# Journal Pre-proof


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# The role of clinical simulation in preparing for a pandemic

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**Key words**: Simulation-based Education, Patient Safety, COVID-19 Pandemic



**Learning objectives**

By reading this article, you should be able to:

- Describe the range of simulation-based techniques that may be applied for increasing organisational capacity in response to the COVID-19 pandemic.
- Develop training pertinent to the needs of institutions, patients and healthcare workers.
- Employ strategies for conserving PPE whilst maintaining effective training.

## Key points

- Simulation-based educational approaches are crucial strategies for organisational preparation during a pandemic.
- Pandemic-specific training requirements include the proper donning and doffing of personal protective equipment (PPE), and cross-skilling of providers who may be required to work in unfamiliar roles.
- Drills that test the safety of new processes and newly expanded clinical areas may help to identify latent safety threats and strengthen teamwork.
- Pilot testing of novel equipment and technologies may be facilitated, without risking harm to patients or providers.
- Challenges to implementation include rapidly changing circumstances, time pressures, maintaining participants' safety and the need to conserve supplies of PPE.

**Authors' biographies (untitled text box)**

Cliff Shelton MSc PhD FRCA is a consultant anaesthetist at Wythenshawe Hospital. He is also director of simulation and clinical skills, and senior lecturer at Lancaster Medical School. During the first wave of the COVID-19 pandemic in the UK he was departmental lead for simulation, with responsibilities including staff training and evaluating standard operating procedures and equipment.

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Allison Lee MD MS is an associate professor and obstetric anesthesiologist at Columbia University, and medical director of the Margaret Wood Center for Simulation and Education. During the first wave of the pandemic, she developed training for donning and doffing of PPE and tracheal intubation, and designed and ran interdisciplinary cardiac arrest simulation training

## A) Introduction

The coronavirus disease 2019 (COVID-19) pandemic has created one of the largest global health challenges in modern history, with over 41 million confirmed cases and 1.3 million deaths worldwide as of October 2020.[1] Healthcare organisations have grappled with the challenges of mitigating risks to staff members and accommodating surges of critically ill patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), whilst attempting to maintain clinical standards.[2] The safety of healthcare professionals involved in the provision of anaesthesia and critical care is of particular concern owing to their involvement in aerosol-generating procedures such as airway instrumentation and cardiopulmonary resuscitation. As case numbers increase, difficult decisions are required to determine which, and at what juncture, clinical services should be suspended; and how staff who usually work in suspended services can be otherwise utilised and redeployed as priorities for hospital services shift.

Simulation encompasses an array of techniques that involve the replication of real clinical situations, usually for the purpose of education or assessment.[3] Modes of simulation range from focussed task training, where individuals engage in hands-on practice of technical procedures such as central venous cannulation, to the reproduction of complex clinical scenarios involving multiple participants and employing the use of patient actors (i.e. simulated or standardised patients) and high-fidelity manikins.[3,4] Approaches such as walking through patient triage and transport pathways, and exploring clinical scenarios stage-by-stage, also fall under the umbrella of simulation and are crucial for the early development of new clinical protocols. Simulation is an effective mode of team training, with high-quality studies providing evidence of improvements in knowledge, clinical care and patient safety.[5]

In this article, we describe the lessons learned from the ways in which simulation-based approaches have been used in anaesthesia and critical care as a tool in preparing for the COVID-19 pandemic, and how ongoing training may contribute during this and future crises.

## A) Principles of developing simulation during a pandemic

Healthcare systems have been presented with enormous challenges during the COVID-19 pandemic. There must be a solid infrastructure of education to train large numbers of staff rapidly in the face of shortages of personal protective equipment (PPE), surges in critical care cases, staff sickness, shifting infection control guidance, and a constantly evolving evidence base.[6] The scale at which training must occur in a pandemic has the potential to exceed the resources of simulation centres, including the availability of trained facilitators. Thoughtful prioritisation of resource allocation is therefore required.

