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ORIGINAL RESEARCH

COVID-19 Emergency Department Protocols: Experience of Protocol Implementation Through in-situ Simulation

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Purpose: During the outbreak of Coronavirus disease of 2019 (COVID-19), the preparedness of emergency departments (EDs) for triaging of the patients and safety of staff is of utmost importance. The aim of our study was to develop and implement COVID-19 ED triage and protected intubation protocols for COVID-19 patients with in-situ simulation (ISS) training. The latent safety threats (LST) detection also served as a platform to test new system amendments and refine the protocols and workflows with infection control issues. We also explored the effectiveness of this approach based on Kirkpatrick's model of evaluating training outcomes.

Participants and Methods: The protocols and simulation scenarios were developed and validated. A total of 22 triage and 13 intubation simulation sessions were conducted in the ED with multidisciplinary staff (physicians=18, nurses=20) during a period of four months. Each simulation was followed by a debriefing session to discuss the team performance. Pre- and post-simulation performances were compared. LSTs were identified and remediated. An online voluntary feedback was collected from the participants to explore the opinion about the ISS sessions and confidence level using a 5-point Likert scale.

Results: There was a significant improvement in triage knowledge score after ISS [5.5/10 (IQR 4–6) versus 8.5/10 (IQR 8–9), p<0.001]. There was a desirable proportion of correct responses (>75%) following the ISS for triage case scenarios. A pre-designed checklist was used during protective intubation simulations. Some important LSTs were missing medications, lack of mechanism to deliver patient samples to lab and faulty airway maneuvers. The participants' feedback on ISS showed increased skills and confidence level on triaging and protected intubation (p<0.001). They found the protocols easy to follow and they recommended for more such modules in future.

Conclusion: ISS is a quick and efficient tool to implement the ED protocols for preparation of outbreaks like COVID-19. It helps the ED staff to triage and manage the airway safely. We recommend such an approach to train the multidisciplinary staff and continue to improve ourselves through ISS addressing the changing nature of the pandemic.

Keywords: airway management, emergency department, in situ simulation, intubation, latent safety threats, triage

Introduction

COVID-19 is a new challenge of 2020 with the first reported case of pneumonia of unknown etiology on December 31, 2019 in Wuhan, China. [1] Globally, as of September 30, 2020, there are 7,710,077 active cases, 1,018,211 deaths and 25,422,273 recovered cases. [2] China and India, the two geographically linked

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countries to Nepal, have witnessed and utilized their resources to maximum capacity to fight against COVID-19.[3,4] Nepal had its first imported case of COVID-19 which was reported by WHO on January 25, 2020[5] and first reported death due to COVID-19 on May 14, 2020.[6,7] As of September 30, 2020, there are 20,891 active cases, 498 deaths and 56,428 recovered cases.[8] Nepal responded with a nationwide lockdown from March 24, 2020.[9] Nepal was graded by the WHO Health Emergencies (WHE) Program as one of the countries in the South East Asia Region prioritized for support based on hazard, vulnerability and capacities.[10]

During this outbreak, with a surge in COVID-19 suspected cases and anxiety among the staff, the preparedness of emergency departments (EDs) for triaging of the patients and safety of staff is of utmost importance. As a response to this situation, Dhulikhel Hospital-Kathmandu University Hospital (DH-KUH) made some major changes in its operation system. Additional round the clock triage checkpoints to screen all the personnel entering the hospital, redistribution, and reallocation of staff to boost additional services like fever clinic and isolation area were some major changes. EDs in low-income countries like Nepal are still in the preliminary phase and more so, many hospitals lack proper emergency facilities and disaster preparedness.[11] EDs are generally prepared to deal with mass casualties secondary to road traffic accidents but lack preparation and experience for chemical, biological, radiological, nuclear, and explosive (CBRNE) incidents. A report from Nepal shows that the overall preparedness of legal framework, coordination, organizational structure for natural, biological, technological and man-made disasters meets 67% of the required benchmark.[12]

