Effectiveness of 2 Pretreatment Methods in Antifogging of Goggles in a COVID-19 Isolation Ward: A Randomized Controlled Trial

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NCPD Earn Up to 8.5 Hours. See page 616.

Contribution to Emergency Nursing Practice

- Fogging of goggles can seriously affect the quality of medical work of health care staff and pose an unnecessary threat to the lives of patients.
- There is a lack of simple, effective and readily available methods to minimize and prevent the issue of goggle fogging.
- This study's findings can facilitate the prevention of fogging of medical goggles and streamline the work of nursing staff worldwide in the fight against COVID-19.

Abstract

Introduction: This study aimed to compare the effectiveness of the pretreatment of goggles with iodophor solution and antibacterial hand sanitizer to reduce the fogging of goggles.

Methods: A total of 90 health care workers were divided into a control group ($n = 30$), an iodophor solution group ($n = 30$), and an antibacterial hand sanitizer group ($n = 30$). This study evaluated the degree of fogging of goggles and the light transmission, comfort, eye irritation, and the impact of goggles on the medical work of staff.

Results: The antibacterial hand sanitizer group had the lowest amount of goggle fogging and the most transparent view. Participants in the control group reported the worst light transmission and comfort level, followed by the iodophor solution group. In contrast, the goggles in the antibacterial hand sanitizer group had the best light transmission and comfort level. The iodophor solution group participants reported more eye irritation. Participants in the control group reported that the goggles severely impacted their medical work, with a less severe impact reported by the iodophor solution group. The antibacterial hand sanitizer group did not report any impact on their medical work.

Discussion: When the goggles were internally coated with antibacterial hand sanitizer solution (diluted 1:1 with distilled water), the antifog effect was significant. Moreover, the goggles treated with antibacterial hand sanitizer had a clearer field of vision, were reported as non-irritating to the eyes,

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and significantly improved the efficiency of COVID-19 health care workers, including emergency nurses and providers.

Key words: Goggles; Anti-fogging; COVID-19; Antibacterial hand sanitizer; Iodophor solution

Introduction

COVID-19 is highly contagious and has spread worldwide.[1] The main transmission routes that have been identified include respiratory droplets and contact transmission. Aerosolized transmission can occur in relatively closed environments; prolonged exposure to high aerosol concentrations and general population susceptibility can increase the risk of transmission.[2,3] Viruses can be transmitted by droplets in special working environments, such as in emergency departments among emergency clinicians treating patients with COVID-19. This exposes frontline emergency care staff to severe occupational hazards. Therefore, health care workers must take strict personal protective measures to prevent COVID-19 transmission during treatment.

Typically used personal protective equipment (PPE) in China includes surgical masks, double gloves, long-sleeved overalls, and goggles.[4] Goggles are made of plastic material and play an essential role in protecting medical workers from COVID-19. They help prevent eye contact with aerosolized pathogens and are a critical barrier to break the chain of viral infection.[5] The importance of professional medical goggles for health care workers involved in the management of COVID-19 has also been highlighted in published literature.[6,7]

However, in practice, exhaled gases from health care workers can easily fog up goggles, resulting in reduced light transmission and obstructed vision. This can seriously reduce the comfort of health care workers wearing them. Further, large amounts of fogging could potentially put emergency care clinicians at a risk of making errors during emergency procedures that require the clinician to have clear and unobstructed vision. The success of procedures like endotracheal intubation, cardiopulmonary resuscitation, or the insertion of peripheral intravenous catheters depend on clinicians' ability to see clearly. Obstructed vision during these procedures could significantly affect the quality of medical care delivered and pose an unnecessary threat to patient safety.[8] The effective use of goggles is also very important for emergency nurses and providers, as they are often required to take the lead in performing life-saving medical procedures.

Unfortunately, there is a lack of simple and effective solutions to prevent the fogging of goggles. To the best of our knowledge, only a few studies with small samples ($n < 10$),[9] short reports,[10] or letters[11,12] have been published to date, and there is a lack of randomized controlled trials comparing the effectiveness of various methods of antifogging. Therefore, a randomized controlled trial was designed to innovatively compare the effectiveness of 2 pretreatment methods in reducing goggle fogging for health care workers in isolation wards. This study aimed to determine a feasible and straightforward method to prevent goggle fogging for frontline health care workers in the fight against COVID-19.

Materials and Methods

STUDY DESIGN

This randomized, single-blind controlled study was approved by the Ethics Committee of the 900th Hospital of the United Nations Security Forces (2021-008) and performed per the revised Declaration of Helsinki principles. Written informed consent was obtained from all participants before the study. The trial was registered in Clinical Trials.gov (registration number ChiCTR2100054392).

SETTING AND PARTICIPANTS

A total of 98 health care workers working on the frontline of the isolation ward of Wuhan Taikang Tongji COVID-19 Specialist Hospital in December 2021 were selected as study participants. As per the inclusion criteria, participants included those aged 20 to 60 years, of either sex, medical and nursing staff, and those working in the COVID-19 isolation ward and skilled in wearing protective gear and providing daily medical care for patients in isolation. Health care workers who could not wear PPE for prolonged periods (> 3 hours) were excluded.

