Guidelines

Fire safety and emergency evacuation guidelines for intensive care units and operating theatres: for use in the event of fire, flood, power cut, oxygen supply failure, noxious gas, structural collapse or other critical incidents

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Fire safety and emergency evacuation guidelines for intensive care units and operating theatres: for use in the event of fire, flood, power cut, oxygen supply failure, noxious gas, structural collapse or other critical incidents

Guidelines from the Association of Anaesthetists and the Intensive Care Society

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Summary

The need to evacuate an ICU or operating theatre complex during a fire or other emergency is a rare event but one potentially fraught with difficulty: Not only is there a risk that patients may come to harm but also that staff may be injured and unable to work. Designing newly-built or refurbished ICUs and operating theatre suites is an opportunity to incorporate mandatory fire safety features and improve the management and outcomes of such emergencies: These include well-marked manual fire call points and oxygen shut off valves (area valve service units); the ability to isolate individual zones; multiple clear exit routes; small bays or side rooms; preference for ground floor ICU location and interconnecting routes with operating theatres; separate clinical and non-clinical areas. ICUs and operating theatre suites should have a bespoke emergency evacuation plan and route map that is readily available. Staff should receive practical fire and evacuation training in their clinical area of work on induction and annually as part of mandatory training, including 'walk-through practice' or simulation training

and location of manual fire call points and fire extinguishers, evacuation routes and location and operation of area valve service units. The staff member in charge of each shift should be able to select and operate fire extinguishers and lead an evacuation. Following an emergency evacuation, a network-wide response should be activated, including retrieval and transport of patients to other ICUs if needed. A full investigation should take place and ongoing support and follow-up of staff provided.

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This is a consensus document produced by expert members of a Working Party established by the Association of Anaesthetists of Great Britain and Ireland and the Intensive Care Society (ICS). They have been seen and approved by the Board of Directors of the Association of Anaesthetists and by the Council of the Intensive care Society. The following organisations have contributed to these guidelines: the Paediatric Intensive Care Society (PICS); the National Association of Healthcare Fire Officers (NAHFO); the National Fire Chiefs Council (NFCC); NHS Improvement; the British Compressed Gas Association; the Chartered Institute for Ergonomics and Human Factors (CIEHF); the Medicines and Healthcare products Regulatory Agency (MHRA); and the Health and Safety Executive (HSE).
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What other guidelines are available on this topic?

Previous guidance for dealing with a fire on an ICU has been published by the Intensive Care Society (ICS) within its *Guidelines for the Provision of Intensive Care Services* in 2019 [1]. Guidance for dealing with a fire in the operating theatre [2] and evacuation of an operating theatre [3] is included in the Quick Reference Handbook, published by the Association of Anaesthetists (https://anaesthetists.org/Home/Resources-publications/Safety-alerts/Anaesthesia-emergencies/Quick-Reference-Handbook).

Why were these guidelines developed?

At least three fires have occurred in UK ICUs over the last 10 y, all of which required full-scale emergency evacuation of patients, staff and relatives [4, 5]. Many changes were put in place following the fire in Bath [4] in 2011. While writing the *Guidelines for the Provision of Intensive Care Services*, a number of outstanding issues became apparent which needed addressing by a multidisciplinary Working Party made up of clinicians, healthcare fire officers and representatives from industry, the Fire and Rescue Services, NHS Improvement and the Health and Safety Executive (HSE). The Association of Anaesthetists and ICS therefore set up an expert Working Party as a joint venture, and these guidelines have been produced as a result of the work of this group. During the COVID-19 pandemic, issues around fire safety, emergency evacuations and the safe use of oxygen have become especially relevant, and these are discussed in more detail in online Supporting Information Appendix S1.

How and why does this statement differ from existing guidelines?

These guidelines are the first of their kind to include input from such a broad group of experts. They contain educational materials and resources which we hope will be used by hospitals to improve fire safety and evacuation procedures. Existing government guidance states the following: first, ICU design should be based on the prevention of a fire occurring within the hospital spreading into the ICU; and second, the ICU should be divided into clinical and non-clinical fire-rated zones to prevent a fire in a non-clinical area impacting on clinical areas [6]. Little consideration to date has been given to a fire starting within an ICU clinical area.

These guidelines include new recommendations for frontline clinical staff in ICUs and operating theatre suites to be trained to select and safely use fire extinguishers, and to receive their annual mandatory fire training in their place of work, ideally as a multidisciplinary team. While the latter is recommended every 2 years in existing Department of Health guidelines [7], it is something that is rarely done in practice.

Throughout these guidelines, 'ICU' refers to ICU, high dependency units, ICU escalation areas, respiratory high care areas and other areas of the hospital where non-invasive respiratory support is provided. 'Theatre operating suite' refers to operating theatres and theatre recovery wards/post-anaesthesia care units.

Although this guidance is specific to ICUs and operating theatre suites, the general principles may be applicable to any ward using non-invasive respiratory support and in particular high-flow nasal oxygen.

Recommendations

Preparation, planning and training

1 Clinical staff of all grades should receive multidisciplinary training in their place of work as part of annual mandatory training, covering the management of a fire and evacuation of their work area. This should include the location and operation of manual fire call points, oxygen shut off valves (area valve service units), evacuation aids, evacuation routes and procedures as well as the importance of keeping evacuation routes clear. Practical 'walk-through' training and/or simulated evacuations should be practised every 2 y.

2 Nominated clinical staff should be trained to select and safely use fire extinguishers.

3 ICUs and operating theatre suites should be designed to incorporate the latest fire safety features and have individualised evacuation policies and evacuation route plans. Intensive care units and operating theatre suites should be divided into zones, each with its own oxygen shut off valve (area valve service unit), so that oxygen supply to an area affected by a fire can be stopped without affecting oxygen delivery to other areas.

4 Ventilation of ICUs and clinical areas where high-flow nasal oxygen, facemask continuous positive airway pressure and non-invasive ventilation are in use should be > 10 air changes per hour to prevent oxygen enrichment of the ambient atmosphere.

5 ICU and operating theatre fire alarms should be audible throughout the department unless a specific decision is made by clinicians to turn the sound feature off in that area. A computerised fire alarm handler system should be installed in hospital switchboards to make it quicker and easier to liaise with the Fire and Rescue Services.

6 Laminated action cards, specific for that clinical area, should be placed next to all manual fire call points so that they can be followed in the event of an emergency evacuation.