ED is a vulnerable area within the hospital with the major flow of patients. Given the challenge of COVID-19 outbreak, a modified protocol for triage and treatment is needed where non-COVID-19 cases need to be segregated from suspected COVID-19 patients. Redistribution and reallocation of staff with little or no prior experience in triage concept to ED from other departments requires a simple, easy to execute triage protocol. Several resources are available; however, proper, and accurate execution of such protocols is crucial. Intubation of the COVID-19 patients possesses a particular risk to the staff due to aerosolization. There are few international recommendations on protected intubation[13–19] for suspected COVID-19 patients which were adapted according to the available resources. These standardized protocols can reduce variation in care, enhance patient flow and management through available evidence. These contextual protocols can be implemented through deliberate practice in the actual workplace with the multidisciplinary staff working during their duty hours utilizing the available resources via in situ simulation (ISS).[20] Latent safety threats (LSTs) are system-based threats to patient safety that can occur at any time and are generally unrecognized by healthcare providers in day-to-day clinical practice. The identification of the LSTs is one of the targets of the ISS which can help rectify the system errors.[21] Our previous experience showed that LSTs are common.[20] The “rapid cycle deliberate practice” to focus on rapid acquisition of new skills through “learn while doing” by ISS builds staff preparedness in a timely manner for epidemic preparedness.[22,23]

“Emergency Medicine Protocol Development and Implementation Through Simulation in Nepal” is a collaborative project between Kathmandu University School of Medical Sciences (KUSMS) and Medical College of Wisconsin (MCW) awarded by the Sustaining Technical and Analytic Resources (STAR) collaboration laboratory [supported by the United States Agency for International Development(USAID)], a project of the Public Health Institute, in collaboration with the Consortium of Universities for Global Health (CUGH).[24] Several other protocols had been developed and implemented in the ED under this collaborative work.

The primary outcome of this article is to disseminate the ED triage and protected intubation protocols tailored to address COVID-19 at EDs in low resource settings and describes the experience with ISS in implementing these protocols. These protocols may further be implemented in other departments and institutions as a preparation for the influx of COVID-19 patients. The secondary outcomes are to describe the LSTs leading to corrective measures taken to improve our COVID-19 response and to explore the effectiveness of ISS using levels of Kirkpatrick’s model of evaluating training outcomes (reaction, learning, behavior change and results).[25]

Materials and Methods

Study Setting and Participants

We conducted a prospective quasi-experimental study with mixed methods. The study was conducted in the ED triage area and the ED Acute respiratory Infection (ARI) zone of DH-KUH. The multidisciplinary healthcare providers, both current and reallocated, in the ED triage area and the ARI zone participated in the study. They participated in the simulation sessions during their duty hours. The feedback was online and voluntary.

Study Procedure and Data Collection Tools

After ethical approval by the Institutional Review Committee (IRC) for the ED protocol development project under STAR project (IRC number 242/19), the researchers developed ED protocols for the COVID-19 pandemic situation. The triage and protected intubation protocols were developed based on the national guidelines,[26,27] WHO guidelines[28] and various updated guidelines on intubation during COVID-19 pandemic.[13–19] The protocols (Supplement 1 and 2) were developed by the authors and were discussed with the ED faculties and staff. Series of virtual online meetings and onsite discussions were done with the experts for content and face validation. From March 30, 2020, series of ISS sessions were conducted in the newly identified COVID-19 - specific triage area and ARI zone (Figures 1 and 2) following pilot testing. The simulations were conducted by the ED faculties who had past trainings and experience in conducting simulations.[20,29,30]

For triage ISS, we designed case scenarios of the patients arriving in the ED falling under different triage categories (Supplement 3a). The triage personnel interviewed the simulated patients (SiP) portraying various case scenarios and the participants had to allocate the SiP to the appropriate zones (Figure 3). The performance of the triage personnel was recorded. As per the updates and changes in national and WHO guidelines, the triage protocols were updated and disseminated (Supplement 1).

