

SARS, Bird Flu and other scares – *epidemic and pandemic preparedness in intensive care*

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ABSTRACT

Intensive care units are expensive facilities and as a consequence intensive care units are usually maximally utilised. An additional requirement for intensive care facilities is likely to occur during an epidemic. Any additional requirement has the potential to overwhelm existing intensive care resources and therefore it may become necessary to rapidly increase the capability of existing intensive care facilities. The lack of preparedness and proper procedures to facilitate urgent expansion of intensive care unit (ICU) facilities during severe acute respiratory syndrome (SARS) was exposed during the outbreak, and several lessons have been learned. Recommendations for adequate expansion are made on the basis that a reasonable standard of ICU care will be maintained. An assessment of the need for additional staff is made, however, it is unlikely that expansion beyond an additional 60% of current capacity will be possible, based primarily on the necessity for suitably qualified nurses. There is a requirement for prospective training of anticipated additional staff, as well as the establishment of infection control procedures, good communication procedures and the resolution of anticipated ethical dilemmas. Certain other preparations for expansion should also be completed in advance. These specifically include the fit testing of negative pressure respirators, sourcing of material and designs that will allow physical modifications to the ICU and additional equipment supply sourcing, bearing in mind that supply companies will be under pressure from more than one end-user.

Introduction

While the Severe Acute Respiratory Syndrome (SARS) caused a relatively contained pandemic, avian influenza has the potential to be readily transmissible and cause a major epidemic or pandemic. The diseases are however similar in that both are able to cause severe illness requiring intensive care management, and are potentially capable of producing enough victims to overwhelm currently available intensive care unit (ICU) resources. Intensive care is a relatively new speciality, and until recently had yet to be exposed to the demands of a significant pandemic. The SARS pandemic graphically illustrated the impact of even a relatively minor pandemic on intensive care,¹⁻⁴ and has highlighted the need for pandemic preparedness in the ICU.

The threat of a possible avian influenza pandemic is highlighted by the presence of ongoing sporadic human cases and emerging evidence of human-to-human transmission. It is worrisome that published evidence suggests that, at present, pandemic preparations are limited.^{5,6} This lack of preparation may be either because of a lack of awareness of the need for preparation, or the unwillingness of decision makers to commit expensive resources in the presence of so much uncertainty. Of course, the exact nature, timing, and severity of the next pandemic is impossible to predict with accuracy and there is even considerable controversy as to whether the world can expect an imminent event.⁷ Further uncertainty is reflected in that most mathematical models predict such wide ranges of necessary response requirements for ICUs that meaningful preparation is difficult. For example, a mathematical model based on influenza as the infecting organism predicted that between 106 and 28,142 additional patients would require mechanical ventilation over an 8–12 week period in Australia and New Zealand alone.⁸ Others in Europe and North America have estimated that intensive care services would be overwhelmed, even when relatively benign scenarios were modelled.^{9,10}

Given the documented impact of the recent SARS outbreak on ICU resources, the lack of preparedness demonstrated by the ICU systems of most countries affected by SARS, and the general failure to deal well with the challenges,^{4,11} it has become evident that there is a need for better preparation for further epidemics, despite the uncertainties. Two recent published critical care documents provide some guidance on pandemic preparedness. Both concentrate primarily on recommendations for the expansion of existing units and the commissioning of extra ICU beds to deal with the expected surge of patients who will require ICU care.^{12,13}

In principle, the following key aspects of preparedness require attention: the need for expansion of ICU capacity to deal with the increased number of patients, the need to protect patients and staff from cross-infection, the need to maintain staff morale, and the need to meet acceptable ethical standards of practice. It is also important to remember that given the ever-present financial constraints of the real world, funds to support such preparation will be limited. The consequence is that ideal, but unrealistic or excessively expensive, measures are unlikely to be funded by the relevant authorities in the preparatory phase. This paper is restricted to the discussion of initiatives that the authors believe can reasonably be expected to gain institutional and administrative support.

Expanding ICU capacity

Given the variability in predictions of the bed capacity required in a pandemic, as well as prediction even in conservative models of overwhelming numbers of patients, we believe it is reasonable to plan on the basis of what is viable.¹³ In practical terms, an 'ICU bed' is a unit made up of a physical space containing a bed with attendant power, gas supplies and life-support equipment, serviced by specialist doctors, nurses and allied health staff. This unit can only function well with much additional support, including radiology, physiotherapy, laboratory and laundry

services. The 'ICU bed' is therefore expensive to run and, in most countries, therefore fully utilised, even in the absence of a pandemic. In fact, in most countries there is already a shortfall of ICU resources and resource limitation has been reported from the Middle East, Asia and Europe.¹⁴⁻¹⁶ It therefore becomes clear that not much spare ICU capacity exists. So what can be done to expand capacity in times of a pandemic?

