ORIGINAL CLINICAL RESEARCH REPORT

A Developing Nation's Experience in Using Simulation-Based Training as a Preparation Tool for the Coronavirus Disease 2019 Outbreak

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BACKGROUND: The coronavirus disease 2019 (COVID-19) pandemic affected and overwhelmed many health care systems around the world at an unprecedented speed and magnitude with devastating effects. In developing nations, smaller hospitals were unprepared to face this outbreak nor had strategies in place to do so at the beginning. Here, we describe the preparation in an anesthetic department using simulation-based training over 2 weeks, as the number of cases rose rapidly.

METHODS: Three areas of priority were identified as follows: staff safety, patient movement, and possible clinical scenarios based on simulation principles in health care education. Staff was rostered and rotated through stations for rapid-cycle deliberate practice to learn donning and doffing of personal protective equipment (PPE) and powered air-purifying respirator (PAPR). For difficult airway management, Peyton's 4 steps for skills training and Harden's Three Circle model formed the structure in teaching the core skills. Several clinical scenarios used system probing to elicit inadequacies followed by formal debriefing to facilitate reflection. Finally, evaluation was both immediate and delayed with an online survey after 1 month to examine 4 levels of reaction, learning, behavior, and impact based on the Kirkpatrick Model. Frequency and thematic analysis were then conducted on the quantitative and qualitative data, respectively.

RESULTS: A total of 15 of 16 (93%) consultants, 16 (100%) specialists, and 81 (100%) medical officers in the department completed training within 2 consecutive weeks. Reaction and part of the learning were relayed immediately to trainers during training. In total, 42 (39%) trained staff responded to the survey. All were satisfied and agreed on the relevance of training. A total of 41 respondents (98%; 95% confidence interval [CI], 87-99) answered 16 of 20 questions correctly on identifying aerosol-generating procedures (AGP), indications for PPE, planning and preparation for airway management to achieve adequate learning. About 43% (95% CI, 27-59) and 52% (95% CI, 36-68) recalled donning and doffing steps correctly. A total of 92 responses from 33 respondents were analyzed in the thematic analysis. All respondents reported at least 1 behavioral change in intended outcomes for hand hygiene practice (20%), appropriate use of PPE (27%), and airway management (10%). The emerging outcomes were vigilance, physical distancing, planning, and team communication. Finally, the impact of training led to the establishment of institutional guidelines followed by all personnel.

CONCLUSIONS: Simulation-based training was a useful preparation tool for small institutions with limited time, resources, and manpower in developing nations. These recommendations represent the training experience to address issues of "when" and "how" to initiate urgent "medical education" during an outbreak. (Anesth Analg XXX;XXX:00–00)

KEY POINTS

- **Question:** How can simulation help our department be coronavirus disease 2019 (COVID-19) ready in 2 weeks with our limitations?
- **Findings:** Using principles of simulation, medical education and crisis resource management training, and institutional needs, we concentrated on areas that will have the highest impact on our department staff: staff safety, patient movement, and airway management.
- **Meaning:** Simulation is a useful tool to plan and practice methods to face challenges in managing the COVID-19 outbreak in our institution.

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GLOSSARY

AGP = aerosol-generating procedures; **CI** = confidence interval; **CDC** = Center for Diseases Control and Prevention; **COVID-19** = coronavirus disease 2019; **CT** = computed tomography; **ED** = emergency department; **ICU** = intensive care unit; **ID** = infectious disease; **MOH** = Ministry of Health; **OSHE** = occupational safety, health, and environment; **OT** = operating theatre; **PAPR** = powered air-purifying respirator; **RT-PCR** = reverse transcription-polymerase chain reaction; **PPE** = personal protective equipment; **PUI** = patient under investigation; **SARS** = severe acute respiratory syndrome; **UMMC** = University of Malaya Medical Centre; **WHO** = World Health Organization

The World Health Organization (WHO) announced the coronavirus disease 2019 (COVID-19) outbreak as a pandemic on the March 11, 2020. In just a few months, COVID-19 has infected more than 700,000 cases in 199 countries with over 33,000 deaths reported around the world.[1] In Malaysia, the first confirmed COVID-19 case was reported on January 25, 2020. At the time of writing, a total of 8246 cases have been tested positive in Malaysia with new cases continuously rising daily.

