolloid dressing 3) oiling agent 4) others (film dressing, band-aid and so on)	1) The prevention and treatment of skin injury by medical staff is insufficient and not standardized. 2) Foam dressing may be a priority in preventing device-related PI.

(*continued on next page*)

Table 2 (*continued*)

Author, year, country	Source of PI	Sample size **Gender (M/F)**	**Age (years)**	Study design	Site of PI	PI grade	DWT	measures	Key findings
Feng, C., 2020, China	①②	45 (8/37)	Average age (32.5 ± 3.5)	Prospective cohort study	Nose, cheeks, auricle, forehead, neck	I, n = 39 II, n = 16	4–4.5 h	1) foam dressing 2) hydrocolloid dressing	1) The pressure on the contact area and the change of temperature and humidity are the two main causes of PI. 2) Self-adhesive ultra-thin soft silicone foam dressing is the best dressing for prevention of device-related PI for medical staff at present
Yu, H., 2020, China	①②	174 (4/170)	Average age (30.11 ± 4.39)	Prospective cohort study	Nose, cheeks, auricle, forehead, neck	I, n = 116 II, n = 20 IV, n = 1	NR	Preventive dressing	1) Medical staff that without previous experience of wearing head and face protective equipment are associated with device-related PI. 2) Medical staff that without relevant preventive measures are related to the occurrence of device-related PI.
Yin, Z., 2020, China	①	NR	NR	Case report	NR	NR	NR	1) hydrocolloid dressing 2) paste benzalkonium chloride patch firstly and using hydrocolloid dressing secondly	1) The strong stickiness of dressing would likely aggravate existent PI. 2) To use benzalkonium chloride patch and hydrocolloid dressing together would reduce the stickiness of central part and not make PI more serious. 3) Improving protective mask is a permanent solution.
Xia, J., 2020, China	①②④	89 (2/87)	Average age (37.83 ± 4.65)	Prospective cohort study	Nose, cheeks, forehead, auricle	I, n = 12 II, n = 3	< 4 h, n = 20 4-5, n = 22 6-8, n = 5 ≥9, n = 7	1) foam dressing 2) hydrocolloid dressing 3) liquid dressing 4) petrolatum gauze	1) Local use of dressings and other protective measures can effectively reduce the incidence of PI. 2) Moisture is an important factor causing stress injury. 3) Protective gowns that with better moisture permeability are advised.
Zheng, R., 2020, China	①	10 (3/7)	Median age 36.5 (25–48)	Prospective cohort study	Nose, cheeks, auricle	I, n = 10 II, n = 2 DTI, n = 1	6–8 h	Hydrocolloid dressing	1) Use hydrocolloid dressings in advance to protect skin and relieve stress to reduce PI. 2) As N95 mask is worn, PIt the upper strap upper, and the lower strap lower can make the wearer more comfortable. 3) People who wear glasses can use a fixed device to relieve the pressure on their noses.

Notes. PI = pressure injury, DWT = daily wearing time, HCW = health care workers, NR = not reported; EG = experimental group; CG = control group; DTI = deep tissue injury; PPE = personal protective equipment; ① masks; ② goggles; ③ face shield; ④ protective clothing.

Table 3
Summary of the studies on pressure injuries in patients treated for COVID-19.

Author, year, country	Source of PI	Sample size **Gender (M/F)** Age (years)	Study design	Site of PI	PI grade	Prone time	measures	Key findings
Peko, L., 2020, Australia	NR	NR	Case-control study	Forehead, chin	NR	16 h–24 h	Multi-layered silicone-foam prophylactic dressings	1) Prone positions are used during surgery and ventilation of COVID-19 patients. 2) These surgical and COVID-19 patients are at risk of facial PI. 3) Dressings applied to forehead and chin effectively protect these regions.
Zingarelli, E. M., 2020, Italy	Breathing tube	1 (0/1); 50	Case report	Lips, chin, perioral area, both cheeks, left zygomatic region, and superior and inferior left eyelids	NR	At least 12 h daily	1) thin silicone foam dressing 2) Silver Sulfadiazine 3) Hyaluronic Acid And Sodium and sterile gauzes 4) hyaluronic acid sodium salt collagenase and ointment	1) Invasive ventilation is associated with reduced aerosolization and is thus considered safer for staff and other patients. 2) Prone ventilation is likely to reduce mortality among patients with severe ARDS when applied for at least 12 h daily. 3) Prone position increases the risk of medical device-related PI in the facial area.
Martinez Campayo, N., 2020, Spain	NR	1 (1/0); 78	Case report	chest	NR	13 sessions of 20 h each	1) chemical debridement 2) hydrocolloid dressing	1) A thin silicone foam dressing can represent a valid precaution approach. 2) The position of patients placed in prone position should be changed every 2 h and sides should be switched.
Perrillat, A., 2020, France	Breathing tube, feeding tube	2 (2/0); 27/50	Case report	Forehead, cheeks, labial commissure	II, III	6–9′ sessions of at least 12 h each	1) debridement of necrotic tissue 2) paraffin gauze dressing	1) A specific softer prone -positioning head cushion with space for the breathing tube is recommended to use, and a better distribution of pressure points on the whole face or silicone gels or silicone foam dressings. 2) Head position should be changed 2 or 3 times during a prone position session and the position of the breathing tube should be changed between each prone position session.