7 Each ICU bed space and operating theatre should have appropriate and sufficient evacuation equipment stored in an easily accessible location, including evacuation aids, evacuation boxes and a torch. Intensive care units and theatres should have sufficient numbers of appropriately trained staff working on each shift to enable an emergency evacuation to occur at any time.

8 Oxygen cylinders should be stored, handled and used according to the gas supplier's instructions, using the correct sequence of actions when administering oxygen and using an oxygen cylinder bed bracket at all times.

9 Major incident planning should include plans for internal incidents, where the staff themselves are victims and unable to work and where ICU and operating theatre suites become unusable for patient care. Critical care networks should have plans in place to enable emergency retrieval, transfer and ongoing care of critically ill patients from one hospital to another in the event of a fire or similar emergency.

During a fire or life-threatening emergency

10 Staff safety must be the priority. If staff find themselves dealing with a fire or other potentially life-threatening emergency situation, they should make an emergency 'dynamic risk assessment' weighing up their responsibilities to their patients against the risk to their own life and using the best information they have available at the time.

Following an emergency evacuation

11 All staff involved in a fire or similar emergency should be supported following the event, attend a short operational debrief, be assessed by their occupational health department before re-starting work and have access to confidential counselling services. The use of peer-support tools, such as trauma risk management, has been shown to be beneficial.

12 A full investigation of any critical incident should be carried out looking at all relevant contributory factors, ideally by an independent team and using a human factors and ergonomics investigative tool, and lessons identified embedded into future planning.

Introduction

Over the past 15 years there have been at least three fires in UK ICUs; each fire required a full-scale emergency evacuation of patients, staff and relatives [1, 4, 5]. Fires have occurred in operating theatres during the use of lasers [8], including in combination with high-flow nasal oxygen (HFNO) [9] and with dental implants [10], and have also been caused by diathermy interacting with chlorhexidine [11]. Evacuation of other UK ICUs has occurred following flood, power cut and air conditioning malfunction with noxious gases being unintentionally pumped into an ICU (T. Clutton-Brock, personal communication).

ICU fire, Bath, 2011

An ICU fire at the Royal United Hospital, Bath, was caused by an oxygen cylinder in 2011 [1, 4, 12]. The oxygen cylinder was laid on a patient's bed ready for transfer, caught fire as it was turned on and appeared to explode. Flames were seen rising up from the bed and the mattress and bedding burnt violently, resulting in the ICU being filled within seconds with noxious, thick, black and irritant smoke: This reduced visibility to 1 metre and made breathing extremely difficult for staff, patients and their visitors. The fire rapidly spread to the patient's legs, bedding and mattress, then the curtains surrounding the bed space and finally the flooring beneath the bed. The patient on the burning bed was pulled to safety, 10 other patients were evacuated within 7 min, and a 12th patient (ventilated in a side room and not immediately affected) 15 min later. The fire was put out by two doctors using five fire extinguishers. The patient on the bed suffered burns to her lower legs but no other patient was harmed; two members of staff suffered smoke inhalational injury requiring hospital admission [1, 4]. Twenty-five consultant anaesthetists arrived within 30 minutes to help deal with the aftermath of the fire, transfer five patients to neighbouring ICUs and set up a temporary overnight high dependency unit in the post-anaesthesia care unit (PACU) for the remaining seven patients. The oxygen cylinder was almost completely destroyed in the fire, hampering subsequent investigations, but it is believed that the fire started within the oxygen cylinder valve [1, 4, 13].

ICU fire, Royal Marsden Hospital, London 2008

In 2008, a fire started in the roof of the Royal Marsden Hospital, London, which spread very rapidly and resulted in the destruction of the ICU [1, 5]. A complete and successful evacuation of the building occurred within 28 min [1, 5]. At the time, there were six patients in the 16-bed ICU and three patients in the operating theatres. All ventilated patients were transferred to the ICU of the neighbouring Royal Brompton Hospital. No patients or staff were injured. The unlikely need for complete evacuation of the building had not been included in the hospital's major incident plan, but the timing (2 January at 1pm) was fortunate in that both hospitals had relatively low occupancy as their work-load is mainly elective [1, 5].

ICU fire, Royal Stoke Hospital, 2017

A fire at the Royal Stoke University Hospital in 2017 occurred when a fire was started deliberately in a shared corridor between theatres and the ICU [1]. Although the fire was dealt with promptly, smoke permeated into the ICU resulting in poor visibility and an acrid odour. Twenty-four ICU patients were evacuated immediately and transferred to PACU and operating theatre suites elsewhere in the hospital building. No patients or staff came to harm.

A key difference between a fire or other emergency that necessitates the evacuation of an ICU or operating theatre suite, and a similar situation occurring in a standard hospital ward, is that ICU patients and those within an operating theatre suite are likely to be critically unwell, with a significant oxygen requirement and dependent on respiratory and/or other system support. These patients are therefore entirely dependent on staff to evacuate them. As a result, emergency evacuation of these areas requires different guidance and a more focused approach compared with the rest of the hospital. On a standard hospital ward, staff are advised to evacuate all patients, shut the fire doors and wait for the hospital internal fire response team and the Fire and Rescue Services to arrive to deal with the firs. However, ICU and theatre staff may be faced with difficult decisions as to whether they can safely evacuate their patients without compromising their own safety. The same may be true for staff in emergency departments, coronary care units and other monitored beds elsewhere in the hospital. In addition to the need for different evacuation guidance, staff themselves may be injured and unfit to work following such an emergency, meaning that incident response plans to guide management of the aftermath of such an event need to be adjusted to take this into consideration.

Design of operating theatre suites and ICUs

The best strategy to improve fire safety and ensure emergency evacuations run without complication is to

use the design of new and refurbished ICUs and operating theatre suites as an opportunity to incorporate recommended fire safety features: These are well described in existing national guidance and include designing ICUs and operating theatre suites with multiple exit points, and ICUs with small fire-rated bays (ideally for no more than six patients) or side rooms, ground floor location, interconnecting routes with operating theatre suites to facilitate an evacuation, smoke control systems and misting fire suppression systems. If a ground floor location is not practical, evacuation lifts with a dual electrical supply should be provided. Low-level ICU emergency lighting may be very beneficial but there are currently no recognised standards for this in the UK [6]. Design of a new or refurbished ICU/operating theatre suite must be according to national guidance [1, 6], include factors listed in Table 1 and must comply with current Department of Health regulations concerning fire retardant bedding, mattresses, curtains around bed spaces and flooring [1, 6]. Fire safety of existing ICUs and operating theatre suites is individual and unique to each area; any fire safety issues in these areas should be identified in that area's annual fire risk assessment [6].