On March 13, 2020, University of Malaya Medical Centre (UMMC) was declared as 1 of the 27 designated centers to handle COVID-19 patients in the country.[2] Weeks before the announcement, plans were made to lay down the brickwork of organization. After that particular date, everything went ahead in full intensity. Lessons from around the world, especially from our colleagues in Italy, had taught us that time is essential to prepare and plan before the full calamity of escalating COVID-19 cases sets in.[3]

The department has 2 main units, comprising anesthesiology and intensive care unit (ICU), which is similar to most developing countries. Anesthesiologists face the risk of occupational exposure to infectious aerosols from airway management and perioperative care of COVID-19 patients.[4] In ICU, intensive care doctors have to manage the airway, ventilate, and care for the critically ill COVID-19 patients.[5] There is always a high potential of exposure to respiratory droplets or aerosol from patients' airways. Therefore, readiness was recognized as a pressing issue very early in our workplace, knowing that the time frame toward achieving it was restricted and constantly narrowing.

The objective of this article is to describe a simulation-based training program in anticipation of the COVID-19 crisis in a single department. The planning, implementation, and evaluation of this program took into account institutional time, equipment, and personnel constraints with suitable local adaptations. The latest updates on recommendations and guidelines will not be described here and can be found in major websites or publications.[6,7]

METHODS

Ethical approval and informed consent were not applicable for staff training as it was compulsory to follow the recommendations of the COVID-19 task force in UMMC. A training module to ensure our team's COVID-19 readiness was developed based on Kern's framework for curriculum development, applied widely within medical education across multiple specialties and training.[8,9] But for simplicity, the 6 steps were shortened using McLean's adaptation to 3 phases: planning, implementation, and evaluation.[10]

Planning

Institution needs' assessment enabled recognition that simulation-based training for health care providers was the best method to put knowledge and skills of COVID-19 management to practice in a safe environment. Training sessions were conducted in small groups with hand hygiene, distancing of at least 1 m, and wearing face masks made compulsory. Before each session, a roll call to confirm attendance and checklist of COVID-19 screening questions was performed (Supplemental Digital Content, Document 1, http://links.lww.com/AA/D227).

For learners' needs' assessment, consultant N.H.M.H. with a background in health care simulation led the training plans in collaboration with experts from the Infectious Disease (ID) Control team, and Occupational Safety, Health, and Environment (OSHE) Department. Information and guidelines were revised as needed according to the latest updates and evolving knowledge of the virus and its pathological behavior in the human host.

The goals and objectives were set when areas of priority were identified. They were broadly divided into 3: staff safety, movement, and possible clinical scenarios. Figure 1 details the timeline since the official announcement of UMMC as a COVID-19 hospital and the number of personnel involved at each step since mid-March. The sequence of conduct depended not necessarily on urgency and priority of need, but on the availability of staff and equipment for teaching at that particular stage with an overarching aim as a crisis resource management training.[11]

Implementation

Strategies. Simulation trainings were conducted in batches of small groups rostered in a particular time at convenient locations, away from COVID-19–related