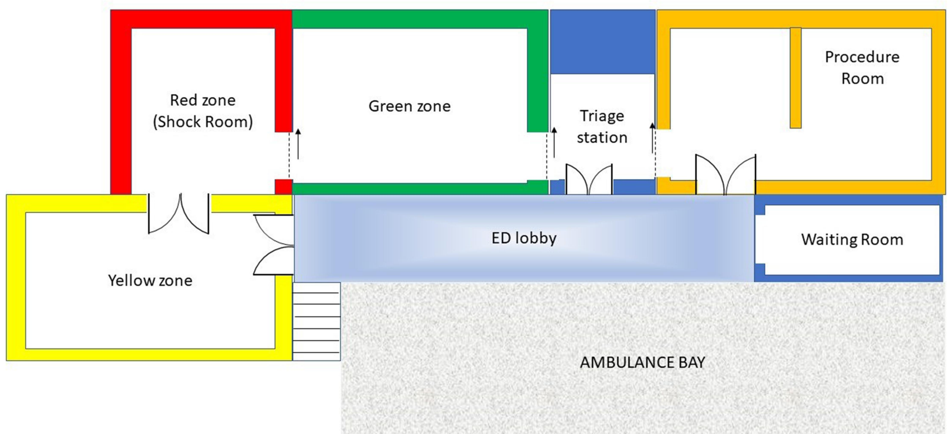

Figure 1 Various zones in the Emergency Department before COVID-19 outbreak.

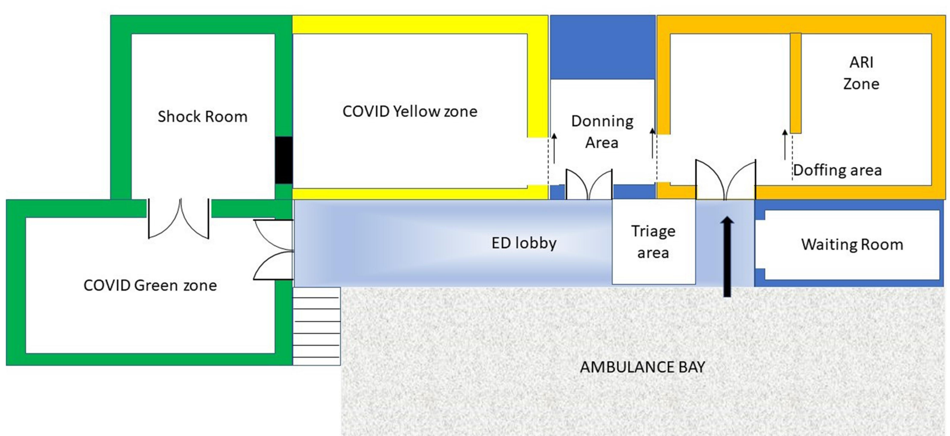

Figure 2 Re-designated triage and ARI areas in the Emergency Department.

Figure 3 (**A**) Triage officer interviewing a simulated patient. (**B**) The multidisciplinary ED staff discussing the triage algorithm for COVID-19.

For implementation of the COVID-19 protected intubation protocol (Supplement 2a and 2b), a case scenario (Supplement 3b) was designed where an acutely unwell patient with fever and SOB presented to the ED requiring intubation. An intubation manikin was used for this purpose. Participants utilized the equipment available in the ARI zone (Figure 4). This case tested the preparedness of the multidisciplinary staff posted in the ARI zone, equipment and the safety in regard to infection prevention during the aerosol generating procedures. The participants followed the mandatory donning and doffing protocols (Supplement 2c and 2d) of level 3 PPE prior and after each airway simulation session. The performance of the team was recorded based on the protected intubation protocol. The LSTs were divided into equipment/medication, individual and system errors based on a debriefing template (Supplement 4). Each simulation session was followed by a debriefing session in which the performance of the team was discussed (Figure 5). Further discussions were then held within the faculties and appropriate remediation was undertaken after each simulation session.

The effectiveness of this training approach was evaluated with the levels of Kirkpatrick model of evaluating training outcomes. The participants' evaluation of the ISS sessions and their self-reported change in skills and confidence levels before and after the simulation sessions were collected within a week time of session via an online feedback form (Supplement 5). Their opinion on these

Figure 4 Instructor familiarizing the multidisciplinary staff with protected intubation protocol.