The expansion of services will inevitably result in a dilution of existing ICU resources. The result of dilution will be a proportional decrease in the quality of care provided. Tarnow-Mordi WO, Hau C, Warden A and Shearer AJ demonstrated that a small ICU expansion led to an increased mortality, despite employing temporary staff to care for additional patients.¹⁷ While some decrease in quality of care might be acceptable, with uncontrolled expansion the quality of care is likely to deteriorate progressively. Ultimately a point will be reached when this loss of care is so great that complications from poorly applied ICU care may outweigh its advantages. It is our opinion that expansion should not exceed that where reasonable standards of monitoring, life support, and patient and staff protection from occupational hazards can be maintained.

Given this objective, the critical resource limiting expansion is likely to be trained specialist staff.¹³ This is an opinion supported by others who also concluded that adequately trained staff was likely to be the limiting factor in providing ventilatory support in a pandemic.⁶ Let us briefly examine why this is so. More physical space is reasonably easily achieved by the commandeering of operating and recovery rooms, high dependency areas and even general wards, although the gas supply and central suction capability of the hospital may limit extreme expansion. Extra equipment such as ventilators, monitors and intravenous infusion pumps are often available as part of the standard operational backup supply. Additional spare or redundant equipment can be rapidly recommissioned, it may be borrowed from redundant operating rooms, or it can be purchased in sufficient quantities. Trained ICU doctors are scarce in most medical systems, however, in a supervisory role the specialist's expertise can be spread over several patients if assistance from non-specialist doctors is available. The immediacy and physical nature of the ICU nurse's role makes a supervisory role more difficult. Nurses, on the other hand, must usually be present at the bedside to continuously monitor and troubleshoot life-support systems. Nursing interventions are frequent and time consuming. In addition, during a pandemic the need for nurses to wear restrictive personal protective equipment further limits the ability of a nurse to move freely and supervise effectively outside her immediate environment. Thus it is here that the ability to expand, without serious loss of function, is most limited.

Given the above considerations, it has been estimated that the maximal realistic expansion of a modern ICU in a well functioning hospital would be by an additional 60% of existing pre-outbreak capacity.¹³ This estimate was based on the consideration that specialist staff, particularly the availability of trained nursing staff, would be the critical factor limiting functional expansion. More relaxed nursing ratios suggested in a second consensus document might allow marginally greater expansion.¹²

Even such limited expansion is based on recruiting substantial numbers of non-ICU healthcare workers to assist existing intensive care staff. It is therefore recommended that ICUs retain a list of all medical and nursing staff who have worked in the unit previously in order to facilitate rapid and appropriate drafting

of staff familiar with Intensive Care should a pandemic occur. Of course, affected staff should be fully informed of the nature and intended use of such lists.¹³ Surgical and operating theatre staff may be the most appropriate non-intensive care trained group to recruit. Anaesthesiologists and operating theatre nursing staff are familiar with caring for unconscious ventilated patients and are likely to be underutilised during a pandemic as elective surgery will almost certainly be suspended. To facilitate rapid and effective deployment in an emergency, basic training in key areas of critical care for such staff should be organised in advance and updated at reasonable intervals. A local training course could be developed, although readily available short introductory ICU courses such as the Fundamental Critical Care Support (www.sccm.org) or Basic Assessment and Support in Intensive Care courses (www.aic.cuhk.edu.hk/web8/BASIC.htm) are available.

Current avian influenza data indicate that a large proportion (up to 25%) of those requiring intensive care are paediatric cases.^{18,19} Globally, the usual proportion of ICU beds providing paediatric care is much lower than this, and ICU staff not familiar with children may expect to be called on to manage paediatric cases. It may therefore be prudent for ICU staff usually treating only adult patients to acquire a basic knowledge of paediatric ICU principles.

Properly planned expansion of intensive care requires the cautious stockpiling of equipment, drugs and disposable items. Detailed guidelines on the choice of appropriate respiratory equipment ranging from bag-valve resuscitators to full feature mechanical ventilators have been published.^{20,21} The long-term storage of redundant but still functional equipment should be considered. Given occupational safety concerns, equipment that requires the caregiver to remain in close proximity to the patient (such as the use of bag valve resuscitators as ventilators) is less suitable.