MATERIALS

We used 90 pairs of 3M brand (1621AF, Xuzhou Chuquan Electromechanical Technology Co, LTD, China) goggles made of polycarbonate. The iodophor solution (item number: 29924671903, Shanghai Likang Disinfection Hi-tech Co, LTD, China) and antibacterial hand sanitizer (item number: Q/ALX42, Shandong Lilkang Medical Technology Co, LTD, China) used in this study were both products of Lilcom Medical Technology. The iodophor solution is a disinfectant solution with polyvinylpyrrolidone iodine as the main active ingredient, with an effective iodine content of 0.20% to 0.22% (Weight/Volume, W/V). Antibacterial hand sanitizer contains chlorhexidine gluconate [0.2% ± 0.02% (W/V)] as the main active ingredient.

RANDOMIZATION AND INTERVENTIONS

This was a parallel-group randomized controlled trial in which all participants were enrolled in the same period and randomly allocated to 3 different groups at the same time for the same duration of follow-up. Using computer-generated randomization codes provided by laboratory biostatisticians, a simple randomization procedure was used to assign participants to 3 single-blind (participants were blinded) treatment groups in a ratio of 1:1:1. The 90 codes corresponded to 90 participants who were randomly sorted into 3 groups of 30 participants. The code was kept by the researcher involved in the evaluation of the effects of the trial, who provided the pretreated goggles to participants, with each goggle package consecutively numbered and prepared according to the randomization scheme.[13,14]

A total of 90 health care workers were divided into 3 groups. These were the control group (goggles were coated with distilled water, $n = 30$), iodophor solution group (goggles were coated with iodophor solution, $n = 30$), and antibacterial hand sanitizer group (goggles were coated with antibacterial hand sanitizer and distilled water, mixed at a 1:1 ratio, $n = 30$).[9-12]

The pretreatment of the goggles was conducted by a dedicated group who were trained in advance to ensure uniform coating for each pair of goggles. The training covered ratios, volumes and drying methods for pretreating goggles. The 3 standard sets of pretreatments for goggles were derived from the results of several pretests and clinical experience. For the control group, 2 mL of distilled water was used to coat the inner side of the goggles and a hairdryer was used (Philips, power 1000 Watts, low speed, 30 seconds) to dry them. For the iodophor solution group, an iodophor solution was used to coat the inner side of the goggles. A dry cotton ball with 1 to 2 mL of iodophor solution was used to apply a thin layer. Further, the inner surface of the goggles was coated evenly at various locations, taking care not to apply it too thickly so as to prevent any impact on vision and staining of the goggles. A hairdryer was used to dry the goggles after applying the solution. For the hand sanitizer group, antibacterial hand sanitizer solution was diluted with 1 mL of distilled water at a ratio of 1:1 to coat the goggles.[15] Dry cotton balls were used to apply an appropriate amount of antibacterial hand sanitizer, creating a thin layer. Application of the solutions with dry cotton balls ensured even coverage across the entire surface of goggles and that the line of sight was not affected by excess solution in the form of droplets. Following application, the goggles were also dried with a hairdryer and then considered ready to use.

Group participants did not know which group they would be assigned to or which antifog treatment method would be more effective. The 3 groups of participants used goggles with 3 different pretreatments on the same working day and wore the goggles for 4 hours per shift. Goggles were not to be removed until the end of the trial, which was the end of the participants' 4-hour shifts. There were no significant differences in the temperature and humidity of the working environment among the 3 groups during the day of trial (the temperature in the isolation ward was maintained at 22 °C-24 °C and the humidity at 40%-60%). All participants wore their goggles following the COVID-19 protocols for donning and doffing PPE.[16]

ASSESSMENTS

Goggle Fogging Level

The primary outcome measure of this study was the degree of fogging of goggles. The degree of fogging of the goggles was divided into 4 grades (Figure 1): fog that covered < 30% of the goggle area, fog that covered 30% to 50% of the goggle area, fog that covered 50% to 80% of the goggle area, and fog that covered > 80% of the goggle area. At the end of the 4 hours of medical work, the goggle fogging grading of the 3 groups of health care workers involved in the study was judged, photographed, and recorded. The locations were photographed with consistent light levels and the same brand of camera (D750; Nikon camera, Japan). Photographs were taken within 2 minutes of participants removing their goggles. Nine assessors were trained to score the fogging immediately after taking the photographs. At the end, one dedicated inspector checked the scores against the goggle fogging photos.

Questionnaire

A questionnaire (see Appendix) was orally administered to all 3 groups of health care professionals immediately after the trial by one dedicated person (after wearing the goggles for 4 hours). This researcher-designed questionnaire was pretested with nurses working in isolation wards (these nurses were not involved in the formal trial) and revised accordingly before implementation. The survey included participant-reported light transmission of the goggles,