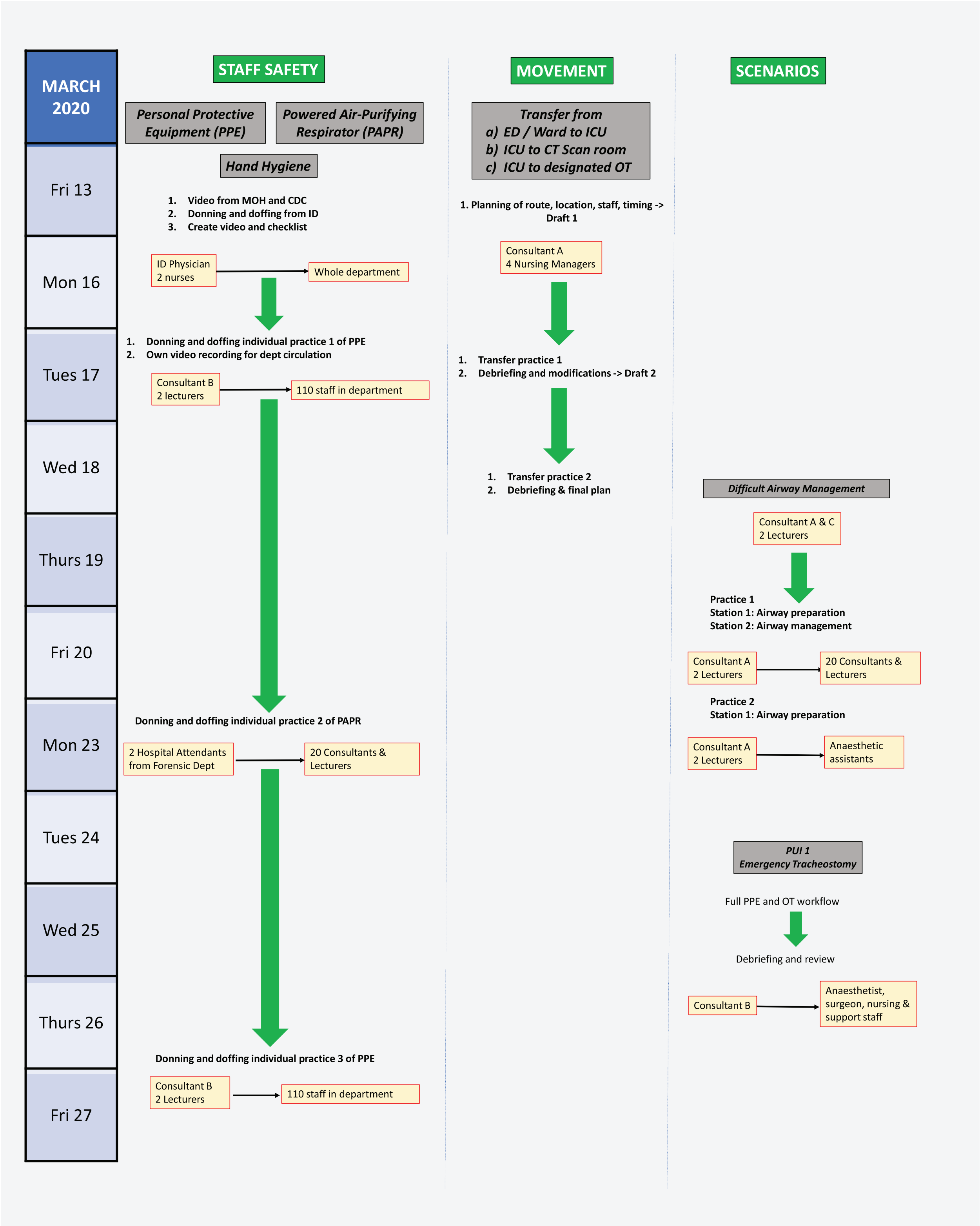

Figure 1. The timeline and workflow for training in the department within 2 wk. CDC indicates Center for Diseases Control and Prevention; CT, computed tomography; ED, emergency department; ICU, intensive care unit; ID, infectious disease; MOH, Ministry of Health; OT, operating theatre; PUI, patient under investigation.

workplace. Information communication technology played a significant role to help sustain the repetitive practice and recall in accordance with the implementation of social distancing. Group chats with relevant members were created for fast and easy dissemination of the latest guidelines, plans, and teaching materials.

The theoretical basis of training encompasses:

1. Harden's Three Circle model for outcome-based education: the core skill to be performed (doing the right thing: safety training and airway management), using the correct approach (doing the thing right: content and instruction based on institutional needs and educational theories), and the professional performing of the skill (the right person doing it: practicing clinicians as instructors with the learners performing the procedures).[12]
2. Rapid-cycle deliberate practice was chosen as it is efficient for specific skills training. The 3 underlying principles of repeating right away, which provided learners with multiple opportunities to do the thing right, expert feedback, based on institutional guidelines, and psychological safety, where the focus is on coaching and practice in a safe environment, are clearly an advantage.[13]
3. Peyton's 4 steps for skills training (demonstration, deconstruction, comprehension, and performance). As these 4 steps were designed for 1:1, trainer/trainee ratio, they were modified according to the learners' needs because of time and resources limitations. The first learner from each session received demonstration as per Peyton's 4 steps with subsequent learners for each group observing the deconstruction using a prepared checklist. Comprehension phase was achieved by the first learner actively performing the skill. Then, feedback was provided by the second learner based on the checklist prepared and learning points emphasized by the instructor. The second learner who provided the feedback was the next to perform the skill and rotate so forth with the others.[14]

Training Implementation.

Staff Safety. Performing correct hand hygiene, donning and doffing of personal protective equipment (PPE), and use of powered air-purifying respirator (PAPR) became our priority to protect all health care providers at risk of contact with COVID-19 patients and patient under investigation (PUI). Official videos from the Malaysian Ministry of Health and Center for Disease Control and Prevention were sourced and added into the department group chat for viewing as a preliminary guide, followed by a live demonstration from the UMMC ID Control team in 3 sessions to accommodate all the staff in the department. The process and sequence were adapted to suit locally available materials and equipment.