Figure 5 Debriefing session after the protected intubation protocol ISS.

simulation sessions was described and the pre- and post-simulation self-reported confidence level and skills to manage such cases in real patients were compared.

Data Analysis

The data were entered in Microsoft excel and statistical analysis was performed with SPSS version 21. Categorical values were expressed as proportion and continuous values as mean with standard deviation or median with interquartile range. The pre- and post-simulation scores were expressed as median and compared with Wilcoxon signed rank test. The pre- and post-simulation scores were compared in relation to occupation using independent samples Mann–Whitney U-test. The self-perceived pre- and post-simulation confidence level was rated using 5-item Likert scale and compared using Wilcoxon signed rank test. The open comments from the participants were coded and themes were generated by two authors.

Results

Participants

In the period between March 30–July 30, 2020, 22 triage sessions and 13 airway management ISSs were conducted with a total of 38 participants {[ED=33 (86.8%) and non ED=5 (13.2%)] and [male 21 (55.3%), female 17 (44.7%)]}. The five non-ED staff participated in triage sessions and 33 ED staff participated in both the sessions. Among them 18 (47.4%) were physicians, and 20 (52.6%) were nursing/paramedics. We included only ED staff for airway management sessions; among them, 18 were physicians and 15 were nurses/paramedics. The participant details are summarized in Table 1.

Table 1 Participants' Details, N= (38)

Variables	n (%)
Gender	
Female	17 (44.7)
Male	21 (55.3)
Department	
ED	33(86.8)
Non-ED	5(13.2)
Profession	
Physician	18 (47.4)
Nurse/paramedic	20 (52.6)
Topic	
Triage	5 (13.2)
Both	33 (86.8)

Abbreviations: n, number of participants; ED, emergency department.

Triage Scenarios ISS

There were a total of ten triage case scenarios (Supplement 3a). The median pre-simulation triage score was 5.5 (IQR 4–6) and the post-simulation score was 8.5 (IQR 8–9). The difference in the pre- and post-scores was statistically significant (Wilcoxon signed rank test, p<0.001) (Figure 6). The difference in pre-simulation scores for the triage protocol between nurses/paramedics and physicians was not statistically significant [5(4–6) versus 6 (4–6); p-=0.806]. Similar findings were true for post-simulation scores [8.5 (7–9) versus 8.5 (8–9); p=0.478]. The details of pre- and post-simulation responses to individual triage cases (Supplement 3a) are depicted in Table 2.

Airway Management ISS

A total of 13 airway management simulation sessions were conducted and 33 multidisciplinary ED staff participated (Supplement 3b). During the sessions, various LSTs were identified which are illustrated in Table 3.

Self-Reported Feedback

The participants' evaluation of the ISS sessions and their self-reported change in skills and confidence levels before and after the simulation sessions are summarized in Figure 7 and Table 4. All of them agreed that the ISS had potential to identify errors within the clinical environment. The difference in self-reported pre- and post-simulation confidence level and skill in both triage and protected airway management was statistically significant.

Common themes and verbatims from the staff on ISS sessions are as follows:

Knowledge and skills practice: "made me aware of essential steps", "great approach to preparedness for COVID-19", "useful and necessary in today's context", "repeated practice helped spontaneity in critical actions".

Confidence of staff: "made me confident", "more challenging cases we simulate, more fluent we become in our practices", "More practical experience gained after multiple sessions of simulation, and it decreases anxiety".

Safety issues: "helped all the participants how to apply safety measures and work safely", "very useful donning and doffing practice: we won't know until we do it".