Notes: PI = pressure injury, ARDS = acute respiratory distress syndrome, NR = not reported.

4. Discussion

This systematic review synthesized results of 16 studies on pressure injuries associated with COVID-19. It demonstrated that there were two main types of pressure injuries caused by the COVID-19: pressure injuries that are caused by protective devices in the prevention process and pressure injuries caused by prolonged prone position in the therapy process. The use of prophylactic dressings, such as silicone foam dressing and hydrocolloid dressing, can effectively reduce the occurrence of pressure injuries [16,20]. At the same time, it is also very important to strictly limit the continuous wearing time of medical protective equipment.

Additional studies were sourced that confirmed this conclusion. The main risk factors and mechanisms of pressure injuries associated with COVID-19 are as follows. First, wearing medical protective equipment, such as N95 masks and goggles, and maintaining a prone position for a long time will increase the local pressure and friction on the skin [17,27,28]. Medical staff with pressure injuries wear medical protective masks (N95 masks and surgical masks) continuously for more than 4 h daily, especially in the case of nursing staff [29,30]. Meanwhile, the application of prone positioning has expanded sharply during the present COVID-19 pandemic placing more patients at risk of pressure injury development. In ICUs, those patients with ARDS are mechanically ventilated and typically placed prone for sessions of approximately 16 h or more and up to 24 h, in order to improve their lung mechanics and tissue oxygenation [31,32]. Besides, the shortage of supplies at the beginning of the COVID-19 outbreak also extended the wearing time of protective equipment to a certain extent. Second, most protective gowns are disposable sterile medical protective clothing with the standard of GB19082, which is made of isolation material and has poor moisture permeability. Therefore, the use of face masks and goggles and wearing protective gowns for a long time will increase medical staff's skin temperature and sweat profusely, leaving the local skin in a moist environment. The high skin temperature and profuse sweating accelerate pressure injuries [33].

Although hydrocolloid dressing is often used to prevent and cure pressure injuries [34], some researchers have found some of its flaws in its use [23]. Due to the strong stickiness of hydrocolloid, it may aggravate an existing pressure injury when one is removing a mask as it rips away the dressing [7]. Some studies suggested that a paste benzalkonium chloride patch be used before wearing the mask, as a means of effectively relieving the problem of using a hydrocolloid dressings. Zinc therapy has also been suggested as a promoter of wound healing, because suitable zinc levels can maintain the body's immune function [35,36]. What's more, Surgical pearl, a novel technology for wearing ear-ring masks to reduce ear pressure, thereby reducing ear pressure injuries has also been proposed as a possible solution [37].

This systematic review suggested that medical staff should pay great attention to the prevention of pressure injuries. In term of themselves, using preventive dressings before wearing protective equipment can