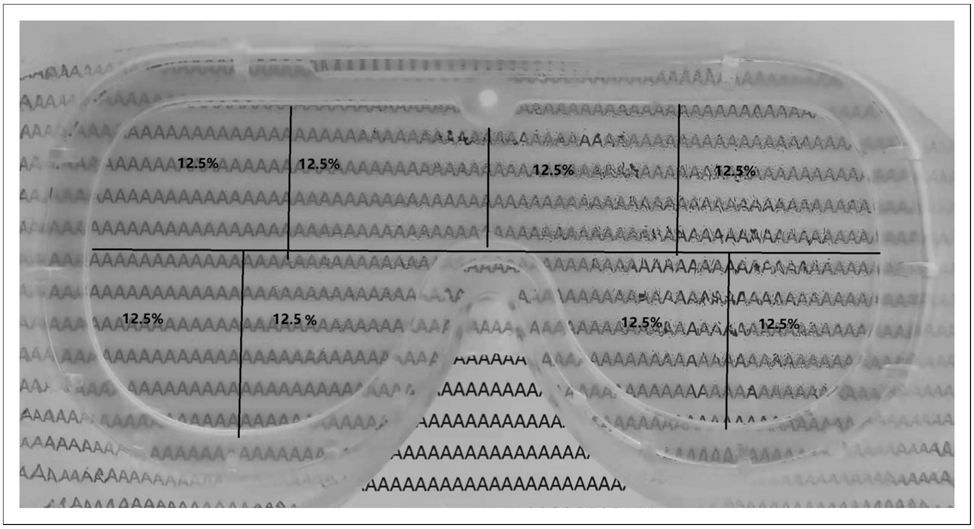

FIGURE 1
The uniform criteria for measuring the percentage of fogging of goggles.

comfort of wearing the goggles, goggle irritation to the eyes, and whether the goggles had any impact on medical practice (also participant-reported). The 3 groups of health care professionals rated the above 4 measures according to their perception: 10 = very good light transmission, very comfortable, no irritation to the eyes, and no impact on any medical work/patient care; 7 to 9 = good light transmission, comfortable to wear, less irritation to the eyes, and no effect on general medical work/patient care work; 4 to 6 = poor light transmission, average comfort, significant irritation to the eyes, and a small-scale impact on medical work/patient care; and 0 to 3 = very poor light transmission, incredibly uncomfortable to wear, severe irritation to the eyes, and profound implications for medical work/patient care. Eye irritation scores are inversely proportional (lower numbers indicate higher levels of irritation). The highest score possible for the 4 items is 40, with higher scores representing better overall results and satisfaction.

STATISTICAL ANALYSES

The sample size was calculated using A'Hern's single-group phase 2 method. With a deviation estimate of 7% obtained from a preliminary experimental result, we estimated that 28 patients in each group would be required, for a total of 84 participants ($\alpha = 0.05$, $\beta = 0.1$). To account for a potential dropout rate of 10%, we aimed to enroll more than 90 participants. All experimental data were statistically analyzed using SPSS Windows software version 25.0 (Chicago, IL). For baseline characteristics of participants, the mean and SD were used to describe the degree of sample variation among the groups. The chi-square test for experimental normally distributed measures was performed using Levene's test (0.05). One-way analysis of varience and Fisher's least significant difference tests were used for the sample mean in each group that met the requirements of the chi-square test. The Kruskal–Wallis H tests measured data that did not meet the requirements of the chi-square test. The experimental data were expressed as mean (SD), and $P < .05$ indicated that the difference was statistically significant.

Results

STUDY POPULATION

Initially, 96 health care workers working in the frontline of the isolation ward were included. Six of them were later excluded based on the inclusion criteria (self-reported inability to wear goggles and strict PPE for more than 4 hours, possible discomforts such as vomiting and vertigo). Finally, 90 participants were randomly allocated to 3 groups: control (distilled water, $n = 30$), iodophor solution ($n = 30$), and antibacterial hand sanitizer ($n = 30$). Health care professionals in all 3 study groups completed the trial successfully (Figure 2). Baseline characteristics of participants were similar in the 3 groups (Table 1).

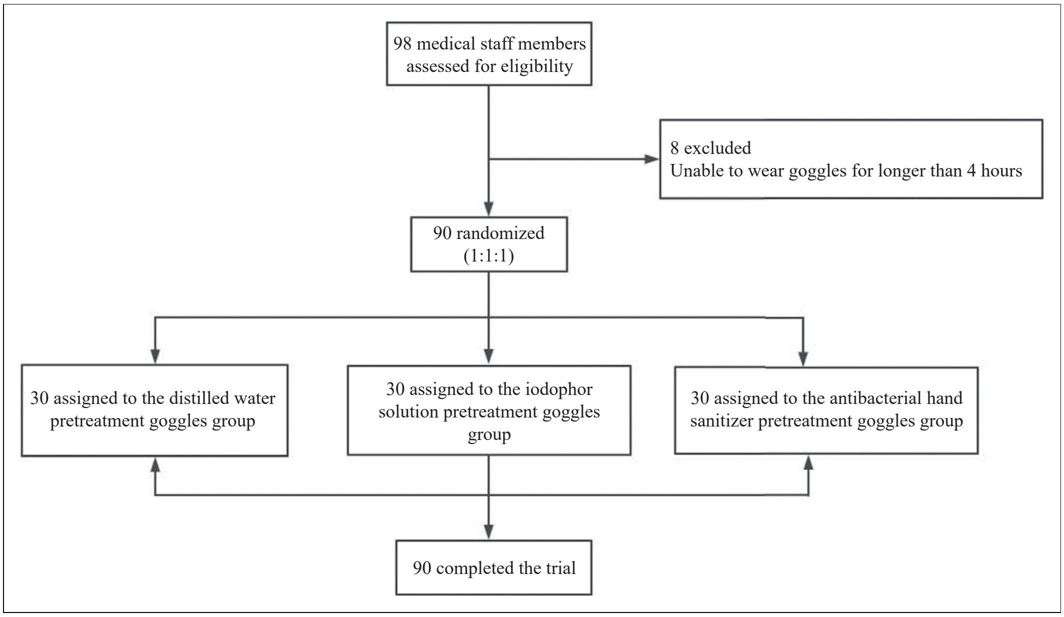

FIGURE 2
Trial profile.