Subsequently, rapid-cycle deliberate practices were conducted over a week, involving repetitive performance to familiarize learners with the intended psychomotor skills in a focused domain. Typical implementation strategies such as splitting into segments, microdebriefing in the form of "pause, debrief, rewind and try again," and procedural assessment using checklists and video review were included.[15] The main learning objective was the protection from exposure to direct contamination, aerosols, and transmission droplets while handling COVID-19 cases without any occurrence of breach.

Small groups of 5, given approximately 30 minutes each, were rostered in a timetable to attend over 5 days. An official video of the processes was shown in the prebrief, followed by individual practices under trainer's assessment and immediate feedback. Video recordings were done for our internal use as reference to facilitate individualized learning at participant's own opportunity or convenience.

Movement. Movement of COVID-19–positive patients or PUI was anticipated as more of them required admission. Hence, transport of these patients in 3 routes was planned: (1) emergency department or ID wards to ICU, (2) ICU to a computed tomography (CT) scan suite, and (3) ICU to a designated operating theatre (OT). The initial draft, drawn by a working group led by consultant N.H.M.H. in collaboration with nursing, security, and facility managers, was aimed at probing the system and transfer routes, identifying safety and logistic challenges of transporting a critically ill and intubated patient with the relevant personnel.

The approach captured clinical variation of possible requirements for admitting COVID-19 patients in terms of physical transport.[11] Most importantly, plans were finalized to maximize patient safety and minimize risks of exposure and accidental breaching for the accompanying health care providers, besides saving time and resources. Developing a comprehensive plan before implementation protects everyone from uncertainties in current clinical situations where mistakes can be detrimental.

Scenarios.

Airway management. The first simulation-based scenario was airway management with focus on personnel safety. Ideas were brainstormed for suitable equipment and sequence organized into plan A for normal intubation, stepping up to plan B/C for possible difficult intubation scenarios. Adaptation of the Difficult Airway Society Guidelines was made to accommodate the current clinical setting and infectious risks.[16,17]

Again, rapid-cycle deliberate practice and modifications of Peyton's 4 steps approach was used (Figure 2).[13,14] Because of limited resources and time,

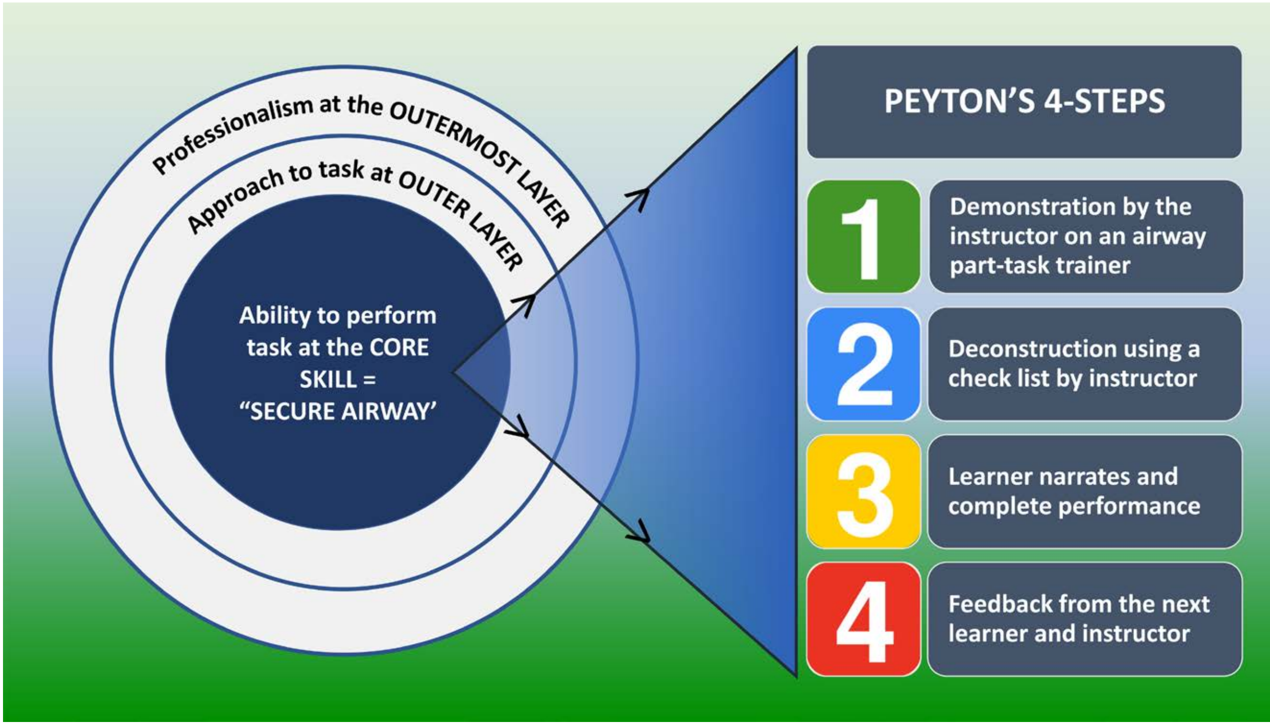

Figure 2. Fundamental basis of simulation training adapted as a preparation tool.