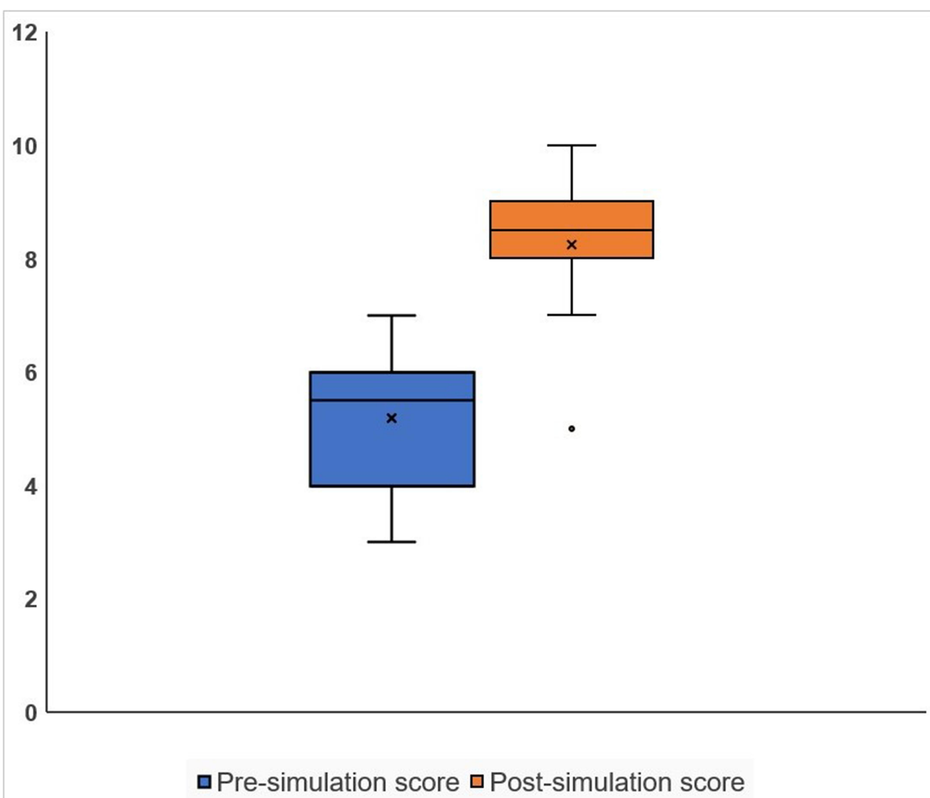

Figure 6 Box plot of pre- and post-simulation score for triage simulation sessions.

Table 2 Pre- and Post-Simulation Responses to Individual Triage Scenarios (N= 38)

Triage Case Scenarios [a]	Pre-Simulation, n (%)		Post-Simulation, n (%)	
	Correct	Incorrect	Correct	Incorrect
Case 1	28 (73.7)	10 (26.3)	37 (97.3)	1 (2.7)
Case 2	17 (44.7)	21 (55.3)	35 (92.1)	3 (7.9)
Case 3	14 (36.8)	24 (63.2)	36 94.7)	2 (5.3)
Case 4	10 (26.3)	28 (73.7)	37 (97.3)	1 (2.7)
Case 5	25 (65.8)	13 34.2)	37 (97.3)	1 2.7()
Case 6	24 (63.2)	14 36.8)	34 (89.5)	4 (10.5)
Case 7	21 (55.2)	17 (44.8)	30 (78.9)	8 (21.15)
Case 8	23 (60.5)	15 (39.5)	34 (89.5)	4 (10.5)
Case 9	19 (50.0)	19 (50.0)	32 (84.2)	6 (15.8)
Case 10	20 (57.1)	18 (42.9)	33 (86.8)	5 (13.2)

Note: [a]Supplement 3a.
Abbreviation: n, number of participants.

Optimization of logistics and environment: "need suitable environment for COVID-19 patient as well as visitors", "some equipment need improvement", "negative pressure room to manage COVID-19 cases", "need to extend the EHR system to the newly identified ARI zone".

Team approach: "team-based crisis management", "learned how to communicate with the team while wearing a N95 mask and face shield!".

Updates to the protocols: "address the protocols regarding the ongoing updates", "Other updates to be in place as the transmission of the disease increases", "inclusion of prehospital protocols".