It is difficult to predict what the cause of the next pandemic will be. It is widely believed, however, that an influenza virus has high potential as a causative agent, and therefore many countries have increased their stock of neuraminidase inhibitors such as oseltamivir. An alternative, zanamivir, is administered as an inhaled powder and is difficult to administer to severely ill or ventilated patients.²² Bacterial superinfection associated with influenza is common and probably results in an increased morbidity and mortality.^{7,23} Therefore increasing the immediately available stock of locally relevant antibiotics may also be important.²³

Personal protective equipment (PPE) usage will greatly increase during an outbreak. Under pandemic circumstances sufficient stock for all staff in the ICU must be ensured. It has been recommended that sufficient PPE for 48–72 hours be maintained in preparation for emergency use.^{12,13} As national or global supplies may be limited, rational policies to control the use of PPE at a sustainable rate should be developed. These might include the careful reuse of respirators (even against current recommendations), rather than discarding them immediately after each use. As there will be an increased risk of contamination when reusing equipment, clear policies and protocols to govern any such action are essential, and staff must be fully informed of the reasons underlying such measures.

Infection control

Protection of patients and staff from cross-infection is one of the most important considerations in preparing for a pandemic.

In particular, illness and/or loss of morale among healthcare workers may result in significant loss of ICU capacity. During the SARS pandemic almost 30% of Toronto's ICU bed capacity was lost as a result of staff illness and quarantine policy.¹ It is a reasonable assumption that ensuring staff safety will improve staff morale and increase the number of staff capable of treating further patients.

Infection control can be considered under the following headings: management, physical environment, source isolation, and personal protective equipment.

Infection control management

An infection control management team should be responsible for determining infection control policies and procedures and ensuring disciplined implementation both prior to and during a pandemic. In order to achieve this effectively the membership of the team must include senior management, medical and nursing staff, with sufficient authority to approve and implement policy. The essential components of an infection control programme are:

- Development and implementation of measures to prevent transmission of infectious agents and to reduce risks for device and procedure related infections
- Surveillance to monitor patients and healthcare personnel for the acquisition of infection and/or colonisation
- Investigation of infection problems identified by surveillance or relevant individual observations
- Effective management of identified infection problems prior to and during outbreaks

The programme should have mechanisms to ensure that all personnel working in a patient setting receive documented

training and regular updates on infection control procedures. It is not possible to achieve this efficiently if proper infection control training is implemented only once a pandemic occurs.

Physical environment

Different measures and isolation policies will be required depending on the mode of transmission of the pandemic disease. However, in the absence of definitive knowledge it appears reasonable to initiate preparations for airborne and contact precautions and proceed to downgrade if appropriate.¹³ Taking the likely example of influenza, while the mode of spread is likely to be primarily by droplets, there is some reason to believe that it may be airborne during pandemics.²⁴ Guidelines for physical environmental control and isolation procedures for airborne diseases, using the model of tuberculosis, are available from the Centers for Disease Control and Prevention (CDC).²⁵ The basic requirements for different levels of isolation, with advice on the use of personal protective equipment and appropriate sanitation, are summarised in Table I.²⁶

Air circulation in clinical areas is often insufficient for an infectious environment. It has however been demonstrated that the rapid installation of simple ventilation systems, such as window-mounted industrial extraction fans, is possible and is an effective way to increase ventilation capacity of clinical areas.¹³ The rationale for environmental infection control and a summary of the behaviour of respiratory droplets and aerosols has recently been reviewed.²⁴

There should be adequate procedures for the routine care, cleaning, and disinfection of environmental surfaces. Often-forgotten surfaces in this category include keyboards and telephones. Frequent cleansing and disinfection of high-use

Table I: A summary of infection control isolation methods.