COMPARISON OF THE DEGREE OF FOGGING OF GOGGLES AMONG THE 3 GROUPS OF HEALTH CARE WORKERS

The fogging levels of goggles were measured by a trained researcher and compared among the 3 groups of participants after 4 hours of wear. The photographed comparison chart (Figure 3) shows that the degree of fogging of the goggles differed significantly among the 3 groups. The goggles worn by participants in the control group were tinted with distilled water, almost entirely fogged and severely impeded participants' visual field (Figure 3A). In the iodophor solution group, the fogging was reduced compared with the control group (Figure 3B), but the visual field was still affected. The goggles in the antibacterial hand sanitizer group showed almost no fogging and the visual field was bright and clear (Figure 3C).

The degree of fogging of the goggles among the 3 groups was further quantified and analyzed, as shown in Table 2. There was an increase in the number of cases where the proportion of goggles fogged < 30% (barely fogged) in the iodophor solution group compared with the control group ($\chi^2 = 17.917$, $P < .001$). On comparing the number of goggles with 30% to 50% fog coverage (light fogging) among the 3 groups, the antibacterial hand sanitizer group showed the most significant increase in the number of lightly fogged goggles, with a statistically significant difference ($\chi^2 = 9.144$, $P = .003$). When comparing the number of goggles covering 50% to 80% of the area (moderate fogging) in the 3 groups, the number of cases was similar and not statistically different ($\chi^2 = 3.621$, $P = .164$). The number of goggles with > 80% fog coverage (heavy fogging) was significantly lower in the antibacterial hand sanitizer group than in the control group ($\chi^2 = 26.667$, $P < .001$). In contrast, the amount of fogging in the iodophor group fell between that of the control group and the antibacterial hand sanitizer group.

QUESTIONNAIRE RESULTS

A researcher-designed questionnaire was orally administered to each of the 3 groups of health care workers at the end of the trial. The results of the questionnaire are shown in Figure 4. When comparing the light transmission and comfort level of the goggles among the 3 groups, the control group reported the worst light transmission and the lowest comfort level. The iodophor solution group reported improved light transmission ($F = 3.379$, $P < .01$; Figure 4A) and comfort compared with the control group ($F = 1.483$, $P < .01$; Figure 4B). The antibacterial hand sanitizer group reported the best light transmission (vs control, $F = 6.103$, $P < .01$; vs iodophor solution, $F = 2.724$, $P < .01$; Figure 4A) and the best comfort level (vs control, $F = 5.448$, $P < .01$; vs iodophor solution, $F = 3.966$, $P < .01$; Figure 4B) of the goggles, with statistically

TABLE 1
The baseline characteristics of participants

Characteristics	Control group, (n = 30); n (%)/mean (SD)	Iodophor solution group, (n = 30); n (%)/mean (SD)	Antibacterial hand sanitizer group, (n = 30); n (%)/mean (SD)
Male sex, n (%)	12 (40)	9 (30)	13 (43)
Age (y)	37.3 (4.2)	35.2 (4.7)	35.9 (3.7)
Professional category			
Nurse	9 (30)	8 (27)	11 (37)
Nurse practitioner	2 (7)	2 (7)	3 (10)
Charge nurse	3 (10)	4 (13)	4 (13)
Associate chief nurse	3 (10)	2 (7)	3 (10)
Chief nurse	1 (3)	0 (0)	1 (3)
Doctor	21 (70)	22 (73)	19 (63)
Resident doctor	2 (7)	2 (7)	3 (10)
Attending doctor	8 (26)	9 (30)	8 (26)
Associate chief doctor	6 (20)	8 (26)	5 (17)
Chief doctor	5 (17)	3 (10)	3 (10)
Years of working experience			
< 10 y	11 (37)	10 (33)	13 (43)
≥ 10 y	19 (63)	20 (67)	17 (57)

significant differences compared with the other 2 groups. On comparing reported levels of eye irritation among the 3 groups, participants who wore the goggles treated with distilled water and antibacterial hand sanitizer reported little to no eye irritation (control vs antibacterial hand sanitizer, $F = 0.517$, $P > .05$; Figure 4C). The iodophor solution group reported more irritation to the eyes than the other 2 groups (vs control, $F = -5.069$, $P < .01$; vs antibacterial hand sanitizer, $F = -4.552$, $P < .01$; Figure 4C).

