ICU fire evacuation preparedness in London: a cross-sectional study

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Background. Hospital fires present a sporadic but significant threat to patients and staff. This is especially so within an intensive care unit (ICU) setting, due to the complexity of moving acutely unwell patients reliant on invasive monitoring and organ support. Despite an average of 500 in-hospital fires reported to the UK department of health per annum, causing 65 injuries and 1–2 fatalities, the readiness of ICUs for urgent evacuation has not been assessed.

Methods. A cross-sectional survey of all 50 adult and paediatric ICUs within the London Postgraduate Deanery was conducted; neonatal units were excluded. The senior nurse at each unit was asked to complete a 90-question structured questionnaire, covering unit patient characteristics, design, equipment, training, and their evacuation plan. Thirty-five of 50 (70%) responded within 2 months of the study.

Results. Significant weaknesses were reported in unit design, equipment, and planning. Unit design was compromised by inadequate fire doors (20%), ventilation cut-outs (17%), and escape routes (up to 60%). The ability to evacuate multiple patients simultaneously may be limited by a lack of portable monitoring equipment (49% of beds) and emergency drug supplies (20% of beds). Evacuation plans were often limited in their scope (96% expected to remain on their floor; 14% had plans to obtain medications after evacuation), and not rehearsed (60%). Staff training, while well provided for permanent staff, is less so for temporary staff (34%).

Conclusions. Forward planning for an urgent evacuation can be improved.

Keywords: education; intensive care; risk; safety

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A hospital fire threatens patient and staff safety, disrupts supply lines, and damages infrastructure, making it one of the most difficult and dangerous challenges clinicians face. This is perhaps greatest in the intensive care unit (ICU), due to the complexity of moving acutely unwell patients who are dependent on organ support and invasive monitoring. Although severe fires are comparatively rare, there were 10 662 fires reported to the UK Department of Health (DH) in the decade 1994/5 to 2004/5; of these, ~500 per annum were in acute hospitals, causing 4769 people to be evacuated, 651 injuries, and 17 fatalities. More recently, in January 2008, a fire starting in the roof of the Royal Marsden Hospital in Chelsea necessitated emergency evacuation of all staff and patients from the ICU.

Despite this very real threat, there have been few studies examining the level of preparedness of ICUs for an urgent evacuation, in terms of organization, equipment, or practice. In this exploratory study, we assessed the state of readiness of ICUs in London. We used a structured questionnaire to consider their organization, equipment, and level of practice in the context of their size and location.

Methods

The clinical audit committee of the Royal Marsden Hospital approved this study (Ref. ANAES55).

No patient-identifiable data were collected, and all participants were informed in writing of the intended use of the data before collection. All adult and paediatric ICUs within the London Postgraduate Deanery were eligible for enrolment; neonatal units were excluded due to the difference of their population. London was chosen as it offered a good number of units and a fair diversity of hospital types. ICUs and their senior staff were identified using the London Deanery website, hospital websites, and by telephone. The study was conducted from December 2008 to January 2009.

We developed a 90-point structured questionnaire using existing guidelines, supplemented by a literature review.
review,2–7,12–14 and input from staff who managed the Royal Marsden Hospital ICU evacuation. Questions covered ICU design and patient characteristics, allocation of responsibilities, evacuation plans, specialized equipment, training, and practical experience of evacuation. Questionnaires were sent to the senior nurse (e.g. ICU matron) at each eligible ICU, re-sent after 4 weeks to non-responding units, and followed up by telephone after a further 4 and 8 weeks. Electronic copies were sent on request. One author (G.R.F.M.) collated the data.

We analysed data using descriptive statistics. We calculated percentage responses according to the number of respondents per question. We calculated equipment availability assuming 100% bed occupancy.

Results

Fifty eligible units were identified, of which 35 (70%) completed the questionnaire. Two units returned anonymized questionnaires; these were included in the analysis. Unit characteristics and response rates are described in Table 1. Questions covered training and policy, ICU design, command structures, response to fire, and equipment. Weaknesses were identified in all domains; some key results are highlighted in Figure 1.