### B) Faculty

Simulation-based education should be facilitated by trained faculty members with expertise relevant to the scenarios and intended learning outcomes. At the outset of the COVID-19 pandemic, clinical experience of managing the disease was limited. As such, collaboration between clinicians with relevant skills and knowledge, and experienced simulation educators was therefore required to interpret and apply evolving guidelines as evidence emerged.[6,7] Simulation-based education is demanding of both faculty and time, so educators who also have clinical roles must be afforded the time to contribute to training, which may require release from clinical work. Institutions and clinical departments must therefore support simulation-based education by enabling the faculty to attend, which, during a pandemic, may require the appropriate suspension of elective services. Maintaining an up-to-date understanding of a novel disease amongst faculty members is challenging, and mechanisms should be put in place to disseminate relevant information as knowledge and experience progresses.[7,8]

**B) Scenario design**

Content should be developed using best practices for simulation-based education, and this requires the input not only of subject matter experts in anaesthesia, critical care and infection prevention; but also others including physicians, nurses, respiratory therapists, estates services and security officers.[7] Learning objectives should consistently address provider safety and teamwork behaviours.

Scenarios do not need to be designed completely from scratch. Facilitators should take advantage of free open access resources (see supplementary materials), which can be adapted rapidly to local needs in order to maximise the efficiency of the educational design process in a time-critical context.

**B) Briefing and debriefing**

Regardless of the purpose or approach used, effective briefing and debriefing are essential for maximising educational value. Facilitators must cultivate a safe learning environment and communicate the purpose of the session (i.e. education, not assessment). Participants, especially those learning unfamiliar skills, may experience high levels of anxiety, compounded by the stressful circumstances of an evolving pandemic. Facilitators should therefore adjust the intensity of the simulation to minimise anxiety, whilst meeting the needs of the learners. Employing a “safe word or phrase”, such as ‘this is not a simulation’, as used by the Center for Medical Simulation, Boston, MA, allows participants to alert others to real concerns, such as the need to withdraw if overwhelmed.[8] Facilitators may also set ground rules such as allowing participants to pause the scenario in order to ask burning questions.

Because of widespread shortages of PPE shortages, the plans for the use of mock or alternative PPE should be clarified beforehand. In the authors’ institutions, approaches to this included the use of disposable warm-up jackets donned backwards as mock impermeable gowns, plastic sheets from office supplies crafted to be used as face shields, and the use of fluid-resistant surgical masks with ‘FFP3’ written on them in place of respirator (filtering facepiece) masks (Figure 1). Other educators have suggested using cloth face coverings and bandanas to substitute for masks.

The debriefing process allows facilitators to encourage participant reflection and provides an opportunity to address performance and knowledge gaps.[9] Facilitators must, however, acknowledge current unknowns regarding the constantly-evolving evidence base and changes in clinical guidelines. Participants' observations and feedback may lend unexpected insights about guidelines and processes, which are likely to be in a state of development during the early phase when case numbers are increasing rapidly. These learning points should be summarised and reported back to clinical leaders and hospital managers in order to improve real-world practice.[10] Debriefing may also become a forum during which participants may bring up their fears. Facilitators may take the opportunity to encourage supportive group discussion, supply answers in order to help allay anxiety and invite input from any content experts who may be present.

**B) Location**

Dedicated training centres equipped with simulated clinical spaces and briefing rooms are convenient for scheduling the training of large numbers of attendees, and for undertaking traditional drills and task training. Simulation centres are therefore well-suited to hosting training covering the donning and doffing of PPE or cardiac arrest management, since these procedures may be undertaken in a range of clinical locations and the physical environment has little influence on the basic principles involved in undertaking them.

*In situ* simulation provides valuable opportunities to evaluate logistical issues involving the same environment in which care is delivered, can help to identify latent safety threats, and to train staff without them having to leave work areas.[5,11] It is particularly beneficial in the context of the COVID-19 pandemic because of the ways in which clinical environments may influence both staff and patients' safety. For example, the potential for viral transmission via droplet contamination of surfaces in the clinical environment can be explored using manikin-based simulation that incorporates the use of fluorescent powder or dye to mimic respiratory secretions, in order to develop strategies to mitigate risks in clinical practice.[12] Well-documented potential drawbacks of *in situ* simulation include the risk of distracting caregivers from clinical responsibilities and for simulated medications and fluids to become mixed with supplies for patients.