<p>Standard precautions</p> <ul style="list-style-type: none"> • Hands must be cleansed before and after every patient contact – see text • Gloves, gowns and eye protection must be used in situations where exposure to body secretions or blood is considered possible • Sharp instruments and needles must be disposed of safely in special containers • Soiled linen must be disposed of in impervious bags • Blood, faeces, urine and substances significantly contaminated with such body fluids must be disposed of in proper sanitary facilities
<p>Droplet precautions</p> <ul style="list-style-type: none"> • Patients should be isolated in single rooms • Wear a good quality surgical mask when within 1-2m of the patient • Eye protection such as visors, full-face shields or goggles are optional and their use depend on specific circumstances, e.g., excessive patient coughing, closeness of contact and the need for performing high risk procedures (endotracheal intubation, bronchoscopy, non-invasive ventilation, etc.)
<p>Airborne precautions</p> <ul style="list-style-type: none"> • Patients require single isolation rooms with negative air pressure and a minimum of 8 to 12 air changes per hour • When entering the room, wear a mask respirator with a particle filtering capacity of at least 95% (N95, or FFP2), and that allows a tight seal over the nose and mouth. Individuals should have been “fit tested” to establish which make of mask is most suitable. Correct mask placement technique is important • Eye protection such as full-face shields or goggles are optional and depend on specific circumstances, e.g. excessive patient coughing, closeness of contact, need for high risk procedures (endotracheal intubation, bronchoscopy, non-invasive ventilation, etc.)
<p>Contact precautions</p> <ul style="list-style-type: none"> • Patients should be isolated or cohorted with patients who have the same infection • Wear gloves and an apron for all patient contact • Wear gowns if there is likely to be prolonged direct contact with the patient (e.g. daily clinical examination) or any infective material. • All protective equipment must be removed prior to exiting infected areas

objects in patient areas can be achieved with hypochlorite-based solutions or other hospital-use-approved detergents/disinfectants. For large blood or body fluid spills, use a 1:100 dilution (500–615 ppm available chlorine) to decontaminate nonporous surfaces after cleaning. The use of disposable barrier coverings for keyboards and similar objects can be considered.

Source isolation

Preventing the spread of infected particles from the patient to the environment should be a high priority. Spontaneously breathing patients should wear surgical masks to reduce droplet and aerosol spread. In mechanically ventilated patients, high-efficiency bacterial-viral filters should be used in the ventilator circuit to minimise environmental contamination. Hydrophobic filters may be more effective than electrostatic filters.²⁷

Aerosol-generating procedures such as non-invasive ventilation (NIV), nebulisation, bronchoscopy, open suction and the use of very high-flow oxygen should be avoided if possible.²⁸ These procedures are particularly dangerous because airborne respiratory particles and aerosols remain suspended in air for long periods of time, with the resultant potential for spread throughout the room. It has been shown, in a simple simulation model, that the simple, nonbreathing, and Venturi-type oxygen masks produce exhaled smoke plumes over minimum distances of 0.1 to 0.2 m, 0.2 to 0.4 m, and 0.3 to 0.4 m, respectively.²⁹ The same researchers found that when using NIV at inspiratory pressures of up to 18 cm H₂O, a plume of smoke may extend up to 0.45 m above the head of a patient simulator and spread horizontally along the ceiling of the room.³⁰ These patterns of spread represent very high-risk areas (within about half a metre of the patient's face), but airborne particles or aerosols may spread substantially further. In the clinical setting non-invasive ventilation has been demonstrated to be independently associated with hospital-acquired outbreaks of SARS.³¹ Another study of events occurring during the SARS outbreak failed to demonstrate a close association between NIV use and infection, but the number of events in this study were too small to support the conclusion that the use of NIV was safe.³²

Personal protective equipment

Personal protective equipment usually includes the use of mask respirators, eye protection, gloves, gowns, and sometimes head and shoe protection.

Because of their relative convenience and low cost, mask respirators are most commonly used to provide respiratory protection to healthcare staff exposed to potentially infectious respiratory pathogens. Under test conditions N95/FFP2 grade respirator masks are much more effective at removing particles from inhaled air than surgical masks are.³³ There is however little good evidence that they reduce infection in the clinical setting. There are several reasons for this, including ethical considerations that preclude the use of randomised controlled designs. There have also been few opportunities for large observational studies. Nevertheless, based on technical data and predictive models, it is recommended that in the initial stages of a pandemic it is preferable to use a fit-tested N95/FFP2 mask respirator. Some experts recommend the use of surgical masks instead of N95/FFP2 masks in the event of an influenza pandemic, but this is controversial. Not all mask designs fit all facial types and fit-testing is a formal process that involves testing different types of masks on an individual to ensure that leakage around the edges of the mask is not excessive and that performance is adequate (similar to rated performance). The process requires

special equipment and is time consuming, but necessary, to ensure mask efficacy.³⁴ For this reason, all staff that currently work or will potentially work in the ICU during a pandemic should be formally fit-tested. It must be remembered that formal fit-testing only identifies the type of mask that generally suits an individual. Therefore, before each use the user is still required to test the adequacy of the mask seal according to the manufacturers' instructions. The mask type most likely to fit a population of staff depends on the facial characteristics of that population³⁵ and it may therefore be possible to identify a mask type that best fits the healthcare workers in a particular unit. It must be remembered that repeat testing is recommended annually and following a bodyweight change of more than 10%. Bearded subjects are not suitable for facemask respirator use.