Finally, the 3 groups of clinical staff rated whether the different treatments of goggles interfered with medical care. Lower rating levels indicated higher interference. The control group reported the lowest rating and reported the highest interference with medical care related to fogging, indicating severe interference with medical care. The iodophor group reported a better rating than the control group ($F = 4.464$, $P < .01$; Figure 4D). The antibacterial hand sanitizer group reported the highest rating compared with the other 2 groups. The antibacterial hand sanitizer did not interfere with medical care (vs control, $F = 6.500$, $P < .01$, vs iodophor solution, $F = 2.036$, $P < .01$; Figure 4D). Our dedicated statistician summed the 4 scores above, which revealed that the control group had the lowest overall score and the iodophor solution group had a better overall score than the control group ($F = 4.1786$, $P < .01$; Figure 4E). However, the antibacterial hand sanitizer group had the highest overall score, significantly better than the other 2 groups (vs control, $F = 17.4643$, $P < .01$, vs iodophor solution, $F = 13.2857$, $P < .01$; Figure 4E).

Discussion

Our innovative study was designed as a randomized, single-blind controlled study. Frontline clinicians caring for COVID-19 patients wore goggles pretreated with 3 solutions (distilled water, iodophor solution, and antibacterial hand sanitizer) to measure the fogging of the goggles. The results of our study suggest that goggles pretreated with the antibacterial hand sanitizer (diluted with distilled water at a 1:1 ratio) were the most effective at preventing fogging after 4 hours.

Numerous reports claim that the eyes may be the gateway for COVID-19 to invade the body and that the virus can cause infection through the conjunctiva.[17,18] One of the current requirements of the Chinese government for medical staff caring for patients infected with COVID-19 is to maintain eye protection. In China, wearing goggles is an integral part of the daily routine of health care workers in the COVID-19 ward. In addition, the more acutely ill and infectious patients are admitted to isolation wards, so clinical staff working in isolation wards are required by the government to use goggles rather than face shields. Adequate safety measures to avoid exposing the eyes to hazardous environments can effectively interrupt the spread of COVID-19 and protect emergency clinicians on the front lines performing endotracheal intubation, cardiopulmonary resuscitation, and other life-saving medical procedures.[5]

However, the goggles currently used can easily fog, creating issues for staff during their clinical work. Owing to temperature differences between the inner and outer surfaces of the goggles, moist, warm air emitted from staff during respiration can condense into tiny droplets on the inner surface, which obscures the clarity and visibility of the

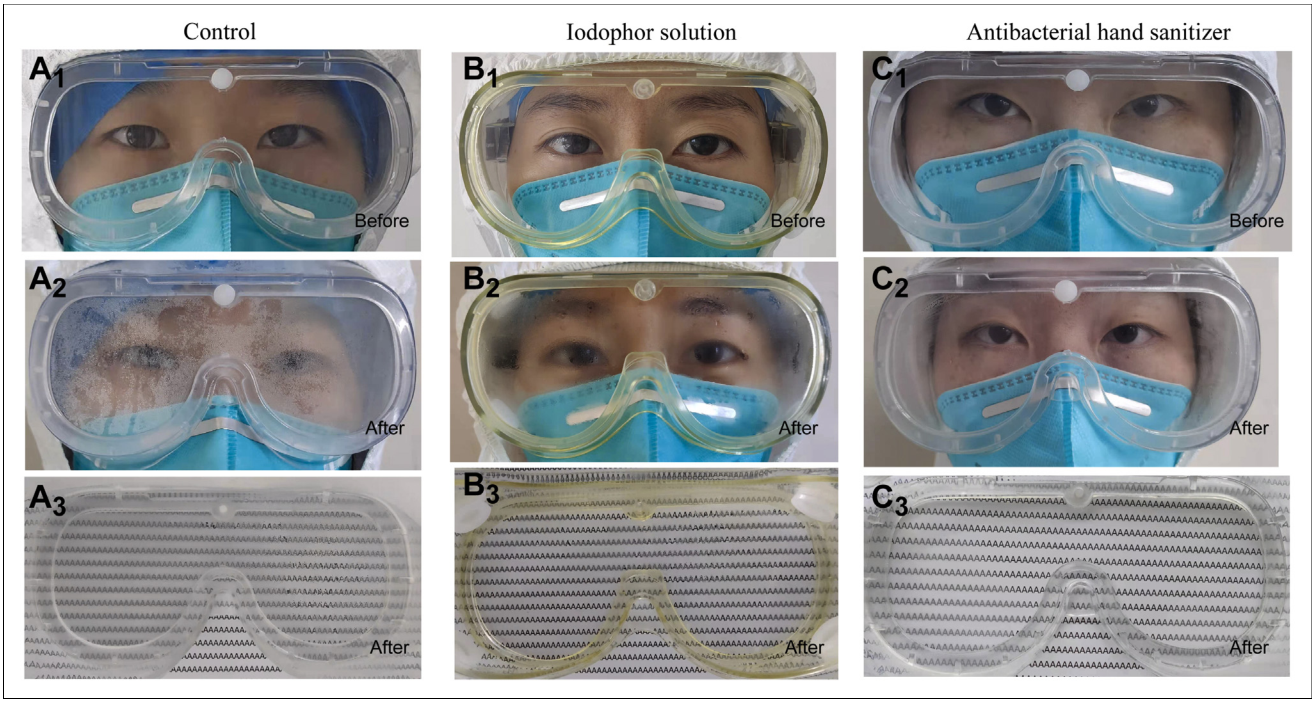

FIGURE 3

Comparison of the degree of fogging of goggles among the 3 groups of health care workers. (A) Comparison of the control group before and after 4 hours of goggle wear (1-3). (B) Comparison of the iodophor solution group before and after 4 hours of goggle wear (1-3). (C) Comparison of the antibacterial hand sanitizer group before and after 4 hours of goggle wear (1-3).