The pandemic has raised interest in the conduct of remote simulations, with learners participating over web-based platforms, as well as the value of virtual and augmented reality simulation technologies.[13,14] These approaches have the advantage of supporting physical distancing in the context of the pandemic, and can potentially be conveniently conducted from participants' homes. Remote learning may help to minimise the impact of limited availability of training facilities by allowing the participation of larger groups of learners than would be feasible in person and may help avoid the disruption of training.[13] As with face-to-face simulation, debriefing is a critical part of the learning experience, and considerations must be made regarding how best to accomplish this when remote technologies are used.[15]

**B) Attendees**

During the initial stages of a pandemic, when decisions are made to cancel elective surgery, educators should take advantage of the large numbers of staff who may temporarily be available to attend training. Many of these redeployed staff will have cross-skilling needs as they may be deployed to unconventional COVID-19 critical care areas such as repurposed wards or operating theatre recovery areas. High clinical demands at the peak of a crisis may make the full participation of all staff members in simulation exercises challenging to achieve. At a minimum however, clinical and peer educators should be targeted as a priority for training, the learning points from which can subsequently be disseminated locally. Buy-in and support of the need for training must occur at the highest levels of hospital leadership to overcome logistical barriers and acquire necessary resources. Communication between education and clinical practice leaders should remain open and fluid, to ensure that what is being taught remains accurate and in line with rapidly changing policies. Learning may be supplemented by the dissemination of infographics, checklists and educational videos (see supplementary materials).

**B) Ensuring participants' safety**

The safety of staff during simulation is vital. In the context of a high-impact respiratory pathogen, sessions may be conducted concurrently with advice for members of the public to physically distance or remain at home. In the authors' experience, staff are nevertheless often highly motivated to attend and engage with simulation training as the content is immediately applicable, and the ability to learn how to practice safely helps allay anxiety and develop self-efficacy.[16]

Simulation centres should therefore develop guidelines for screening participants for COVID-19 symptoms, calculate room capacities in advance in order to ensure that there is sufficient room for the training to take place (sample calculator: https://www.banquettablespro.com/social-distancing-room-space-calculator), and limit the size of groups to allow appropriate physical distancing. Appropriate PPE (e.g. fluid-resistant surgical masks) should be utilised by attendees, particularly when physical distancing cannot be maintained due to the requirements of the scenario, and equipment and high-touch surfaces must be frequently sanitised according to regulatory body recommendations (e.g. https://www.cdc.gov/coronavirus/2019-ncov/community/disinfecting-building-facility.html).

If *in-situ* simulation is used, additional COVID-19-specific concerns include a heightened risk of contamination of equipment and viral transmission to attendees and faculty. The use of *in situ* simulation should therefore be circumscribed, particularly in areas in which patients with SARS-CoV-2 are receiving care, and should therefore be conducted only with the appropriate staffing and expertise to support its safe conduct.

**B) Evaluation**

Several approaches to evaluation may be used to assess the quality and impact of simulation-based education. These include informal discussion, feedback questionnaires from learners and faculty, and assessments of learner knowledge (e.g. multiple-choice questions), skills (e.g. structured skills assessments), and practice (e.g. scenario-based testing).[3,17]

The workload demands of the initial phase of the pandemic presented a challenge to conducting in-depth educational evaluation as resources were focussed on meeting the need to rapidly deliver training to large numbers of staff. However, because a number of novel educational approaches were employed, evaluation was arguably of even greater importance than in more routine circumstances.

In the authors' institutions, a pragmatic approach to evaluation was adopted in order to avoid excessive workload and enable the rapid refinement of educational practice. This approach is based on a combination of short evaluation questionnaires, group feedback from learners at the end of sessions, and ongoing discussion within the faculty. Given the stressful circumstances of the pandemic, formal testing of knowledge and skills was not undertaken in order to avoid provoking further anxiety amongst learners.[7] Departmental audit was also used as a surrogate approach to assessing the effectiveness of training. Although safety incidents during previously unfamiliar procedures such as prone positioning were low, gaps identified in performance have informed the content and focus of subsequent simulation training.

**B) Educational leadership**

The prominent role that simulation-based education has played in many institutions during the COVID-19 pandemic has highlighted the importance of educational leadership in healthcare organisations. Educators are well-positioned to identify both system issues and the degree of staff preparation, and can therefore project general training needs.