an airway part-task trainer with relevant airway equipment were adequate for the teaching of this important skill.

A total of 2–4 sessions of practice were conducted on 5 consecutive days using isolated direct-focused skill stations; one for airway equipment preparation to be checked and sealed into plan A/plan B double bags, and the second for the airway intubation process. An anesthesiologist and a single assistant were paired up each time to simulate real-time clinical setting in compliance to institutional protocol. This was done to limit personnel during aerosolization procedures.

Perioperative management. On March 24, 2020, a patient requiring an urgent tracheostomy for tracheal stenosis became the first full-scale in situ simulated scenario in the OT for team training to test workflow, manpower, and safety preparations. Written informed consent was obtained from the patient's legal surrogate. The patient resided in a COVID-19 hotspot location and had a recent history of respiratory symptoms and malaise. However, her first result of real-time reverse transcription-polymerase chain reaction (RT-PCR) was negative. Therefore, she was treated as PUI with all precautions taken at team brief, procedure, and postoperative care.

Consultant N.H.M.H. assessed the feasibility of the workflow of transport, allocated locations for donning/doffing/anteroom, and studied the team dynamics and adherence to the protocol checklist. The following day all participants were invited to a formal postevent debriefing to facilitate reflection and analysis. Finally, a thorough review and summary of any weaknesses in the system and suggestions for improvement were noted. This became the basis of the institutional recommendation for all patients requiring emergency surgery and transport to the OT.

Evaluation

To check the effectiveness of training, outcomes were evaluated based on 4 levels adapted from the "Kirkpatrick Model."[10,18] Figure 3 describes levels 1–4 and the related methods used. The first evaluation for reaction and learning was immediate and ad hoc during the training practice. A second evaluation was conducted 1-month posttraining using an online survey distributed for a week to the whole department, with questions related to levels 1–3 of the model.

Frequency analysis for all quantitative responses was performed using SPSS Version 23.0. Respondents needed to be able to answer a minimum of 16 of 20 questions (80%) correctly on how to identify aerosol-generating procedures (AGP), indications for PPE, and airway management to be considered as achieving adequate retention of learning in level 2. They were also examined for listing the correct sequence in the steps for donning and doffing.

The data for all open-ended questions toward behavioral changes were qualitative in nature. Hence, an inductive approach to thematic analysis was