Intensive care units and ICU escalation areas should have ventilation systems that ensure > 10 air changes occur per hour to prevent oxygen enrichment of ambient air [14]. This level of ventilation is also that recommended for good infection prevention and control and is especially important when high levels of HFNO, facemask continuous positive airway pressure (CPAP) and non-invasive ventilation are in use [15].

At the time of writing, any healthcare areas that were affected by the outcomes of the national cladding review following the Grenfell Tower fire in 2017 have been addressed or are in the final stages of remediation. However, uncontrolled external spread of fire by combustible cladding systems may still need consideration when looking at the overall delivery system of care within a hospital but would not fall within the immediate remit of this document.

Fire safety equipment

Fire and smoke detection and alarm systems

When a fire alarm system is activated, a signal is sent to an alarm receiving centre, usually located within the hospital switchboard, which alerts switchboard staff to call the Fire and Rescue Services and bleeps internal fire response

Table 1 Factors to be prioritised when designing or refurbishing a new ICU or operating theatre suite.

Well-marked fire manual call points, fire extinguishers and oxygen shut-off valves (AVSUs) [16, 18]
Location of AVSUs that allows individual areas or zones of the ICU or operating theatre suite affected by a fire to be isolated without necessarily shutting off the oxygen supply to the whole ICU/theatre suite [18]
Multiple exit routes: ideally each department should have three separate exits [6, 16], with two of the three exits allowing for horizontal evacuation [6, 16]
Adopting smaller fire-rated bays (ideally six beds or less) or side rooms, rather than large open areas, to assist with smoke control and help prevent spread of fire [1, 2, 6, 7]
Sufficient ventilation to ensure that ICUs have > 10 air changes per hour to prevent oxygen enrichment of the ambient atmosphere when HFNO, facemask CPAP and non-invasive ventilation are used [15, 33]. Operating theatres typically have 25 air changes per hour, anaesthetic rooms 15 and operating theatre recovery areas 10 [14]
Consideration of ground floor location for ICUs, and easy interconnecting routes between ICU and operating theatres to make evacuation easier [1, 6]. If a ground floor location is not practical or realistic, then vertical evacuation lifts with a dual electrical supply should be installed
Separating clinical and non-clinical areas [1, 2, 6]
Door widths on bays and side rooms should be big enough to allow bariatric beds to pass through without adjustment [1, 2, 7]
Automatic smoke control systems in ICU and consideration for low-level emergency lighting to assist with emergency evacuations
Consideration of modern sprinkler and misting systems [6, 20, 29]
Operating theatres should be arranged in zones so that > 50% of operating theatres remain unaffected by a fire should one occur, for example, an operating theatre complex of 8 theatres in a row can be divided into two blocks of four theatres, separated by a 30-min fire-rated sub-compartment
Operating theatres should have an override and control of smoke control and ventilation system
A ceiling void, with removable ceiling tiles and electrical cabling located here, should only be included in the design of an ICU/operating theatre suite if no other alternatives are possible [18]
ICU pendants improve the electrical safety [43], are likely to reduce fire risk [43] and are recommended

AVSU, area valve service units; HFNO, high-flow nasal oxygen; CPAP, continuous positive airway pressure.

teams. A continuous fire alarm indicates a fire in that particular zone: In an ICU or operating theatre suite, this should prompt immediate investigation as to whether there is an actual fire, tackle the fire with fire extinguishers if staff are trained and feel safe to do so and start an evacuation [6]. An intermittent alarm indicates a fire in an adjacent zone and should prompt staff to prepare for an evacuation [6]. A fire alarm system that meets UK standards and is appropriate for each individual ICU or operating theatre suite is mandatory [6]. If a department is large and/or has a complex layout, more than one fire alarm repeater panel may be required to help quickly determine the location of a fire [6].

Staff respond better to a combined audible and visual fire alarm compared with an alarm with only a visual alert [16]. The Working Party recommends that the audible alarm feature is not inactivated in ICUs as has been standard practice in the past [17]. Discussions with clinicians in operating theatres should guide any decisions to inactivate audible alarms where this may be dangerously distracting for staff.

Computerised fire alarm handler systems

Installing a computerised fire handler system in hospital switchboards, or other alarm receiving centres, makes it quicker and easier for hospital switchboard operators to contact Fire and Rescue Services and potentially reduce their response times for a confirmed fire [6].

Fire extinguishers

Firefighting equipment can reduce the risk of a small fire developing into a larger one [7]. The safe use of an appropriate fire extinguisher to control a fire in its early stages may reduce the risk to others by allowing staff more time for evacuation of patients and aid staff past a fire [7].

We recommend that nominated staff in ICUs and operating theatre suites should be trained to select and safely use the appropriate type of fire extinguisher, depending on the likely cause of the fire, with such training organised by the hospital Fire Safety Officer. Practical fire extinguisher training is recommended where possible. Some fire experts recommend the use of 'universal' type fire extinguishers (P50s or misting type) as these can reduce the issues around fire extinguisher selection and fire source identification: however, this is controversial, and we recommend that local hospital Fire Safety Officers make decisions about such equipment. Each shift should ideally have one member of staff who has been trained to select and safely use a fire extinguisher and who is ideally not the member of staff in charge: This would allow the member of staff in charge to lead an evacuation and direct operations.

Oxygen shut off valves (area valve service units)

Each area of an ICU or operating theatre suite should have oxygen shut off valves, also known as area valve service units (AVSU), which allow the pipeline oxygen supply to each area to be isolated. Operating an AVSU in the event of a fire will stop the flow of oxygen to the area affected by fire, thereby reducing its impact and spread and extending the time available to safely evacuate patients [18]. Of note, operating the AVSU will stop the flow of oxygen to all patients in that area, many of whom may be dependent on oxygen for survival. This is a clinical decision which can only be taken by the most senior clinical member of staff present. If necessary, oxygen cylinders can be used to administer oxygen to patients as an alternative to pipeline oxygen in this situation. Ideally, an ICU or operating theatre suite would be divided into different areas, each with their own AVSU, enabling oxygen to be shut off to one area without disrupting oxygen supply to another. If oxygen is not a direct contributory factor to the fire, that is, if a ventilator or oxygen cylinder has not ignited, this should be the last action before the ICU or operating theatre suite is evacuated of patients.

Area valve service unit locations should be included in fire safety and evacuation drawings [18]. Oxygen training for all healthcare professionals within the ICU or operating theatre suite should include information as to where AVSUs are located, how to operate them and the implications for patients of operating AVSUs as above [1, 5, 6, 12, 18]. Dual oxygen circuits are recommended in ICUs to improve oxygen supply resilience [18], meaning that two AVSUs may need to be turned off to isolate one zone [18].