Training and policy

Although 32 units (91%) were aware of a hospital fire policy, only 19 (40%) had an ICU-specific policy. Thirty-four units (97%) had regular fire training for permanent staff, typically annually, while only 12 (34%) had training for temporary staff. Eight units (23%) had conducted a drill and six (17%) a genuine evacuation.

ICU design

Figure 2 summarizes the number of escape routes in different units. One unit (3%) did not have fire doors, and six (17%) lacked automatic closure mechanisms.

Eighteen units (51%) reported their air-conditioning system had an automatic cut-out to prevent smoke circulation; 26% were unsure about this facility. Twenty-one units (60%) had an in-unit fire alarm ‘repeater panel’ displaying the activated zone(s) if the alarm was triggered.

Command structure and responsibilities

Fourteen units (40%) had a formal triage policy for evacuation, based on illness severity or proximity to the fire. Control of the situation rested with different individuals in different ICUs—the nurse in charge (40%), fire warden (34%), ICU consultant (29%), or fire brigade (17%).

Table 1 Surveyed hospital characteristics

<table>
<thead>
<tr>
<th>Hospital type</th>
<th>Response rate (%)</th>
<th>Mean beds (range)</th>
<th>Mean ICU floor (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>District</td>
<td>16/20 (80)</td>
<td>10 (6–13)</td>
<td>1 (0–4)</td>
</tr>
<tr>
<td>Teaching</td>
<td>8/17 (47)</td>
<td>14 (11–25)</td>
<td>4 (0–11)</td>
</tr>
<tr>
<td>Specialist</td>
<td>5/8 (62)</td>
<td>14 (9–20)</td>
<td>1 (1–1 to 3)</td>
</tr>
<tr>
<td>Paediatric</td>
<td>4/5 (80)</td>
<td>14 (6–21)</td>
<td>2 (1–2)</td>
</tr>
<tr>
<td>Anonymous</td>
<td>2/50 (4)</td>
<td>15 (12–18)</td>
<td>3 (3–3)</td>
</tr>
<tr>
<td>Total</td>
<td>35/50 (70)</td>
<td>12 (6–25)</td>
<td>2 (1 to 11)</td>
</tr>
</tbody>
</table>

Fig 1 Summary of key results.
two units (6%) cited a major incident team plan. Although staff were routinely made aware of the site of gas-control valves in 24 units (69%), only four (11%) had a plan to switch them off at some point in an evacuation.

Response to fire
All but one unit did not expect to evacuate using stairs, but only seven (20%) had step-free ground floor access. A minority of units (43%) had reached a formal agreement with another hospital to receive evacuated patients.

There were limited formal instructions on the emergency management of sedation or inotropes (23%), haemofiltration (17%), and ventricular assist devices (3%). Four units (11%) had a checklist of items to evacuate with each patient. All units expected a fire brigade response time of 15 min or less; four units (12%) expected a response time under 3 min.

Equipment
Equipment supplies were patchy and often inadequate. Twenty-five units (71%) had emergency packs of drugs always available, but supplies were adequate for 20% of total beds on average. Only five units (14%) had a plan to procure additional supplies after evacuation.

Thirty-four units (97%) had fully portable monitors, although only for 49% of their beds. The same number had portable ventilators, but again only for one-fifth of patients.

Better news was that 33 units (94%) had portable oxygen cylinders with flow meters for each bed; all of these units checked them either daily or every shift. All units had battery-powered infusion pumps and portable suction devices available, and 28 units (80%) had at least one portable defibrillator.

Eight units (23%) had an under-mattress evacuation sheet for every bed; three units (9%) reported that they had alternative evacuation aids.