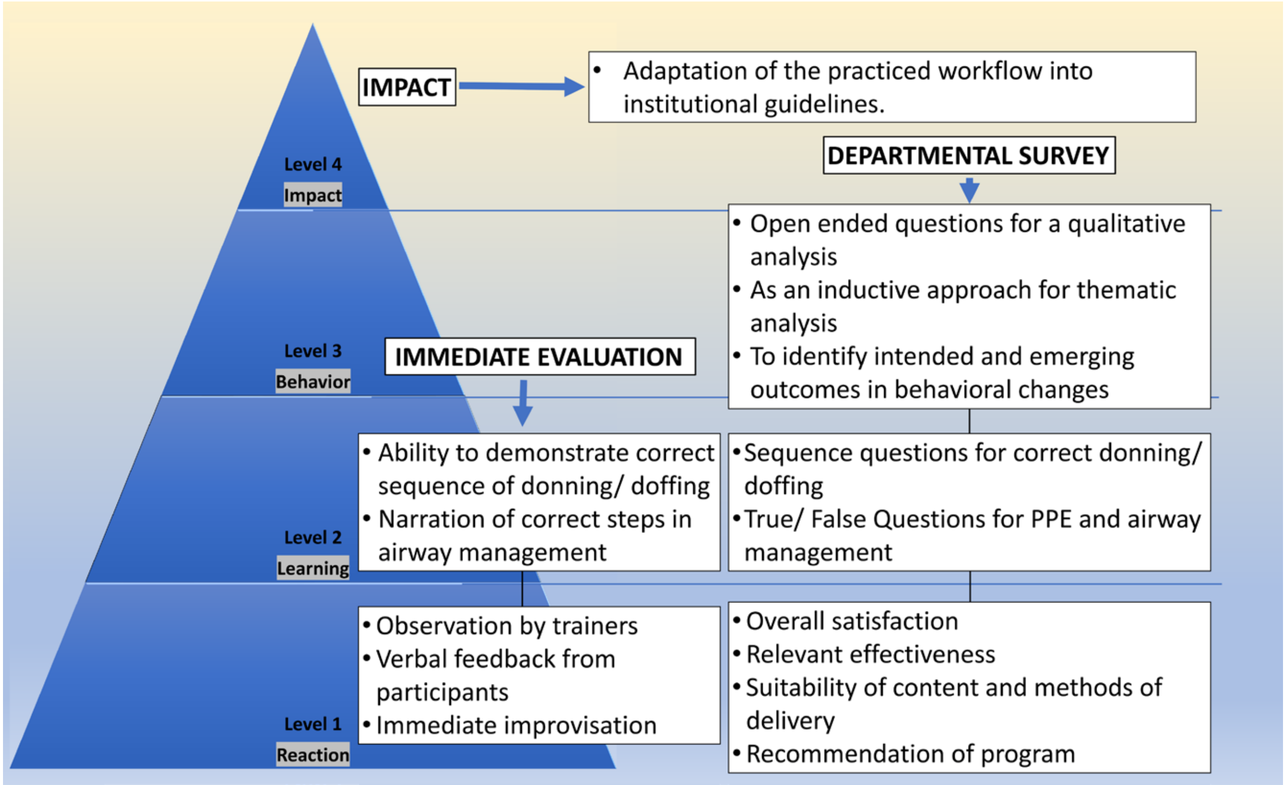

Figure 3. Adaptation of Kirkpatrick Model for evaluation of simulation-based training during the COVID-19 pandemic. COVID-19 indicates coronavirus disease 2019; PPE, personal protective equipment.

performed based on examples given by the respondents to fulfil evaluation in level 3.[19] These changes were coded and reexamined for themes to identify intended and emerging outcomes. Finally, the last step for evaluation at level 4 was achieved by determining the impact of training on how the institution adapted the simulated workflow into protocols for local practice.

Figure 4 summarizes our workflow for planning, implementation, and evaluation of this program.

RESULTS

There were 16 consultants, 16 specialists, and 81 medical officers under training in the department during this period of COVID-19 outbreak. Overall, a total of 15 consultants (93%), 16 specialists (100%), and 81 medical officers (100%) completed training within 2 consecutive weeks of the simulation program. Only a single consultant did not attend after opting for nonclinical duties during the pandemic. During the program, trainers were 2 lead consultants, with learners themselves taking turns as assistants in some of the sessions.

The findings of the immediate evaluation were instantly relayed to the trainers. The posttraining survey received 42 responses (39%) from the number of successfully trained staff, excluding the 6 authors, and will be described below:

Reaction

All of the respondents were satisfied with the training and agreed that it was relevant to ensure their safety and effectiveness in performing clinical duties during the COVID-19 pandemic. All but 1 respondent agreed that the content and delivery methods were suitable, and therefore would recommend this program to their colleagues.

Learning

A total of 41 respondents (98%) correctly answered at least 16 questions of 20 on identifying AGP, indications for PPE, and planning and preparation for airway management as adequate retention of learning. However, the findings in their ability to recall the exact sequence for donning and doffing were different. Only 18 of the 42 respondents (43%; 95% confidence interval [CI], 27-59) were able to recall the correct steps for donning and the most common deviation was immediate placement of N95 mask after hand hygiene (38% respondents; 95% CI, 23-54). For doffing, 22 respondents (52%; 95% CI, 36-68) correctly recalled the sequence and 37 respondents (88%; 95% CI, 74-96) were able to recall the first and last steps correctly, that is, removal of soiled gloves and the N95 masks.