Well-constructed training, with clearly communicated goals may contribute to decreasing providers' sense of helplessness in the face of a novel and potentially deadly disease. In their role of supplying feedback to administrators, education leaders may help to advocate for staff members who otherwise may struggle to be heard and may serve as visible and reliable sources of information with whom colleagues can share questions and concerns.

The establishment of 'simulation lead' roles in anaesthetic and critical care departments has historically not been universally considered essential but based on the lessons learned during the months since the pandemic began, we suggest that this should now be strongly encouraged.

**A) Applications of simulation for COVID-19 preparation**

**B) Organisational Planning**

Modifications to the hospital physical environment are often necessary to aid the segregation of infected patients in order to limit SARS-CoV-2 transmission. Changes to the clinical workflow may also be indicated to decrease staff exposure to the virus. For example, because aerosol-generating procedures should ideally be performed in in a separate room, patients with COVID-19 who require emergency tracheal intubation may have to be transferred rapidly to other areas of the unit or hospital.[18]

Before implementing organisational changes and new clinical infrastructure, a "design thinking" approach beginning with tabletop simulations allows key stakeholders to meet and talk through theoretical clinical scenarios, sit with physical blueprints of the relevant units and build a framework for pathways of care.[19,20] Following this, mock-up and walk through exercises, which do not necessarily require the use of a high-fidelity manikin, are critical for orientating planners to the physical spaces and to improving understanding of the current workflow. Such exercises should be less focussed on clinical management and more on mapping out workflows and identifying latent safety threats, which may then guide staffing levels, changes to the physical environment, and inform the ongoing development of unit- and institution-specific protocols. Think-aloud methods are valuable, whereby participants voice questions and concerns brought to mind in real time.[10]

A simple walkthrough simulation undertaken at one of the authors' institutions replicated the transport of a patient from the planned COVID-19 surgical ward to the emergency operating theatre, via a service corridor that was previously not used for transferring patient but was the proposed route for transporting patients with COVID-19 during the pandemic. This brief simulation required only a few members of staff and a hospital bed but was highly valuable in identifying obstructions that needed to be moved and the number of staff required to undertake a safe transfer, prior to commissioning the route for patient use.

Abrupt changes in workflow and to the physical environment are likely to increase clinicians' stress and cognitive load. Inviting a range of both senior and junior staff members to join in walk throughs and provide feedback can enhance staff awareness of pending changes, aid planning and promote the dissemination of information.

**B) COVID-19-specific protocol development**

Existing local guidelines (e.g. on emergency operating theatre use) must be reconciled, to the best extent possible, with national or international COVID-19 best practices for infection prevention and control, such as those found at www.*icmanaesthesiacovid-19.org* in the United Kingdom.

Simulation drills are invaluable for informing local protocols. For example, the emergency tracheal intubation checklist in one author's institution, which was based on national guidance, had to be tailored to their own context, based on lessons learned from drills conducted in the clinical workplace (Figure 2). Protocol development is often an iterative process, with repeated drills identifying new system issues, leading to further revisions.

***C) Donning and doffing of personal protective equipment***

At the most basic level, institution-specific protocols regarding the proper use of PPE to prevent SARS-CoV-2 transmission should be developed and situated within a plan for widespread staff training (Figure 3). Institutional protocols must be tailored to whichever types of equipment are available and approved, and the appropriate levels of PPE required should be clarified based on the SARS-CoV-2 transmission presented by a given procedure and level of patient contact.[18]

***C) Airway management***

Healthcare workers involved in the airway management of patients with SARS-CoV-2 infection are considered to be at elevated risk of infection due to the potential for the aerosolisation of respiratory secretions containing the SARS-CoV-2 virus. Simulated practice in rapid sequence induction (RSI) and tracheal intubation allows providers to rehearse key recommendations such as the careful donning of PPE despite the potentially urgent clinical situation; limiting the numbers of healthcare staff present during airway management procedures;, avoiding bag-mask ventilation if possible; incorporating viral filters in the path of any exhaled gas; using videolaryngoscopy; and using positive pressure ventilation only after inflation of the tracheal tube cuff.[21] Cognitive aids, including checklists, which highlight best practices (e.g. Figure 2) are useful tools that may be incorporated into the training.