Discussion
Among the 35 ICUs who responded to our survey, major weaknesses were reported in many areas of preparation. Although all but one unit provided mandatory fire training for permanent staff, 66% had no training for temporary (locum) staff. Although nursing agencies may provide generic training, this cannot cover important site-specific issues, which are mandated in DH guidelines. Reported unit design was often outdated; 60% of units had either one or two escape routes, which is inadequate for any unit over 1000 m². 20% had inadequate fire doors, compromis-
ing the fire barrier needed for a horizontal evacuation, and at least 17% lacked automatic cut-outs on air-conditioning systems, which could allow smoke to recirculate. These design flaws could significantly reduce the time available for a safe evacuation.

The reported chain of command varied considerably between units; while we cannot tell from these data if an individual unit has a clear line of accountability, this hetero-
genity suggests that appropriate training for temporary and rotating staff is all the more important to avoid confusion. It is also concerning that only 40% of units reported a formal triage policy. According to the DH, patients should be triaged for movement by immediate danger, then most to least ambulant. The decision to switch off gas supplies to the ICU must balance the risk of asphyxiating ventilated patients against the possibility of an explosion due to an oxygen-enriched environment. Newer designs such as bed-by-bed oxygen cut-outs may help, but it remains surpris-
ing that only 11% of units had a plan to turn off gas supplies once patients were disconnected.

Perhaps most concerning is the lack of preparation for an evacuation outside the building. The experience at the Royal Marsden in 2008 was that the entire hospital had to be rapidly evacuated, with the fire spreading unpredictably via oxygen ducts and falling roof timbers from the attic to the first floor of the ICU. Only one of 28 (4%) units above ground floor reported planning to evacuate down stairs and only 39% had specific equipment to do so, despite DH guidance stating that ‘The need for a vertical movement strategy for… [ICU patients] must be recognized, and appro-
riate measures installed to reduce the risk’. The ability to transfer patients safely, possibly for extended periods of time, may be severely compromised in 74% of units by the lack of enough portable monitoring equipment. Similarly, while all units had battery-operated infusion pumps, 26% had no emergency drug packs, and none reported enough for all their patients.

We found no directly comparable study published to date. Several case reports exist describing both evacuation drills and real evacuations, which suggest that ICUs can be evacu-
ated safely and efficiently. There are also formal government guidelines covering unit design and evacuation planning. Despite these, our study suggests that many units may have weaknesses in their design, and a lower level of preparedness for urgent evacuation than might be expected.

This study has a number of limitations. The observational, cross-sectional design and the lack of a validated questionnaire make it difficult directly to relate stated answers to actual prac-
tice. It is also limited to one city and health system, so some
problems identified may be local. Nonetheless, we believe that it highlights genuine flaws in unit design and evacuation planning. We also believe that it raises several important general principles for planning effective evacuations that are applicable internationally and across specialities. Future studies might address the optimal means of evacuation in different circumstances, and actual practice in simulated or real evacuations.

In conclusion, our study suggests that weaknesses may exist in unit design, staff training, available equipment and supply lines, and forward planning for definitive transfer. Collectively, these shortcomings may impair the ability of ICU staff, when confronted by fire, to evacuate their patients to a place of definitive safety for ongoing care. The principles of crisis resource management\(^\text{15}\) suggest that anticipation and planning are the keys to a successful outcome. On the basis of these principles and the NHS firecode,\(^{10, 11}\) we suggest that the following measures may improve forward planning for evacuation.

- Review the ICU layout with the hospital fire officer to ensure that there are adequate fire compartments and escape routes, and that fire doors and ventilation systems will not compromise these.
- Design and practice a clear ICU evacuation plan, which links to the hospital major incident plan. Consider including a checklist of items (e.g. oxygen, drugs, notes) for each bed to take with them, and be prepared to evacuate the building completely.
- Consider the need for evacuation aids appropriate to your unit, such as under-mattress evacuation sheets, to facilitate rapid exit of patients both horizontally and vertically out of the ICU.
- Ensure adequate portable monitoring equipment and life-support systems for all beds; this may pay dividends in safety and efficiency for routine transfers and emergency evacuations.
- Have a plan for managing patients after a major fire, including procuring supplies and transferring to other units; this might involve your regional ICU network.

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**Conflict of interest**

None declared.

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**References**