Automatic smoke control systems

Provision of automatic smoke control systems should be considered during the design and refurbishment of ICUs [6, https://www.smokecontrol.org.uk]. These increase the time available for an emergency evacuation to take place by reducing the temperature and concentration of smoke and by improving visibility [6].

Automatic fire suppression systems

Partial sprinkler/water mist protection systems can help mitigate localised fire risks in non-clinical areas [6, https://www.bafsa.org.uk]. In the past, they have not been recommended in ICU and operating theatre clinical areas for the following reasons: water ingress into electrical sockets and medical devices resulting in total power

Table 2 Factors which should be included in ICU and operating theatre suite emergency evacuation policies.

Environment	Other locations within the hospital where ICU care can be provided and anaesthetised patients looked after temporarily, ideally which can be reached by evacuating patients in a horizontal manner. Possibilities would include other ICUs, operating theatre suites and the emergency department [6]
	Evacuation routes, both primary (main exit route) and secondary (alternative route should the primary route be obstructed or not safe to use) [6, 16]
	Design of ICUs and operating theatre suites which allow patients to be compartmentalised [6]
	Possible co-existing power or equipment failure [6]
	Layout of the building and the need to negotiate stairs during an evacuation [6, 16]
	In a major fire, serial evacuation may be required with a staged move to the outside and eventual evacuation of the whole hospital [1, 5, 12]
Patients	Triage of patients in the following order: 1 Evacuate patients nearest a fire first 2 Then evacuate the least unwell patients 3 Then evacuate the most unwell patients 4 Evacuate patients within side rooms last
	Ensure that bariatric beds fit through the relevant doorways in evacuation routes, and that plans are in place for evacuation of bariatric patients in upstairs wards with the possibility of lifts being inaccessible [12, 16]
	Consider nursing patients receiving ECMO or other therapies involving bulky and relatively immobile equipment furthest from the exit, to prevent bulky equipment hampering the evacuation of other patients
Clinical	Provision of ventilatory support (transport ventilators or hand ventilation if necessary) with accompanying oxygen cylinders [1]
	Requirement for drug infusion pumps (with fully charged battery power) and a supply of emergency medications [1]
	Likely need for continuation of invasive monitoring [1]
	Temporary discontinuation of renal replacement therapy or ECMO [1]
Communications	Transfer of patient notes if paper notes are used
Staff	Consider the fact that staff may themselves be harmed by a fire and therefore unfit to continue working [1, 5, 12]

ECMO, extracorporeal membrane oxygenation.

failure; generation of large quantities of steam; risk of water pooling and subsequent electrocution; potential temperature shock to patients; cooling of toxic smoke; risk that the weight of water can exceed the loading for the building leading to structural collapse and/or flooding of wards below [19]. However, many fire safety experts now believe that modern sprinklers or water mist systems are extremely reliable in limiting fire growth and extinguishing fires [20]. We recommend that such systems are considered in conjunction with the overall package of fire safety precautions for the hospital's fire safety strategy (https://www.bafsa.org.uk).

Automatic emergency low-level lighting

Smoke can significantly reduce visibility in the event of a fire within an ICU or operating theatre suite and hamper an emergency evacuation [4, 12]. Many fire experts recommend that low-level emergency lighting should be installed when ICUs and operating theatre suites are built and refurbished to improve visibility even when ceiling lighting is ineffective [7, 21–23]. Fire alarm systems which automatically trigger emergency low-level lighting, smoke control systems and fire suppression systems for clinical areas would reduce the cognitive load of clinical staff involved in an emergency evacuation.

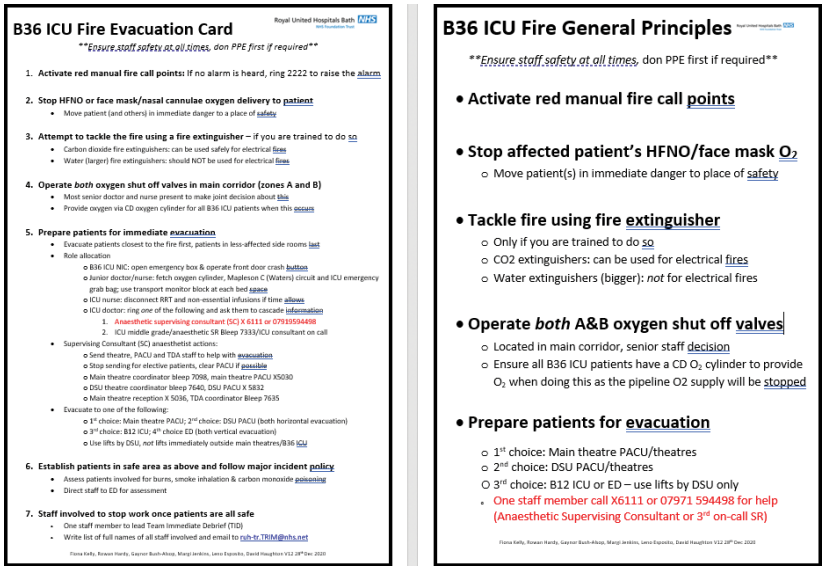
Emergency evacuation policies

Each ICU and operating theatre suite must have a bespoke evacuation policy in place, specific for a fire but also applicable for other types of emergency evacuation (Table 2) [1, 3, 6, 12, 16]. These policies must be reviewed and updated regularly.

Strategies to improve safe emergency evacuation of patients

Accessible evacuation policies and action cards

Local evacuation policies should be readily available digitally as well as printed and laminated in a folder in a central area of the ICU or operating theatre suite. In addition, an emergency evacuation route map should be