Behavior

A total of 92 responses from 33 respondents was considered for the qualitative analysis. All respondents

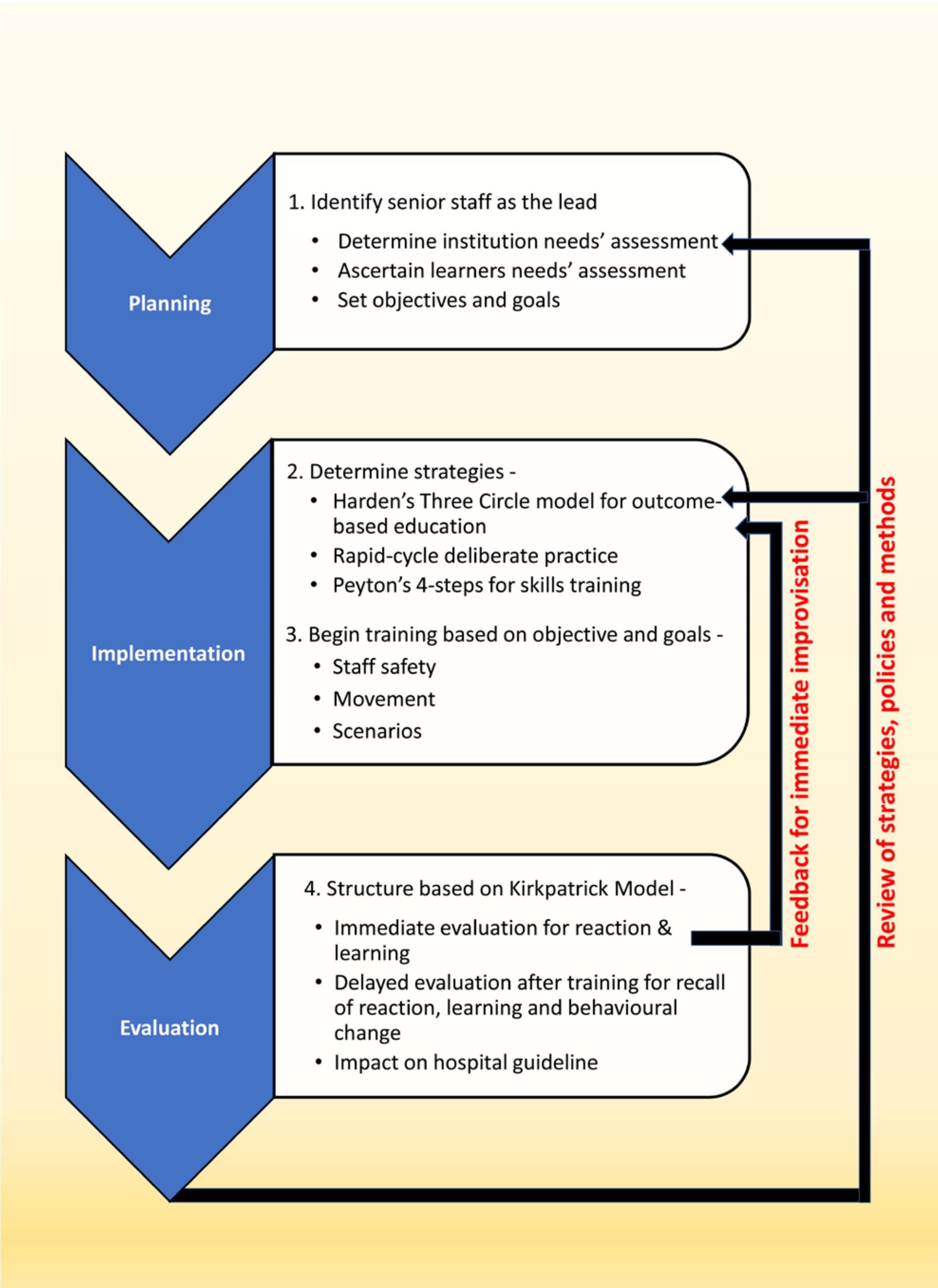

Figure 4. Summary of workflow for planning, implementation, and evaluation.

presented at least 1 behavioral change with reported examples such as performing hand hygiene more frequently, describing a systematic approach to airway management and preparation, describing new norms for intubation/extubation, ensuring close communication with team members during airway management, and correct donning/doffing of PPEs followed by proper disposal of used PPEs.

The derived initial codes were then divided into PPE-related procedures (appropriate level for AGP, sequence for donning and doffing, and checklists for donning and doffing), hand hygiene practice, airway management procedures (personnel preparation, viral filters in circuit, use of video laryngoscopy/aerosol box, and modified rapid sequence induction), and colleagues and personal safety (planning, increased vigilance while managing patients, physical distancing, and communication).

Following were the themes from reexamination of the codes.

Intended Outcomes. This theme defined the main outcome intended by the program encompassing hand hygiene practice (n = 18, 20% responses), appropriate use of PPE (n = 25, 27% responses), and airway management procedures (n = 9, 10% responses). All self-reported change in behavior echoed the department's priority for staff safety.