***C) Cardiopulmonary resuscitation***

Cardiac arrest teams must make significant modifications in their behavioural response and management of cardiac arrest in patients with suspected or confirmed SARS-CoV-2 infection, particularly given the daunting statistics that only ~20% of patients who suffer in-hospital cardiac arrest will survive.[22] Apart from the issues described above with respect to airway management, specific considerations include adding the "bouncer" role to control entry to the room and assess that the proper donning of PPE has been performed, conducting team huddles before room entry, working around the challenges of maintaining effective communication whilst wearing PPE, adding the new roles of personnel who can pass equipment into the room from outside, and emphasising proper doffing of PPE and cleaning of equipment post-resuscitation. Institution-specific guidelines should be informed and refined by experience gained from simulated cardiac arrest drills.

**B) Cross-skilling**

The rapid expansion in critical care bed requirements creates an urgent need for cross-skilling of healthcare workers including medical, surgical, anaesthetic and operating theatre staff. Although many redeployed staff are well trained and skilled in their own fields, they are often asked to operate at a less expert level in an unfamiliar context, provoking uncertainty, potentially impacting resilience and risking burnout.[23]

Leadership from critical care departments is essential to identify which skills can be addressed and refreshed through training. Cross-skilling courses commonly include the principles of mechanical ventilation and ventilator management in the critically ill, and the safe prone positioning of critically unwell patients. Developing and encouraging the utilisation of cognitive aids such as checklists is extremely valuable for supporting the learning needs of staff asked to take on new roles.

**B) Technology evaluation**

The COVID-19 pandemic sparked a flurry of innovation, attempting to address potential problems such as shortages in ventilators and PPE, and reduce the viral exposure during aerosol generating procedures. Novel "home-made" technologies such as intubation boxes, ventilator splitters and improvised PPE should not be used in clinical practice without appropriate usability testing.[24-26] Simulation offers an opportunity for such innovations to be evaluated prior to introduction into clinical spaces without risking patient harm.

One example of our experience with usability testing was simulation exploring the use of an intubation box, based on the design by Canelli and colleagues, for tracheal intubation using a McGrath videolaryngoscope (Medtronic, Minneapolis, MN, USA) and a gum-elastic bougie (the first-line equipment for rapid sequence induction (RSI) in the COVID-19 setting in one author's institution).[27] The simulation exercise rapidly indicated that the intubation box would not be compatible with the airway management techniques used in that institution (Figure 4).[24] A subsequent simulation-based study concluded that although intubation boxes may reduce exposure to airway secretions, they can reduce the rate of procedural success and damage PPE.[28]

**A) Conclusions**

The COVID-19 pandemic has highlighted ways in which simulation-based techniques may improve organisational readiness and resilience, by meeting the rapid changes in clinical training needs, helping to shape the development of evolving clinical guidelines, and by providing a safe platform for the evaluation of novel technologies. The crisis has placed high demands on simulation education resources, which points to the need for anaesthetic and critical care departments to prioritise the allocation of resources for both equipment and simulation faculty development, as we collectively prepare to navigate an uncertain future.

**A) Declaration of interests**

A.L is an editor and editorial board member of *BJA Education*; C.S is a former member of the editorial board of *BJA Education.* T.H declares no conflicts of interest.

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**Legends for Figures**

**Figure 1:** Multidisciplinary team drill to rehearse a newly developed institutional protocol for cardiac arrest management in the setting COVID-19. The utilisation of mock PPE (surgical masks instead of respirator masks) assists with identification of technical and human factor challenges without depleting limited supplies.

**Figure 2:** Institution-specific emergency tracheal intubation checklist which was developed and refined based on experiences from multidisciplinary simulation.

**Figure 3:** Illustration of stepwise simulation-based education goals for staff preparation during the COVID-19 pandemic.

**Figure 4:** Usability testing of a novel "intubation box" for simulated tracheal intubation using a McGrath™ MAC videolaryngoscope (Medtronic, Minneapolis, MN, USA) and a gum-elastic bougie.[15] Reproduced with permission.