goggles and can seriously compromise the safety of patient care.[19] In addition, the fogging of goggles can blur the vision of the clinician.[20] Some health care workers may also experience eye strain, dizziness, nausea, and vomiting, which directly affect the efficiency and safety of health care workers.[13] Effectively preventing fogging of goggles can enhance the protection of health care workers caring for patients acutely infected with COVID-19.

Few studies have been conducted on antifogging measures for goggles worn during COVID-19. Provided that COVID-19 is still widespread worldwide,[21] there is an urgent need for effective antifogging measures of goggles. One study, which interviewed health care workers and searched databases, concluded that using washing-up liquid or hand sanitizer is the most effective method for preventing goggles from fogging.[12] However, the above findings are empirical attempts,[9-11] and there are no randomized controlled trials on the effectiveness of several pretreatment methods to reduce goggle fogging. Antifogging agents and detergents used for swimming goggles may also be effective for medical goggles.[10,22] However, these antifog sprays need to be purchased separately, may be cost prohibitive,[10] and may not be readily available or feasible to purchase in rural or under-resourced settings. In the hospital/unit of study, antifog sprays were not commonly available or in stock and were not easily accessible. Therefore, iodophor solution and antibacterial hand sanitizer were compared in this study, as both items were easily accessible in the COVID-19 wards.

In our study, both iodophor solution and antibacterial hand sanitizer showed more effective antifogging than the control group (distilled water). The main component of the iodophor solution is polyvinylpyrrolidone iodine, which is smooth. It can form a protective film on the surface to provide an antifogging effect and is more commonly used in laparoscopic lens antifogging.[23] However, in the application of iodine for laparoscopic antifogging, it was found that there may be several problems after iodophor solution application: (1) this method is effective for antifogging for the first 30 minutes after application, but the effect is poor after 30 minutes; (2) iodophor solution is a colored liquid, which may affect the operator's judgment of the color of intra-abdominal organs when providing clinical care; (3) this method is not suitable for people who are allergic to iodine. Our study confirmed the above problems when using iodine-treated goggles. In this study, pretreatment of the goggles with iodophor solution prevented fogging of the goggles for a brief period.

TABLE 2
Comparison of the degree of fogging of goggles among the 3 groups of health care workers

Area	Control group, (n = 30), n (%)	Iodophor solution group, (n = 30), n (%)	Antibacterial hand sanitizer group, (n = 30), n (%)	χ^2	P value
Dense fog covers < 30% of the goggle area	0 (0)	5 (17)*	13 (43)†‡	17.917	.000
Dense fog covers 30%-50% of the goggle area	2 (7)	8 (27)*	12 (40)*	9.144	.003
Dense fog covers 50%-80% of the goggle area	9 (30)	10 (33)	4 (14)	3.621	.164
Dense fog covers > 80% of the goggle area	19 (63)	7 (23)*	1 (3)†‡	26.667	.000

* $P < .05$ vs control group.
† $P < .01$ vs control group.
‡ $P < .05$ vs iodophor solution group.

However, as the working time increased (generally after 2 hours), participants reported the iodophor solution coated goggles gradually fogged up. The reason for this may be that the active ingredients of the iodophor solution evaporate, resulting in poor light transmission and visual field loss. Our study also found that the goggles had a teal color after the application of iodine vapor, which affected the vision of the medical staff. Notably, the goggles were found to irritate the eyes after the application of iodine vapor, further aggravating the discomfort of the health care staff and thus affecting their medical work. Contrastingly, the main ingredient of antibacterial hand sanitizer is chlorhexidine gluconate. It is a surfactant that reduces the surface tension of water droplets, provides an antifog effect when applied to goggles, and has non-volatile properties.[24] In our study, the antifog effect and antifogging time of goggles which were internally coated with antibacterial hand sanitizer were significantly better than that in the iodine voltage-coated group. It is also relatively inexpensive and simple to use, and the treated goggles have good transparency, less impact on vision, and were reported to be gentle and non-irritating by the participants. Notably, one of the non-negligible advantages of pretreating goggles with antibacterial hand sanitizer diluted with distilled water is that the material is readily available in the hospital environment and easily accepted and used by health care workers.

STRENGTHS

It is worth mentioning that our study tested a solution that is readily available in most health care facilities that may allow clinical staff to wear goggles continuously for a 4-hour work period. Test intervals of various time lengths have been implemented in existing studies to assess the effect of different pretreatment methods on fogging of goggles.[15] The reason we designed the goggles to be worn for 4 hours is based on the shifts (4 hours in the morning and 4 hours in the afternoon) that Chinese hospital staff work in isolation wards. We designed this trial to investigate a more suitable method of preventing goggle fogging for our specific working hours. In the future, we will consider further modifying the study protocol to consider the effects of time intervals and different roles and workloads on goggle fogging.