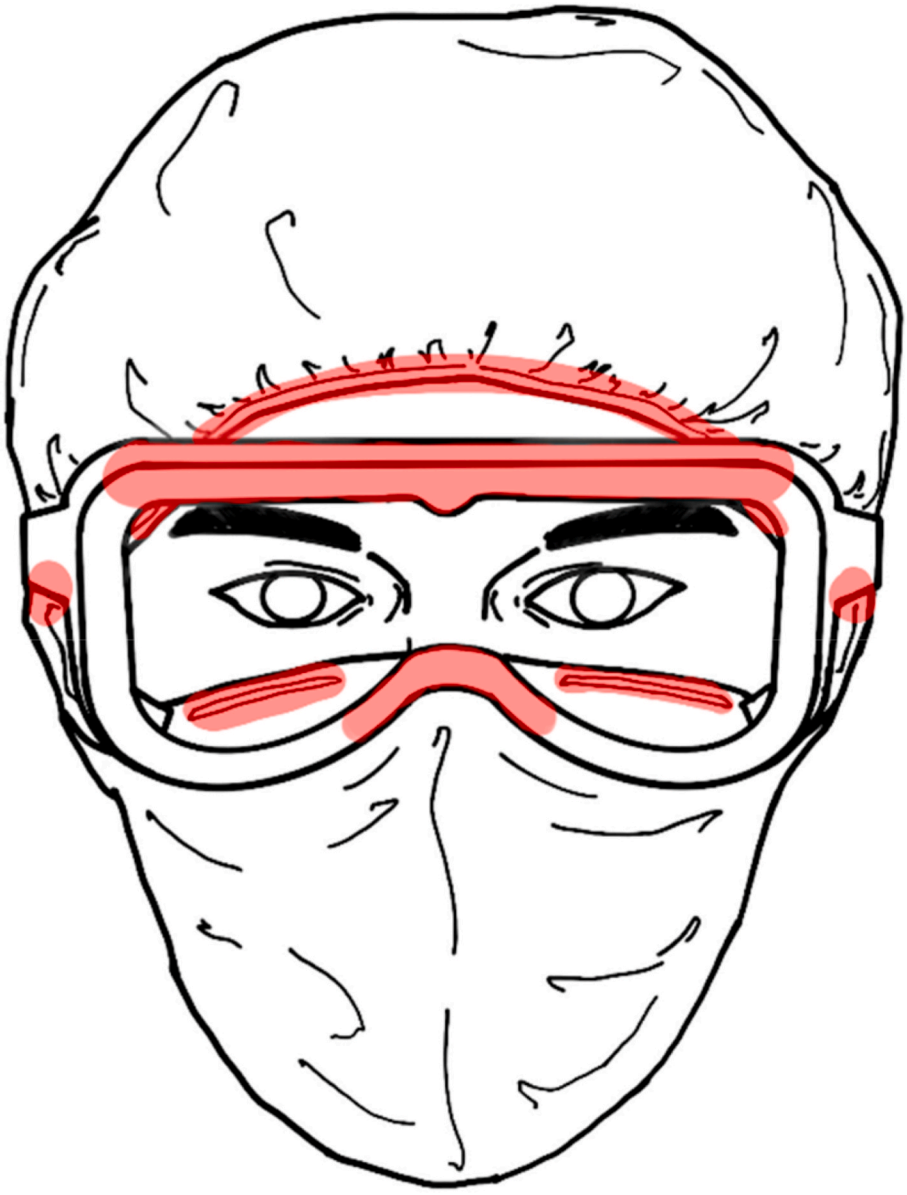

Fig. 2. Diagrammatic sketch of the sites of pressure injuries (marked in red) prone to occur in the prevention. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

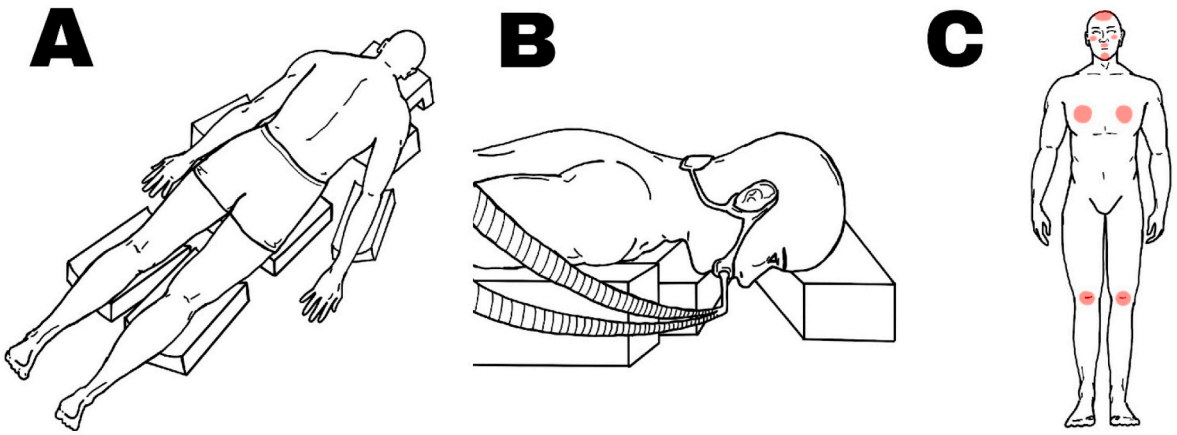

Fig. 3. Diagrammatic sketch of patients in prone position ventilation and the sites of pressure injuries prone to occur are marked in red. (A: schematic illustration of prone position; B: schematic illustration of mechanical ventilation; C: schematic illustration of the location of pressure injuries).

greatly reduce the occurrence of pressure injuries. In term of patients with COVID-19, medical staff should not only use the preventive dressings, but also conduct skin assessment for patients and use assistive devices like the specific softer prone -positioning head cushion with space for the breathing tube to relieve local pressure [38]. Meanwhile, in the process of treating and caring for patients, medical staff should ideally wear protective equipment for less than 3 h. Prone positioning patients' head position should be changed 2 or 3 times during a prone position session and the position of the breathing tube should be changed between each prone position session [25].

There are some limitations in this review. First, the number of included studies is not enough, especially the studies on pressure injuries in the therapy process of COVID-19, both in normal supine position and prone position. There is also a lack of randomized controlled trials. Second, we included some case reports to obtain more comprehensive information, but this will bring some heterogeneity to the article. Third, the grade of pressure injuries that was extracted from the included studies are based on the National Pressure Ulcer Advisory Panel (NPUAP) guidelines, but pressure injuries are still difficult to assess accurately, both in grading them but also in identifying them accurately.

5. Conclusion

In this systematic review, it has been found that during the prevention and therapy process of COVID-19, medical staff and patients of COVID-19 are at risk of developing pressure injuries. Because wearing protective equipment for a long time and long-term prone positioning with mechanical ventilation increase the risk of pressure injuries in the oppressed area, medical staff should pay attention to preventing injury to their own skin and on the skin of their patients.

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Declaration of competing interest

The authors stated that they have no competing interests.

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