Powered air purifying respirators (PAPR) potentially provide a higher level of protection. These devices utilise a battery-engine-driven, high-flow system that drives environmental air through a HEPA filter and into a hood. A disadvantage is potential engine or battery failure, and it may be wise to wear a N95/FFP2 mask underneath the PAPR. This is uncomfortable, but provides a high level of protection. Other disadvantages include the need for significant storage space, routine maintenance and checking. Training of staff in the safe use of the PAPR is essential and careful decontamination after use is required. The benefit of PAPR over N95 masks will be dependent on both the clinical setting and the physical environment. Potential benefit is greater in a highly infectious environment and if the number of air changes is lower.³⁶ It may therefore be more appropriate to reserve their use for situations such as unavoidable aerosol generating procedures.

The use of eye protection such as goggles or face shields, head caps, gloves and water impermeable gowns is relatively uncontroversial (see Table I). A system for the disposal of an unusually large quantity of used PPE must also be implemented, as such items could contaminate the unsuspecting if they are not properly disposed of. Personal equipment such as pagers, mobile telephones and pens may also become contaminated and should never be handled in the clinical area without prior hand-washing.

Ethical and moral considerations

In view of the unusual stresses likely to be encountered, an ethical framework is necessary for the successful management of a pandemic.³⁷ Preparing the groundwork for ethical processes and moral behaviour should be a central part of preparation. Decision-making processes will be complex, but should have the following basic characteristics: accountability, inclusiveness, openness and transparency, reasonableness and responsiveness.³⁸ Decisions should be informed by ethical values, including equity, reciprocity, solidarity and trust. It is generally accepted that healthcare workers have a 'duty of care' to patients in an epidemic even in the presence of an increased risk to their personal health. Equally, the principle of reciprocity requires that those responsible for healthcare delivery, such as administrators, hospital and departmental heads, and society itself, support those who face a disproportionate risk in protecting the public good and take appropriate steps to minimise the impact.³⁷ This may include the provision of a protected environment, safety equipment, adequate quarantine facilities, and even financial compensation or disability insurance. It has been suggested that healthcare workers' demands for additional protection such as enhanced disability insurance are not easily justified without a commitment to provide care in an epidemic.³⁹ Although experience during SARS demonstrated that almost all healthcare workers

accept a 'duty of care' to patients with epidemic diseases, even at considerable personal risk, the point at which duty to care is outweighed by personal risk is unclear and on this issue, in particular, specific guidance from professional bodies is lacking.

Even with good prior preparation and controlled expansion it is possible and even likely that intensive care capacity will be overwhelmed. Under these conditions there are two possibilities. First, a decision can be made to continue to expand the ICU, spreading expertise and equipment ever thinner, until a point is reached when little extra care beyond that of ward care is being delivered. Prior to this, or at this point, a decision to abandon attempts at intensive care, with diversion of resources to general wards and other areas of need could be reasonably considered. Second, an alternative is to resist uncontrolled expansion, maintaining reasonable standards of ICU life support care, and consider ICU admission triage. Triage, the process of prioritising admission when resources are limited, can be managed in various ways. The principle of justice, or fairness in the prioritisation process, is of fundamental importance. Some professional bodies recommend a lottery type of approach, where patients are admitted in the chronological order that they present. The most commonly recommended and reported method, however, is to use a utilitarian approach based on the principle of distributive justice. The aim of this approach to triage is to ensure preferential admission of patients most likely to benefit from intensive care.^{15,40,41} To achieve this an assessment of prognosis is necessary. Assessing the prognosis in patients during a pandemic is likely to be difficult and attempts to address the issue with triage systems have been made.⁴²⁻⁴⁴ These largely provide a systematic approach to identify factors that are associated with poor prognosis in patients with influenza or other infectious diseases. Of course, applicability is limited by the fact that the characteristics of the next pandemic disease are currently unknown. This is one of the reasons why it is important to introduce information technology systems for analysing data from outbreak cases to allow quick sharing of new observations with the wider clinical community.¹² Triage systems do not take into account the needs of critically ill patients who do not have the pandemic disease, and their claim to medical care cannot be ignored.³⁷ Lastly, consideration might be given to preferential admission of critical members of the society's response to the epidemic, such as healthcare workers or senior political leaders.

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