Limitations

There are some limitations to this study. For example, this was a single-center clinical study with a small sample size (n = 90). Therefore, a multi-center, large sample clinical study is needed to further validate the antifog effect of antibacterial hand sanitizer on goggles. We designed the trial with the intention of enrolling an all-nurse sample, but during recruitment, we were unable to recruit sufficient numbers of eligible nurses. In order to further investigate the antifog effect of different solutions in different roles and divisions of work, the target group was modified to include providers in addition to nurses. This study is part of a larger research project, which will be followed by a study on the development and application of functional protective gear specifically for nurses. It is notable that our sample contained primarily emergency nurses and providers (Figure 5). Moreover, since this study was performed to determine the single-time use of different agents, the effect on glasses with regular use needs to

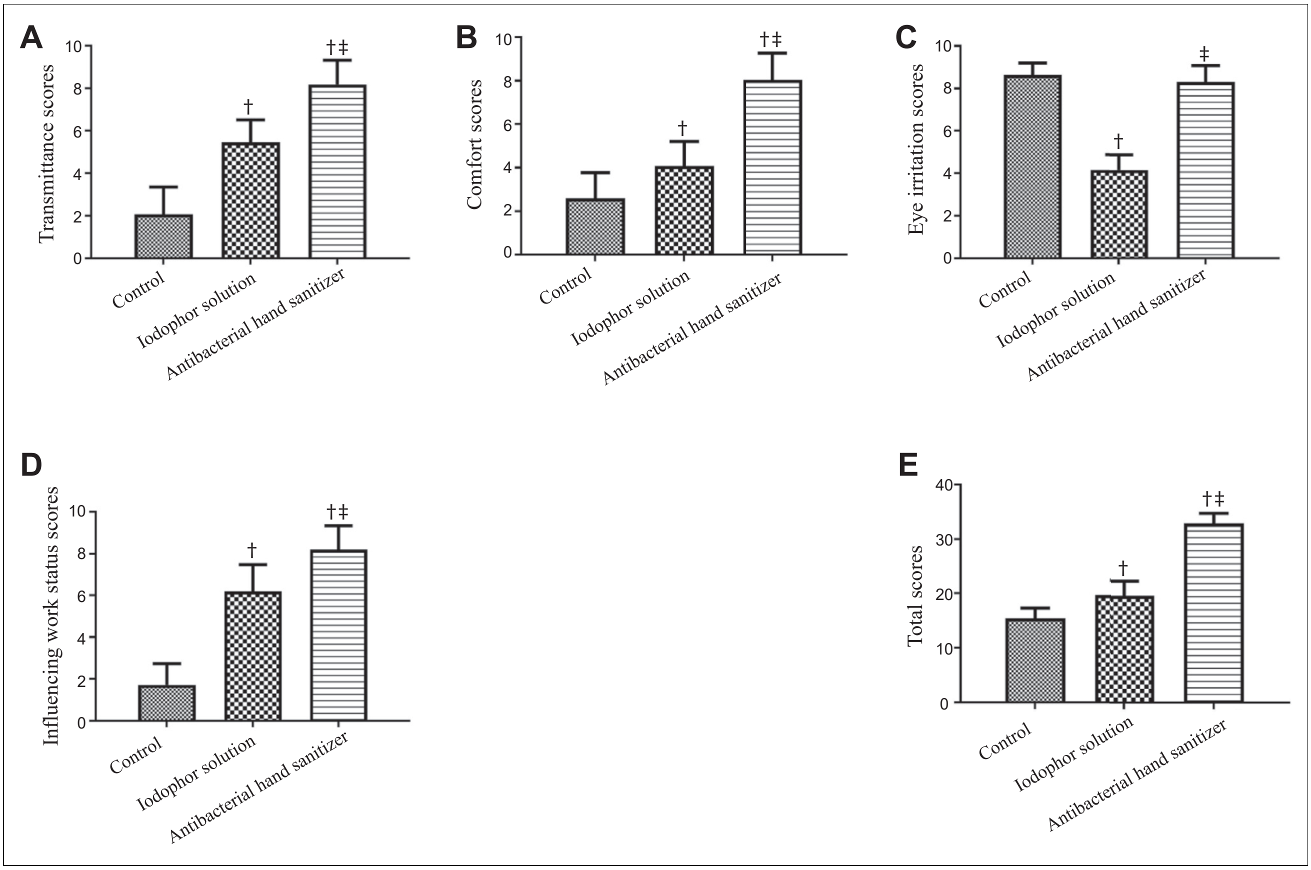

FIGURE 4

Results of the questionnaire for the 3 groups of health care workers. (A) Comparison of the transmittance scores of the 3 groups of goggles. (B) Comparison of goggle comfort scores among the 3 groups of health care workers. (C) Comparison of the eye irritation scores in 3 groups of health care workers (lower score indicates higher levels of irritation). (D) Comparison of the 3 groups of health care workers' self-perception of whether wearing goggles would interfere with their medical work (lower score indicates higher levels of interference). (E) Comparison of the total scores of the 3 groups. Data are presented as means (SD). $^{*}P < .05$ vs control group. $^{\dagger}P < .01$ vs control group. $^{\ddagger}P < .01$ vs iodophor solution group.

be studied with longer follow-up. The fogging degree can also be impacted by perspiration from the participants. Strenuous or high workloads in the isolation ward may have influenced our results. Although we have tried to ensure consistency in the nature of work of the participants (all work in the COVID-19 isolation ward), a participant's workload is likely to be affected by their role (Figure 5).