## COVID-19 Emergency Intubation Checklist: Critically Ill Patients

PPE → Equipment → Plan → In-room → Post-procedure

### OUTSIDE ROOM

**Preparation**

Introductions & allocate roles:
- Intubator (team leader)
- Airway assistant
- Drugs / inside runner
- Outside runner

Agree how runners will communicate

Monitoring (ECG, BP, SpO2, ETCO2)
Ventilator
Other procedures (IV access, NG Tube, lines)
Induction equipment: **see right and overleaf**

**"Aerosol Generating" PPE: all in-room staff**

Pockets empty
Hat
Wipeable shoes
Inner gloves
Long sleeve gown
Outer Gloves
FFP3 mask / PAPR Hood
Eyewear
Names visible
**Full check by buddy**

**Induction Equipment**

Circuit **set-up as overleaf**
Facemask
Guedel
Yankauer (try not to use)
1st choice laryngoscope
Bougie/stylet
Lubricated subglottic ETT
Syringe & ties
Tray for soiled kit
Induction agent
NMBD
Vasopressor
Maintenance sedation

**Rapid availability of 2nd choice laryngoscope & plan B/C/D**

**Final Checks**

PPE safe?
Equipment ready?
Plan A, B, C, D discussed?

**Everyone happy with plan?**

### INSIDE ROOM

**Preparation:**

Anticipate challenges, e.g.
- Mallampati
- C-spine
- OSA
- Mouth opening
- Conscious level
- Hypoxia

Mark CTM?
Check IV Access
Connect monitoring/ETCO2
Optimise position
Optimise haemodynamics
Consider room layout
Bin for bougie at bedside

**Airway modifications:**

- Low-flow PreO2 (aim < 10l/min)
- Avoid open suction if possible
- Two person, low pressure mask-ventilation **only if necessary.**
- Break circuit at angle piece (not mask) to attach to ETT
- Inflate cuff before ventilating

### POST PROCEDURE

- Confirm ETT placement with waveform capnography (avoid auscultation)
- Connect to ventilator (break circuit after HMEF)
- Optimise ventilation to high PEEP and 6ml/kg IBW
- Document intubation (separate sheet, outside room)

**"Doffing" PPE**

**Inside room:**
- Gown – lean forward & pull
- Outer gloves – with gown

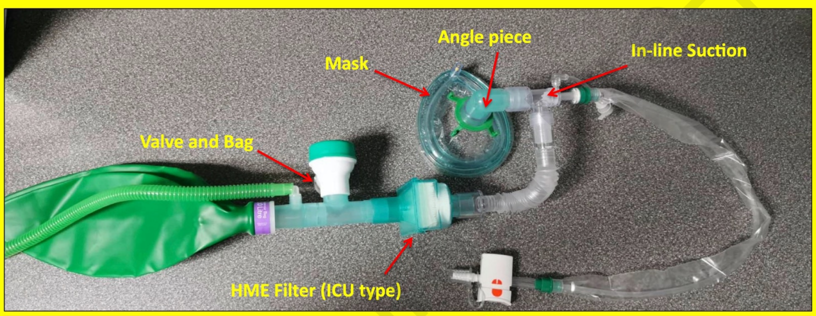
**Outside room:**
- Eye protection (buddy removes spectacles, if worn)
- Inner gloves
- Mask bottom strap then top. FFP3 in bin / respirator in tray
- Wash hands

**Hand hygiene / alcogel inner gloves) between each step**

**Call for help early – rescuers must apply PPE**

V1.3
T Huda, D Greig, C Shelton, E Shardlow 06/04/20

## Set-up of Circuit, including HME Filter and Inline Suction




**The circuit**
- Note the layout of the above circuit, designed to minimise disconnections: mask, angle piece, in-line suction, catheter mount, HME filter.
- Following intubation, the circuit is broken between the angle piece and the in-line suction. The in-line suction is then attached directly to the ETT.
- To commence mechanical ventilation, break the circuit between the HME filter and the valve, and attach the ventilator circuit to the HME filter.