B36 ICU Fire Evacuation Card

Royal United Hospitals Bath NHS

Ensure staff safety at all times, don PPE first if required

1. **Activate red manual fire call points:** If no alarm is heard, ring 2222 to raise the alarm
2. **Stop HFNO or face mask/nasal cannulae oxygen delivery to patient**
   - Move patient (and others) in immediate danger to a place of safety
3. **Attempt to tackle the fire using a fire extinguisher** – if you are trained to do so
   - Carbon dioxide fire extinguishers: can be used safely for electrical fires
   - Water (larger) fire extinguishers: should NOT be used for electrical fires
4. **Operate *both* oxygen shut off valves in main corridor (zones A and B)**
   - Most senior doctor and nurse present to make joint decision about this
   - Provide oxygen via CD oxygen cylinder for all B36 ICU patients when this occurs
5. **Prepare patients for immediate evacuation**
   - Evacuate patients closest to the fire first, patients in less-affected side rooms last
   - Role allocation
     - B36 ICU NIC: open emergency box & operate front door crash button
     - Junior doctor/nurse: fetch oxygen cylinder, Mapleson C (Waters) circuit and ICU emergency grab bag; use transport monitor block at each bed space
     - ICU nurse: disconnect RRT and non-essential infusions if time allows
     - ICU doctor: ring *one* of the following and ask them to cascade information
       1. Anaesthetic supervising consultant (SC) X 6111 or 07919594498
       2. ICU middle grade/anaesthetic SR Bleep 7333/ICU consultant on call
   - Supervising Consultant (SC) anaesthetist actions:
     - Send theatre, PACU and TDA staff to help with evacuation
     - Stop sending for elective patients, clear PACU if possible
     - Main theatre coordinator bleep 7098, main theatre PACU X5030
     - DSU theatre coordinator bleep 7640, DSU PACU X 5832
     - Main theatre reception X 5036, TDA coordinator Bleep 7635
   - Evacuate to one of the following:
     - 1st choice: Main theatre PACU; 2nd choice: DSU PACU (both horizontal evacuation)
     - 3rd choice: B12 ICU; 4th choice ED (both vertical evacuation)
     - Use lifts by DSU, *not* lifts immediately outside main theatres/B36 ICU
6. **Establish patients in safe area as above and follow major incident policy**
   - Assess patients involved for burns, smoke inhalation & carbon monoxide poisoning
   - Direct staff to ED for assessment
7. **Staff involved to stop work once patients are all safe**
   - One staff member to lead Team Immediate Debrief (TID)
   - Write list of full names of all staff involved and email to ruh-tr.TRIM@nhs.net

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B36 ICU Fire General Principles

Ensure staff safety at all times, don PPE first if required

- **Activate red manual fire call points**
- **Stop affected patient's HFNO/face mask O_2**
  - Move patient(s) in immediate danger to place of safety
- **Tackle fire using fire extinguisher**
  - Only if you are trained to do so
  - CO2 extinguishers: can be used for electrical fires
  - Water extinguishers (bigger): *not* for electrical fires
- **Operate *both* A&B oxygen shut off valves**
  - Located in main corridor, senior staff decision
  - Ensure all B36 ICU patients have a CD O_2 cylinder to provide O_2 when doing this as the pipeline O2 supply will be stopped
- **Prepare patients for evacuation**
  - 1st choice: Main theatre PACU/theatres
  - 2nd choice: DSU PACU/theatres
  - 3rd choice: B12 ICU or ED – use lifts by DSU only
  - One staff member call X6111 or 07971 594498 for help (Anaesthetic Supervising Consultant or 3rd on-call SR)

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Figure 1 Example of an ICU fire and emergency evacuation action card (RUH Bath).

displayed on the wall [1, 12, 16]. Laminated evacuation action cards, summarising steps for staff to take in an emergency, specific for that clinical area and with clearly defined roles for each staff member, should be attached to the wall next to emergency fire manual call points (Fig. 1) [1, 12]. In the event of a fire or other situation requiring emergency evacuation, these action cards can be removed from the wall by staff and the steps followed. An example of such an evacuation action card for an ICU is shown in Figure 1 and includes the following points:

- Step 1: Activate manual fire call point. If this fails, call 2222 or the local emergency switchboard number.
- Step 2: Stop HFNO or facemask/nasal cannulae oxygen delivery to any patient affected by the fire and move patient(s) in immediate danger to a place of safety.
- Step 3: Attempt to tackle fire using a fire extinguisher – if safe to do so and you are trained to do this.
- Step 4: Operate oxygen shut off valves to zone affected by fire (decision to be made by the most senior doctor and/or nurse present) and provide oxygen to other patients in that zone using an oxygen cylinder.
- Step 5: Prepare patients for immediate evacuation, allocate roles, contact a nominated co-ordinator and plan evacuation routes and assembly points.
  - Patients receiving HFNO or other non-invasive respiratory support may be difficult to evacuate safely: options include transferring to a non-rebreathing oxygen mask with reservoir plus oxygen cannulae, continuing current oxygen therapy (both options would require taking two oxygen cylinders) or using a Mapleson C (Waters) circuit.
- Step 6: Establish patients in safe areas and follow major incident policy.
  - Assess patients for burns, smoke inhalation and carbon monoxide poisoning.
  - Direct staff to the emergency department for assessment.
- Step 7: Staff involved should stop work once all patients are safe.
  - One staff member to lead a team immediate debrief
  - Write list of all staff involved to help support them following this event, with more senior doctor and nurse present to keep this list in a safe place.
  - Ensure staff involved are safe to return home before they do so.

The evacuation of an operating theatre complex should be done using the steps detailed in the Quick Reference Handbook emergency evacuation section (online Supporting Information Appendix S2) which follows these principles.

Intensive care units and operating theatre suites should be appropriately staffed at all times to allow an emergency evacuation to take place should that be necessary. In operating departments that do not provide a 24-h service, fire doors should be shut as a matter of routine before closing the department.

Intensive care units should be arranged in a way that avoids bulky and relatively immobile equipment blocking

emergency exits. For example, some ICUs are arranged so that patients receiving extracorporeal membrane oxygenation (ECMO) are cared for furthest from the emergency exits: this prevents the movement of other patients to the emergency exit being obstructed by ECMO equipment, should an emergency evacuation be required (M Ralph, personal communication).

Evacuation boxes

Each ICU bed space and operating theatre should have equipment to enable an emergency evacuation, including evacuation aids and evacuation boxes, in an easily accessible location. If individual hospitals feel that the resource implications of having one emergency evacuation box per ICU bed space and one box per theatre are too great, then they may consider having one emergency evacuation box shared between ICU bed spaces or operating theatres in close proximity. The contents of these boxes will depend on individual ICUs and operating theatre suites, taking into account the level of the building that they are on [3]. An evacuation box should contain the following [3]:

- Propofol or other sedative agent
- Neuromuscular blocking drug
- Reversal agent
- Analgesic
- Intravenous fluids
- Vasopressor
- Torch
- Paper anaesthetic charts or ICU charts to enable observations and note recording during an evacuation.

Oxygen cylinders should be kept in a central designated store and fetched in the event of an emergency evacuation [6]. If a paper record system is in use, the patient's notes and drug chart should be evacuated with the patient if possible and safe to do so. If the hospital has electronic patient records and/or an electronic prescribing system, then a system should be put in place to enable staff to rapidly print paper drug charts, possibly in a remote location, and allow for continuity in medication administration.