Discussion

This study has provided us with a unique opportunity to aid in the preparedness of the emergency department in the COVID-19 pandemic. The COVID-19 related protocols on triage and protected intubation prepared the ED staff during the first recorded COVID-related mortality in Nepal[7] and subsequent cases which were managed by the ED team. The simulated cases were designed to assess and improve team preparedness for safe and effective care of a COVID-19 suspected patient from triage. The personal and team safety with a potentially airborne dissemination procedure (airway management) requiring full personal protective equipment was practiced. This ISS-based training focused on system processes more than just individual skills. It provided an opportunity to test the new protocols,

Table 3 Examples of LSTs and Opportunities for Improvement Identified by in situ Simulations for Protected Airway Management

Latent Threat Category	Examples of Threat	Identifying Sources
Medication	• Rocuronium missing • Vasopressors missing • Inventory of emergency medication not maintained	Nurse Paramedic
Equipment	• Resuscitation set-up not user friendly • Inappropriate size of bougie • Freshly relocated manual defibrillator lacks compatible electricity port • Infusion set/pump missing • Correct sized BVM bag and masks missing • LMAs missing • Portable Xray unit missing • Fogging of the goggles/visor	Physician Nurse
Resources/System	• Lack of mechanism to deliver samples to the lab • Proper waste disposal from the suction unit unclear	Physician
Individual	• Faulty airway maneuvers • Wrong dose calculation of Rocuronium • Inadequate donning	Physician Nurses
Miscellaneous	• Knowledge gap regarding when and how to properly don and doff PPE • Additional human resources when the number of critically ill suspected cases increase with the progress of pandemic not identified. • Additional surge capacity for the ARI zone not identified	Physician

Abbreviations: BMV, bag mask ventilation; LMA, laryngeal mask airway; PPE, personal protective equipment.

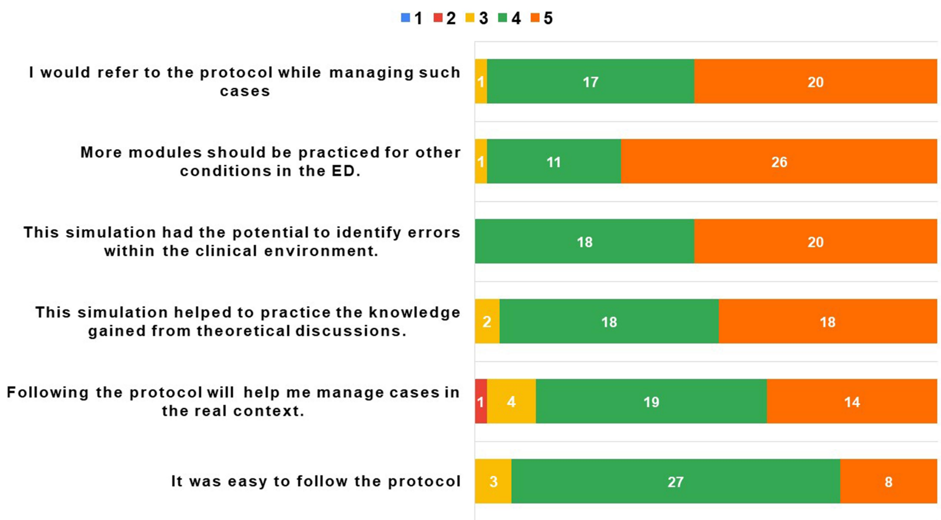

Figure 7 Participants' evaluation of ISS (on a Likert scale of 5; 1 denoting "disagree" and 5 denoting "agree").

deliberate practice, and system changes, while observing LSTs and possible solutions without any additional cost. The study demonstrated that ISS provides a unique opportunity to increase the confidence level and skills of multidisciplinary staff which was also demonstrated in our previous study.[20]

Our previous experience with such pandemics was scarce. We had limited time to prepare for the increased surge of the suspected cases and safety of our staff was the major concern. In situ simulation is a quick and efficient way to train the multidisciplinary staff where they are exposed to real-life-like scenarios and allowed to make mistakes; hence, the concept of "learning by doing" is practiced in ISS. Developing and disseminating COVID-19 protocols referring to various publications from affected countries would only address the first level of the Bloom taxonomy of learning.[31] We had limited time to train the staff, so we decided to focus on "learning while doing", implementing simulations in the actual workplace with the multidisciplinary ED health care providers in duty. Thus, the higher level of Bloom taxonomy (applying and analyzing) was targeted. Andreae et al report in their study that immersive simulation utilizing tabletop exercises can be conducted to train clinicians and to test protocols for novice clinicians in context of rapidly expanding CVOID-19 pandemic.[32] Simulation has also been utilized to test the alternative methods to increase the ventilator support capacity to address the shortage of ventilators in this pandemic.[33]