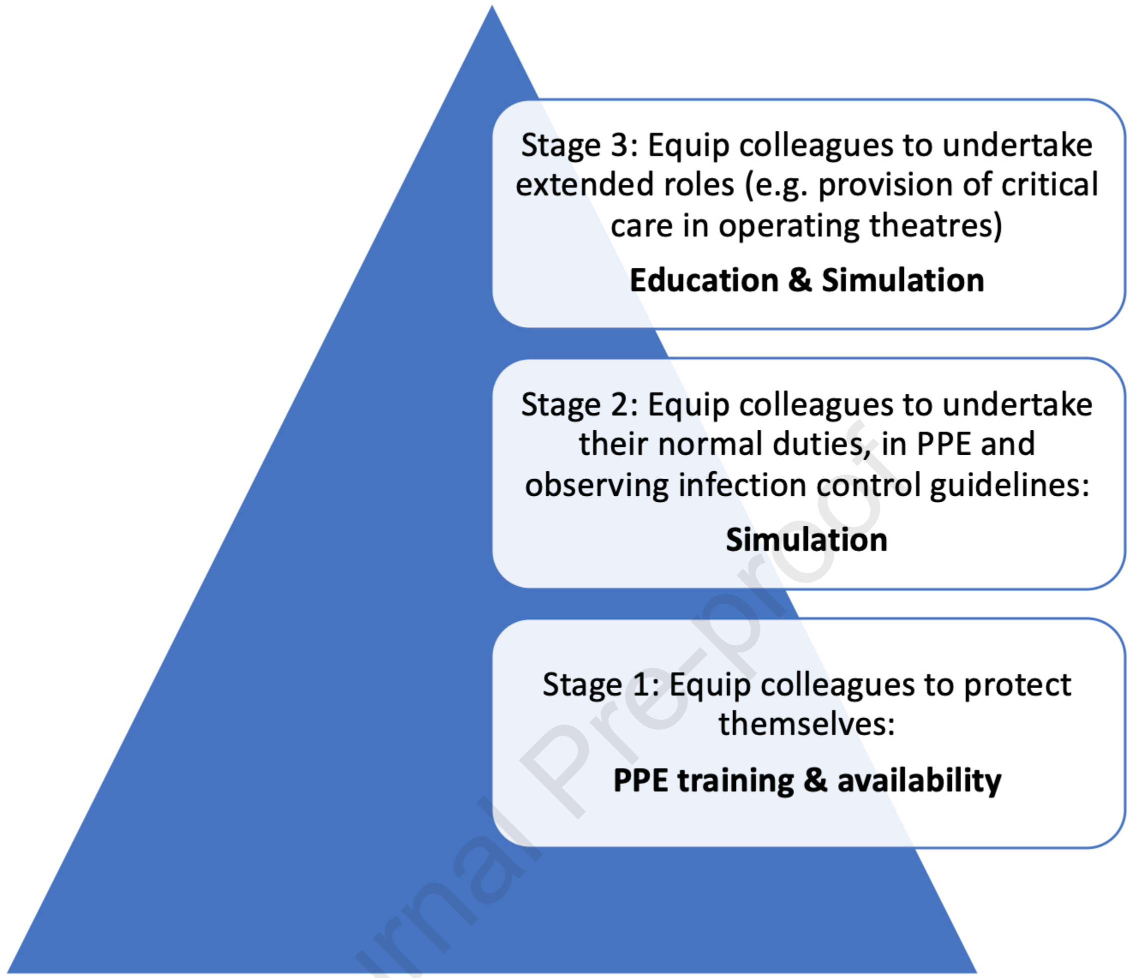
**Tips**
- Shape / mould the bougie or stylet to the shape of the VL blade
- Ensure runners know the difficult airway equipment
- Call for help early
- Prior to intubation, agree which teams are doing lines etc.

**Drugs List preparation** – **Ask the intubator what drugs they require**

| | | | |
|---|---|---|---|
| Fentanyl | undiluted | 1-200mcg | 2-4ml |
| Alfentanil | undiluted | 1mg | 2ml |
| Midazolam* | undiluted | 5mg | 5ml |
| Ketamine | in saline | 200mg | 20ml |
| Propofol 1% | undiluted | 200mg | 20ml |
| Rocuronium | undiluted | 100mg | 10ml |
| Metaraminol | In saline | 10mg | 20ml |
| Ephedrine | in saline | 30mg | 10ml |
| Atropine | undiluted | 600mcg | 1ml |
| Glycopyrrolate | undiluted | 600mcg | 3ml |

*check concentration

V1.3 T Huda, D Greig, C Shelton, E Shardlow 26/03/20


Stage 3: Equip colleagues to undertake extended roles (e.g. provision of critical care in operating theatres)
Education & Simulation
Stage 2: Equip colleagues to undertake their normal duties, in PPE and observing infection control guidelines:
Simulation
Stage 1: Equip colleagues to protect themselves:
PPE training & availability