Evacuation aids

Evacuation of patients on their beds in a horizontal fashion is likely to be the safest and quickest option. The local evacuation policy should be followed: for ICUs and operating theatre suites that are not on the ground floor, recommended evacuation routes may include a combination of horizontal evacuation to a nearby zone, followed by vertical evacuation using evacuation lifts in that zone. It is possible that staff may need to use specialised evacuation aids [24] for evacuations from non-ground floor locations: These should be suitable for bariatric patients, and include the following different types:

- Evacuation sheets which can be fitted on to hospital beds and allow patients to be slid safely along corridors and/or down stairs.
- Evacuation chairs ('stairchairs') which can be used for the evacuation of mobility-impaired patients. These look like a deckchair with skis and wheels underneath: They glide downstairs on the skis and use the wheels to move along flat surfaces, but are only suitable for conscious patients who can hold themselves in a sitting position and understand instructions. They can also be difficult and slow to use.
- Evacuation mats: these look like thin mattresses and can be used for patients who are bed-bound.

All equipment should be regularly maintained and tested, should only be used by staff trained in their use and may not be suitable for some patient groups (e.g. post spinal surgery). In the case of a fire, any aids reliant on mains electricity must not be used.

Smoke hoods

Smoke hoods are used by prison officers attending a fire to give them temporary but immediate respiratory protection from the effects of smoke and fumes during an evacuation [25]. Some fire experts believe that such equipment could be considered in ICUs and operating theatres to protect staff from smoke inhalation and extend the time available to safely evacuate patients. Smoke hoods are classed as personal protective equipment and their introduction would therefore require training of selected clinical staff in their application, operation and limitations, plus regular inspection and maintenance and regular physical training.

Specific measures for use in operating theatres when using lasers or other potential fire hazards

Fires within operating theatres represent a serious safety risk for patients undergoing surgery [26]. The incidence of surgical fires can be significantly reduced by prevention, education, training, planning, good communication within the operating theatre and positively separating the three elements of the fire triangle (oxygen, ignition source and fuel. The risk of a fire in an operating theatre can be reduced by the following strategies [27]:

- Safe use of diathermy, lasers and fibreoptic light sources: regular inspection for evidence of insulation

failure before use (devices, wires and connections), keeping tips of cautery instruments clean and free of char and tissue, and placing devices in a holster or safety cover when not in use rather than placing directly on the patient or surgical drapes.
- Allowing alcohol-based cleaning solutions (e.g. chlorhexidine) time to dry before using diathermy, avoiding pooling of such solutions and removing alcohol-soaked materials, drapes and gowns before diathermy.
- Using closed oxygen delivery systems wherever possible: if an open delivery system is used, additional precautions should be made to exclude oxygen from the operative field.

If a fire occurs, staff should use a bespoke operating theatre emergency evacuation action card and follow the guidance within the Association of Anaesthetists' Quick Reference Handbook [2], which includes the following actions:

- Step 1: Stop the laser or diathermy.
- Step 2: Call for help.
- Step 3: Activate the fire alarm and fetch a carbon dioxide fire extinguisher.
- Step 4: Airway fire – stop ventilation of the patient and stop fresh gas flow, reduce the FiO_2 to 0.21, flood airway with sterile water or saline, remove tracheal tube if on fire, follow QRH actions for further management (online Supporting Information Appendices S2 and S3) including re-intubation, transfer to ICU and consideration of bronchoscopy.
- Step 5: Non-airway fire – remove all drapes and burning material, flood fire with saline or saline-soaked gauze, use a carbon dioxide fire extinguisher and consider risk of patient inhalational injury with potential need for intubation and ventilation and transfer to ICU.
- Step 6: If fire continues, consider operating the oxygen shut off valve (AVSU) for that operating theatre/operating theatre suite area.
- Step 7: Liaise with anaesthetic co-ordinator and operating theatre co-ordinator, who should do the following and aim to evacuate within 30 min:
    - delegate one staff member to update all theatre teams and ask them to stop anaesthetising where possible. Consider whether to stop operating/how to safely suspend operation and prepare for evacuation, await instructions regarding timing/evacuation site.
    - stop theatre reception sending for new patients, send patients from the operating theatre recovery ward back to the wards if possible.
    - liaise with ICU and actions as described in the QRH (online Supporting Information Appendices S2 and S3).

Minimising the risk of an airway fire when using lasers and diathermy requires meticulous preparation and this includes the use of the lowest tolerated FiO_2, matt black laser instruments, the lowest laser energy possible and avoiding the use of monopolar diathermy. Of note, no laser-tracheal tube presently manufactured is laser proof; instead, they are laser resistant and must not be presumed to be a perfect barrier. Wrapping tubes in metal foil to reduce the risk of a fire is a historical practice and is actively discouraged. A carbon dioxide fire extinguisher should be available in theatre when lasers are being used, and staff should have received training in its use [27].

Of note, HFNO is not recommended by some manufacturers when lasers or diathermy are in use [28], although some expert centres have reported it as being possible [29–31]. These studies are small and the use of HFNO with lasers or diathermy should not be considered without further evidence, utmost caution and following close liaison with local laser protection supervisors, laser protection advisors and clinical laser experts as appropriate.

Some hospitals have adapted their Surgical Safety Checklist or team briefing document to include an 'airway fire' risk assessment tool, where an additional fire risk is predicted if two or more of the following are present: surgical site is above the xiphoid, an open oxygen source is in use and diathermy is planned [27]. This encourages planning, risk reduction strategies and procedures to follow if an airway fire should occur.

Fire training

Fire evacuation training

All staff working in ICU and operating theatres should receive annual mandatory fire training in their place of work and ideally as a multidisciplinary team, covering the following: location of fire manual call points; location and safe use of fire extinguishers; evacuation routes and the importance of keeping such routes clear at all times; assembly points; evacuation aids; oxygen shut off valves (AVSUs) [1, 5–7, 12, 16]. This training should be specific to their workplace and take place on induction and annually as part of mandatory training [16]. Practical 'walk-through' training and simulated evacuations should be practised as a multidisciplinary team every 2 y, with staff using emergency evacuation cards (e.g. Fig. 1) to guide their actions and liaising with their hospital switchboard or other alarm receiving centre [1]. Training should allow improvements to be made to the emergency evacuation cards if needed.

Evacuation at night should also be practised [1, 16]. Training should cover the potential need for staff to make an emergency assessment of whether it is safe to evacuate patients or whether they need to place their own safety first.