Implications for Emergency Nurses

Our study has important implications in an emergency clinical practice setting. In the context of the current global epidemic of COVID-19, the number of seriously ill patients continues to increase worldwide. Health care professionals, especially emergency nursing staff, need to be able to safely and efficiently practice on the front lines. The fogging of goggles significantly impedes patient care. This finding of our study can help prevent the fogging of medical goggles and facilitate the work of health care workers worldwide in the fight against COVID-19, especially for emergency nurses and providers who need to wear goggles for extended periods of time.

Conclusion

In summary, in the practical application of COVID-19 medical work, the use of antibacterial hand sanitizer (with chlorhexidine gluconate as the main active ingredient) diluted at a ratio of 1:1 with distilled water and internally applied to goggles was effective in preventing fogging compared with iodine and distilled water alone. Frontline clinical staff reported a clearer view through their goggles after using goggles treated

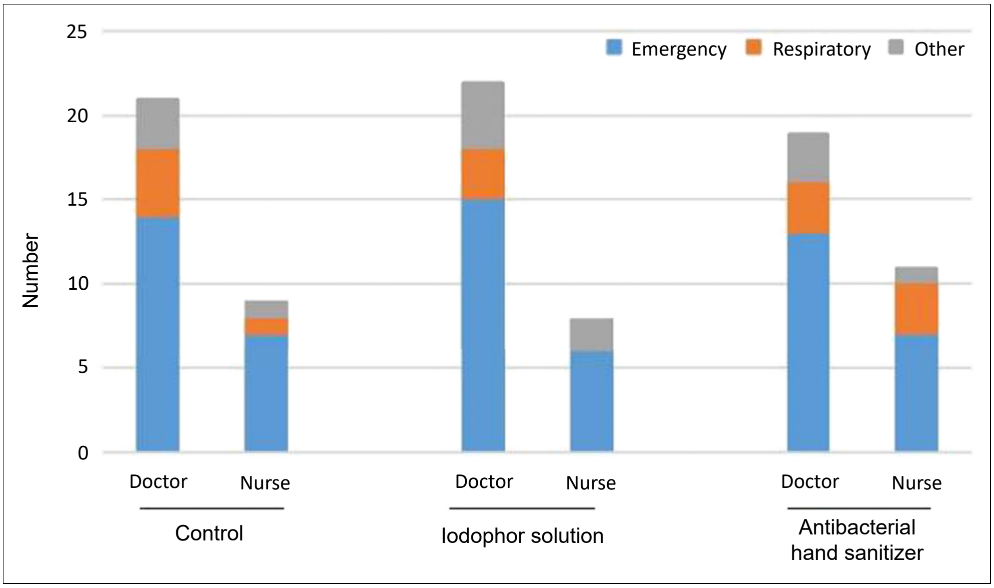

FIGURE 5

Descriptive visualization of roles of participants. Emergency, emergency department nurses, and providers; Respiratory, respiratory department nurses and providers; Other, nurses and doctors from other departments, including cardiology, gastroenterology, etc.

with antibacterial hand sanitizer diluted with distilled water. In addition, because of easy access to the materials involved, this method is easily accessible to clinical staff and could be easily reproduced in other clinical settings.

Data Availability Statement

All data generated or analyzed during this study can be made available. Further enquiries can be directed to the corresponding author.

Statement of Ethics

This study was approved by the Ethics Committee of the 900 Hospital of the Joint Logistics Team (2021-008) and performed per the revised Declaration of Helsinki principles. The trial has been registered in ClinicalTrials.gov (registration number ChiCTR2100054392).

Author Disclosure

Conflicts of interest: none to report.

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Appendix

Questionnaire on fogging of 3 goggle pretreatment methods in isolation area

1. What is your gender
A. Male B. Female

2. What is your professional role
A. Doctor B. Nurse

3. Your age

4. Your length of time employed

5. What is your highest educational background
A. Master degree or above

B. Undergraduate degree

C. Junior college

D. High school / technical secondary school and below

6. How long do you wear goggles at one time (hour)
A. 1-2 hours B. 3-4 hours C. 5-6 hours D. more than 6 hours

7. Is there fog when wearing goggles?
A. Yes B. No

8. When does fogging start while wearing goggles?
A. 0-1 hour B. 1-2 hours C. 2-3 hours D. 3-4 hours E. more than 4 hours

9. Is wearing goggles irritating to the eyes?
A. Yes B. No

10. What is your comfort score when wearing goggles? (10 points: very comfortable without affecting any medical care work;

7-9 is relatively comfortable, and the general medical care work is not affected;

4-6 moderate comfort, affecting a small part of medical care work,

1-3 uncomfortable, seriously affecting medical care;

0 is very uncomfortable, which completely affects the medical and nursing work)

Comfort level

10 9 8 7 6 5 4 3 2 1 0

11. What is your professional title?