Emerging Outcomes. Behavioral change that was not part of the intended outcome will be analyzed as emerging outcomes. These changes were considered positive and relevant. Examples of the emerging outcomes were vigilance while managing patients, physical distancing during social and professional contact, as well as planning and team communication.

Impact

The impact in level 4, after completion of practice and evaluation, was a successful change in institutional practice (Figure 3). The training provided evidence on safety and feasibility to the hospital management for the establishment of guidelines that were accessible to all staff via the official hospital website (Annex 17, Portal UMMC, UMMC management guidelines of COVID-19).[20]

DISCUSSION

Simulation was a method that we implemented in the preparation as a COVID-19 hospital to produce an experience without going through the real event.[21] It had proven to be a useful modality to supplement training in a sudden urgent need on a massive scale within days to weeks, without subjecting learners to unsafe and unfamiliar situations. To simulate the actual management of COVID-19 patients, as their number increased daily, we planned activities to cover 3 dimensions of simulation: scope, modality, and environment.[21] The extent of clinical encounters, such as patient movement and essential skills covered, was unique to safeguard the protection of health care providers and patients.

The simulation activities done within 2 weeks were a powerful form of enactive experiences followed by debriefings to facilitate reflection, learning, abstraction, conceptualization, and connection.[21] It enabled control over the sequence of tasks offered to learners for donning and doffing of PPE, PAPR, and hand hygiene. At the same time, it provided opportunities for support and guidance to learners. Based on the experience, we recommend at least 1 senior staff to spearhead the organization of simulation training and planning as early as possible. This consultant can be assisted by others relevant to the activities on availability or skill basis, and training is to be based on institutional needs and available resources.

The post simulation program evaluation helped us identify learners' needs, especially domains with poor retention. We found factual knowledge with specific principles and methods, such as identifying AGP, indications for PPE, planning and preparation for airway management, was easier to commit to memory and had a good outcome in retention of learning among the learners. The sequence for donning and doffing, however, achieved a much lower outcome in retained learning. Because of this and the fact that donning and doffing were high-impact procedures, checklists were placed for reemphasis in donning/doffing areas, a buddy system was enforced to ensure correct steps were followed, and online teaching videos repeated the instructions to reinforce knowledge and skills. Completed training did not equate to complete learning, and for safety reasons, strategies must be put in place to overcome this discrepancy.

The most common deviation from the actual donning protocol was immediate placement of N95 mask after hand hygiene instead of the protective gown. Because donning is considered an uncontaminated procedure, this was not a mistake; instead it was considered as an accepted deviation that will lead to no harm as long as both were donned appropriately. It is assumed that this deviation occurred because it reflects what is practiced daily as the new norm, masks are always worn first when approaching patients or before proceeding to other steps.

Only half of the respondents recalled the sequence for doffing correctly and this observation mirrors reports from other centers.[22] One study conducted in an acute care hospital setting, where doffing practices were observed among 107 health care providers caring for patients with viral respiratory illness, revealed the overall incorrect doffing sequence of 52%. In another study, features of failed precautionary measures to lower risks of transmission described deviations from recommended procedures as an active failure in PPE use.[23] They also suggested that, although education could be a useful strategy, precaution policies and practices may need to be reviewed on a regular basis.

There were limitations to the simulation exercises. First, limited time was allocated to each trainee, especially for learning during reflection.[24] All activities were based on the latest guidelines and the available literature just before the planning. As we know, new evidence is published daily in journals, official websites, or social media. Therefore, a system of reinforcing new information must also be introduced. Finally, it will be very difficult, if not impossible, to monitor all the specific outcomes of training and system probing as completely "ready" in real-life situations because the number of personnel involved was restricted and documentation completely done post hoc. At least, simulation scenarios increased morale and confidence within our department, similar to previous experience that had been reported.[25] As we write, we will be planning interdisciplinary simulated scenarios with other surgical and medical departments to incorporate the latest evidence.

CONCLUSIONS

In this article, we introduced a new conceptual framework for the development of simulation-based training as a preparation tool for COVID-19 in an institution of a developing country. At the moment, the curve of the pandemic may have flattened and waned in many countries, but it has taught clinicians worldwide that rapidly planning, training, and integrating a safe system is important. Lessons learned, just like those from the previous severe acute respiratory syndrome (SARS) outbreak, will be invaluable for future management of similar threats to safeguard both the sick and health care providers simultaneously.

Everything we do before a pandemic will seem alarmist. Everything we do after will seem inadequate.

Mike Leavitt
US Secretary of Health Human Services (2007)

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