Fire prevention training

Strategies to prevent fire should be covered during staff training [16] and include the following: caution when charging mobile phones and digital devices; caution when using extension leads; avoiding charging multiple electrical devices on one electrical socket; ensuring that alcohol hand gel has dried before using oxygen cylinders; avoiding petroleum-based products (e.g. lip moisturisers) in patients receiving oxygen therapy; ensuring clean hands when using oxygen cylinders [32]. The importance of fire doors and fire warden-led checks within departments should be emphasised [16]. Systems should be in place for staff to raise concerns regarding equipment or practices which may constitute a fire hazard and the need for immediate replacement and/or maintenance.

Fire extinguisher training

Fire extinguisher training should be provided for clinical staff as described above.

Oxygen safety

Safe use of pipeline oxygen

As oxygen can accelerate the rate of a fire, it is important for staff in charge to know where the oxygen shut off valves (AVSUs) are located in their ICU or operating theatre suite, when to use them, how to operate them, who should operate them and the implications for patients of doing so [18].

Safe use of oxygen cylinders

All staff in ICUs and operating theatre suites should be given basic training regarding the safe use of oxygen cylinders [1, 5, 12, 18, 32]. The training should include the correct procedures to be followed when setting up the cylinder: this includes ensuring hands are clean and dry, setting up the cylinder away from the patient, opening the valve slowly to limit the effects of adiabatic compression within the valve and avoiding the use of oil-based creams when administering oxygen to patients. It is important to follow the instructions for use provided by the gas supplier (Table 3) [4, 12, 32]:

- Step 1: Set up cylinder in an upright position and pointing the cylinder away from the patient and the operator.
- Step 2: Open the cylinder valve (on the side of the CD oxygen cylinder) slowly.
- Step 3: Select the oxygen flow rate, using the flowmeter on the top of the CD oxygen cylinder.
- Step 4: Once the oxygen is flowing freely, start administering oxygen to the patient.

Always use a bed bracket (online Supporting Information Figure S1) and avoid placing the cylinder on the bed unless there is no alternative. If placing the cylinder on the bed, ensure the cylinder has been set up and the gas is flowing freely before placing it on the bed.

Integral valved cylinders (e.g. CD oxygen cylinders) are recommended for use within ICUs and operating theatre suites as they do not require an additional regulator to be fitted before use, making them ideal in an emergency. Sufficient oxygen cylinders should be stored in specific oxygen cylinder storage racks (online Supporting Information Figure S2) within the local cylinder storage area so that each patient in the ICU or operating theatre suite could be given a portable oxygen cylinder during an evacuation.

Risk of oxygen enrichment in clinical areas where HFNO, facemask CPAP and non-invasive ventilation are in use

Oxygen enrichment of air above 20.9% will aid a fire and have an accelerant effect on its fire growth rate, and at levels of 23% materials will be more combustible than in ambient air [15, 33].

To prevent oxygen enrichment of air in ICU and other clinical areas where HFNO and facemask CPAP are carried out, the ventilation should be > 10 air changes per hour [14]; electrical equipment that could act as a source of ignition, including ventilators should be carefully designed and maintained; the use of emollients and oil/alcohol-based products should be avoided where possible; and placing a plastic barrier apron on patients receiving HFNO/facemask CPAP to prevent oxygen enrichment within clothing and bedding should be considered [33].

Nominated fire safety and emergency evacuation lead

Each department should have a nominated lead for fire safety and emergency evacuations with the following roles: Liaise with the hospital Fire Safety Officer, hospital Emergency Response lead and major incident response team; carry out any preventative and protective measures; keep abreast of local and national initiatives; be a focal point for dissemination of relevant information; signpost topical issues; and be responsible for liaising with appropriate bodies [16]. Such nominated leads should have appropriate training and support to carry out this role, with time and

Table 3 Recommendations for the safe use of oxygen cylinders.

Oxygen cylinder brackets	Oxygen cylinder brackets for beds or wheelchairs should always be used. Oxygen cylinders should not be laid on a patient's bed unless there are no other alternatives. If this is the case, the oxygen cylinder should be set up and turned on (as described below) before placing on the bed [1, 12, 32] Oxygen cylinder brackets should be stored in the same place as oxygen cylinders
Safe storage of oxygen cylinders in ICU and operating theatre suites	Local oxygen cylinders storage areas should be located in designated areas, away from combustible materials [18, 32] Smaller oxygen cylinders should be stored in a rack or on wall mounted brackets. Larger oxygen cylinders should be stored in a wall mounted pen or in specially designed trolleys [18,32] Local storage areas should have signs to indicate oxygen storage [32] Full and empty oxygen cylinders should be stored separately with signs visible to distinguish between the two [32] Oxygen cylinders should be stored with their tamper evident seal in place to show that they have not been used [32] Oxygen cylinders must be stored with the shut-off valve (on the side) turned off and the flowmeter set to zero [1, 32]. Cylinder stock should be maintained at a level to ensure that there are sufficient cylinders available to deal with emergencies. Cylinder numbers should take account of how many patients may need to be evacuated from the ICU or operating theatre suite and the number of cylinders required by each patient [32]
Recommended sequence for turning on an oxygen cylinder and providing oxygen for a patient [1, 11, 26]	1 Set up oxygen cylinder away from the patient in an upright position, pointing the cylinder outlet away from the patient and operator 2 Check that flow rate selector is set to zero 3 Slowly open cylinder shut-off valve (on the side of the cylinder) with the oxygen outlets facing away from the patient and operator 4 Place oxygen cylinder in the cylinder bed bracket 5 Connect oxygen tubing to the flow outlet and select flow rate on the flow selector (on the top of the cylinder) 6 Attach oxygen to the patient only once oxygen is continuously flowing
Recommended sequence for turning off an oxygen cylinder after use	1 Close the oxygen shut-off valve (on the side) 2 Once the flow of oxygen has stopped, turn the flow rate selector to zero 3 The cylinder can now be safely stored
Reporting oxygen cylinder issues	If an issue with a medical gas cylinder is identified, this must be reported to the medical gas supplier and the MHRA [1, 32]
Post-fire oxygen cylinder management	If oxygen cylinders are stored within an area where a fire has occurred, it is recommended that: 1 Staff are not allowed to go into that area 2 Fire and Rescue Services should be informed of the exact location of the oxygen cylinders within the ICU/operating theatre suite and an indication of the number of cylinders present 3 When the fire has been brought under control, request that the supplier arranges collection of the incident cylinders. Cylinders should be labelled to indicate potential fire damage so they can be tested to ensure they are safe for further use

resources allocated accordingly. The nominated lead may not be physically present when a fire or emergency evacuation is required so it is recommended that there is at least one person per shift trained to the level required level to lead an emergency evacuation. Non-employees, such as contract workers, locum doctors and agency nurses, should be provided with information regarding who the fire safety leads are and the fire safety procedures for that area of work.