The authors describe the "simzone" framework in an article to guide the simulation training developers.[34] Four zones have been proposed. Our simulation sessions encompass zone 3 and 4 where the simulation was employed for the purpose of team and system development. The participants were the native teams of the triage area or ARI zone who worked together in their real shift. We used double-loop learning[35] focusing development of shared understanding within the multidisciplinary team. The structured debriefing sessions followed each simulation session which enabled team involvement. The inputs from the participants also helped in refining the protocols and appropriate system change for better and safe management of COVID-19 suspected patients.

The pre- and post-simulation triage score was not different in relation to the occupation. The improvement was significant for all subgroups. The LSTs that were identified in the ISS were communicated with the participants and remediated immediately post-session. The feedback from

Table 4 Self-Reported Pre- and Post-Simulation Change in Skills and Confidence Level

	Pre-Simulation, Median (IQR)	Post-Simulation, Median (IQR)	P value [a]
Triage skill, n=38	1(1–2)	4(4–5)	<0.001
Airway skill, n=33	2(1–2)	4(3–4)	<0.001
Triage confidence level, n=38	1(1–2)	4(3–4)	<0.001
Airway confidence level, n=33	1(1–2)	4(3–4)	<0.001

Note: [a]Wilcoxon signed rank test.
Abbreviations: IQR, interquartile range; n, number of participants.

the participants was encouraging and the suggestions were considered for future protocols and ED setting.

Limitations

This article has reported the preliminary phase of the preparation; therefore, the number of simulations and the participants was limited. This was not a randomized study.

Conclusion

This study demonstrated enhanced triage knowledge of the multidisciplinary staff after participation in ISS. The baseline knowledge and skill scores including the self-reported confidence level of the staff for triaging and protected airway management for COVID-19 were low. The self-reported enhancement in the technical skills and confidence level was significant.

In-situ simulation is a quick and efficient tool to implement the ED protocols for preparation of outbreaks like COVID-19. It helps the ED staff to triage and manage the airway safely. We recommend such an approach to train the multidisciplinary staff and continue to improve ourselves through simulations with detection of LSTs as in our study addressing the changing nature of the pandemic. There should be a continuous effort to update the available protocols given the dynamic COVID-19 situation and to design more protocols in future and test them by conducting in situ simulation in the actual working area with the real working team members. The available resources should be utilized to fight this “battle” of COVID-19 where the “enemy” cannot be seen and predicted.

Abbreviations

ARI, Acute Respiratory Infection; BMV, Bag Mask Ventilation; CBRNE, Chemical Biological, Radiational, Nuclear and Explosive; CUGH, Consortium of Universities for Global Health; DH-KUH, Dhulikhel Hospital-Kathmandu University Hospital; ED, Emergency Department; KUSMS, Kathmandu University School of Medical Sciences; IPC, Infection Prevention and Control; ISS, In situ simulation; IQR, Interquartile range; IRC-KUSMS, Institutional Review Committee, Kathmandu University School of Medical Sciences; COVID-19, Corona Virus Disease-2019; LMA, laryngeal mask airway; LST, latent safety threat; PPE, personal protective equipment; SiP, Simulated patient; STAR, Sustaining Technical and Analytic Resources; WHO, World Health Organization.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics and Consent Statement

Ethical approval was obtained from the Institutional Review Committee, Kathmandu University School of Medical Sciences (IRC-KUSMS number 242/19). The result of the scores was anonymous and confidential. The feedback form mentioned the voluntary participation, assured confidentiality/anonymity, and informed the possible dissemination and publication of the results. Participants and instructors in the images provided written informed consent for the images to be published.

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Author Contributions

APS and RS conceptualized the study. APS, RS and AS obtained ethical approval, performed data analysis, and wrote the draft manuscript. TS revised and provided valuable input to protocol design. All authors contributed to validation of the questionnaires, data analysis, drafting or revising the article, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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