Staff duty of care

General Medical Council (GMC) Good Medical Practice guidance states that a doctor must take prompt action if they think that patient safety is or may be compromised and offer help if an emergency arises in a clinical setting, taking account of their own safety, competence and the availability of other options for care [34]. If staff have shown negligence in their approach to patient safety before an event, such that material risk developed as a result of that negligence, then they may find themselves open to scrutiny by the GMC. However, if a fire or other life-threatening emergency arises, staff would need to make a swift risk/benefit analysis, balancing their responsibilities to their patients against the risk of personal harm and ensuring their own safety and that of their team comes first [34-36].

Investigation of critical incidents

Following a fire or similar critical incident, a full investigation should be carried out at the earliest opportunity: This should examine all contributory causes, appraise the response of the hospital and identify lessons to be learned. An initial investigation would usually be conducted by the Fire and Rescue Services, the Police and the Health and Safety Executive (if the incident meets the HSE's Incident Selection Criteria), followed by an internal investigation by the hospital and involving the coroner in the event of a death. Ideally, an external investigation would then be carried out by a responsible body such as the Healthcare Safety Investigation Branch. Both internal and external investigations should be performed using a human factors and ergonomics investigative tool, such as the Yorkshire Framework model [37], which considers all possible contributory factors: an investigation should not simply scrutinise the actions of the healthcare workers involved at the time of the event. Investigators should be mindful that the patients, families and staff involved are likely to be affected by such an event and should take necessary steps to ensure that investigations are completed in a timely fashion. Lessons learned should be embedded in future planning for such incidents, and shared with other NHS organisations, their fire safety officers and estates teams plus patients and staff affected by the event.

Major incident planning and role of critical care networks

The timing of an evacuation is crucial: if an evacuation occurs too early then patients may be harmed by a transfer, but if an evacuation occurs too late then patients and staff may be harmed by fire and smoke [1, 5]. Wherever possible, evacuation policies should include liaison with the Bronze (Operational), Silver (Tactical) and Gold (Strategic) commanders, in conjunction with the senior Fire and Rescue officer on scene [1, 5]. However, in reality, most emergency evacuations will have taken place long before this command structure has been implemented, so any incident response plans must reflect this and support clinical staff to make immediate life-saving decisions. In this situation, the Bronze/Silver/Gold command structure will be essential for guiding plans for ongoing care of patients and services affected.

Hospitals, working closely with their own ICUs and operating theatre teams and alongside their incident response plans, must construct plans for dealing with internal incidents. These are situations where hospital staff themselves become victims of a fire or other emergency, and so are unable to care for patients [1]. The short-term solution for such an emergency situation is having a reliable and immediate means of summoning additional hospital staff to assist and replace those affected [4, 12]. In addition, the structure and clinical equipment of the ICU or operating theatre suite is likely to be damaged, rendering the area unavailable for patient care [12]. Major incident planning should involve external agencies including the Ambulance service and the local Fire and Rescue Services.

A hospital's internal incident policy should define an appropriate clinical area in which evacuated patients can be safely cared for temporarily. Suitable alternative clinical areas should be identified within Business Continuity and Incident Response Plans before an incident occurring. Local Fire and Rescue Services should be involved in this planning and awareness of the organisation's fire evacuation processes. Patients will be cared for in these alternative clinical settings until ICU beds in neighbouring hospitals can be identified and transportation arranged. Regional critical care networks are central to this process and all networks should put in place a system whereby ICUs can provide emergency beds and a transfer service to retrieve patients from hospitals affected by an ICU fire or similar emergency [1, 5, 6, 12]. Such systems should be incorporated into network-wide policies to support and plan for major and/or internal incidents in any hospital within the region. We recommend that critical care network lead consultants establish a method of communicating with each other rapidly in the event of such an emergency (for example, a WhatsApp or Siilo group). A checklist for clinical directors, regarding staff training and other factors related to major incident planning, is available in online Supporting Information Appendix S4.

Staff welfare and well-being: dealing with the aftermath of a fire or emergency evacuation

A short operational debrief should be held immediately after a fire and/or emergency evacuation [38]. Staff should then be given the chance to talk through what happened with their peers, 'decompress' and debrief before going home, and be given information about 'psychological first aid' and the range of normal reactions following a potentially traumatic event.

All staff involved in a fire or similar emergency should be screened for acute trauma-stress symptoms and supported following the event using a recognised, protocol-based, critical incident procedure that is compliant with the most recent national guidance on post-traumatic stress disorder [1, 39, 40]. One example is the TRiM (Trauma Risk Management) system [1, 41, 42]. It is

important to support and screen all staff involved in an incident, however, small or peripheral their involvement may seem, as pre-morbid and comorbid experiences can be significant. All staff involved in a serious event should be assessed by a member of the occupational health department before re-starting work. Key aspects of a meaningful staff welfare system include the following:

1. Good staff training and awareness of acute trauma-stress reactions, ideally during normal working life and before a critical event
2. An established critical incident response team to support and screen all staff for trauma-stress symptoms.
3. An effective communication system to ensure that all those involved know the facts about the incident at the earliest opportunity
4. A system that proactively informs staff involved in a critical event of changes and improvements that are made to avoid a similar event occurring in the future. It is important that this process is treated as a confidential and standard operational procedure and is independent to the organisational investigation. Staff will vary as to how comfortable they are in disclosing personal experiences and this needs to be handled sensitively.

It should not be assumed that a member of staff who does not engage in staff support is symptom-free, as withdrawal, numb affect and avoidance are key trauma-stress symptoms. Continuous exposure to stressful situations (cumulative stress) is as important a factor in staff welfare as any one-off incident, so it is important to place any individual experience in context and be aware of the problems that may emerge as a consequence of prolonged exposure to multiple events.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. Fire and oxygen safety and emergency evacuations in the context of COVID-19.

Appendix S2. QRH emergency evacuation card.

Appendix S3. QRH patient fire card.

Appendix S4. Checklist for Clinical Directors of anaesthetic departments and intensive care units.

Figure S1. CD oxygen cylinder bed bracket.

Figure S2. CD Oxygen cylinder storage brackets.

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