Thinking the Unthinkable:
Exposing the Vulnerabilities in the NHS Response to Coordinated Terrorist Actions

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Abstract. The purpose of this paper is to stimulate a public debate about the consequences of a terrorist attack upon a hospital complex. The intention is to avoid what the 9/11 Commission calls the 'failure of imagination' that left society vulnerable to attack in 2001. The scenario that we generate is fictional. However, the response is informed by the emergency plans published by several NHS trusts, by direct involvement in evacuation drills and also by ways in which staff have responded to previous non-terrorist incidents.

Introduction

In 2003, the UK Public Accounts Committee examined changes that had been brought about by a recent reorganisation of the NHS. This gave Primary Care Trusts statutory responsibility for major incident planning, which had previously been the responsibility of local health authorities in England. They argued that 'at a time of heightened risk of terrorist attacks' parts of the NHS are ill prepared to handle the 'emerging threats'. At a national level, the Department of Health lacks information about the risks involved from terrorism or the means to ensure regions have plans, training and equipment consistent with those risks. The Public Accounts Committee went on to criticise poor communications as 'a major weakness in the effective handling of major incidents'. Many of the Trusts' major incident plans did not address communications issues. Those that did consider communication issues were not tested as frequently 'as they should be'. Co-operation with other agencies, especially the fire service and local authorities, was found to be 'patchy'. The Committee argued that there is a need to improve communication across administrative areas, between regions and counties. They recommended that planning for terrorist actions should be based 'on a full assessment of risks' both nationally and locally. There was a concern that current changes in the organisation of the NHS may prevent these 'important functions' from getting the attention they deserve. However, 'training is essential if staff are to respond effectively to major incidents'. The following pages argue that many of these criticism can still be leveled at the NHS and that, arguably, we are less well prepared for terrorist actions than we were in the months after September 2001.

The Scenario

It is 04.25 on a Sunday morning in a major, inner city, acute hospital. The majority of the wards are quiet. A few patients are awake but most are asleep, many under sedation. The few staff that are on duty are beginning to look forward to finishing and going home. Some are beginning to get ready for the early morning flurry of activity. In the entire hospital there are few staff other than the nursing staff on the wards. Many of the nursing staff are agency and bank nurses who are in some cases working their first shift in the ward. None of these staff

have ever participated in fire drills. Most are unfamiliar with emergency response procedures having been recruited since the new NHS (2001) risk-based evacuation policy allowed Trusts greater discretion over these exercises. Suddenly, fire bells begin to sound. Smoke billows into corridors and the automatic fire doors close shut. Staff do not panic. On two of the upper floors nurses discover that some of the designated assembly areas appear to be in flames.

At 04.29, security staff discover a fire by the main entrance. It is burning fiercely and they are quickly driven back by the flames. They contact the central switch board by dialling the 2222 emergency number. The switch board call the emergency services and uses the Trust's pagers to alert the 'first responders' closest to the initial fire. Suddenly, the power fails and then after a few moments the standby generator also fails. All over the hospital, people begin looking for torches and other forms of battery powered lighting. Away from the immediate source of the fire, most staff are unconcerned about their situation and begin reassuring the patients that the alarm was probably caused by the power cut. They rush to support patients whose monitoring and treatment has been jeopardised by the loss of power. Most teams begin to wonder whether the alarm applies to them, even in areas where the bells ring continuously and where the paging system has indicated they are in an affected area. The loss of power has now begun to affect the internal switch board. Nurses begin to use their personal mobile phones to call friends on other wards. Nobody has any information and so the corridors quickly fill with staff leaving their posts to find out about the alarms.

At 04.33, the fire on the ground floor is spreading. Initially, the fire is fed by legacy fixtures and fittings. Under NHS Estates provisions many of these non-fire retardant materials were to be replaced 'as soon as is practicable'. Even some of the newer materials begin to give off noxious fumes and these spread in unpredictable ways. The hospital complex is based around a series of Victorian buildings where false ceilings create routes for smoke and hot gases to build up many meters away from the seat of the flames. Some of the 'first responders' become increasingly concerned, even though their pagers initially showed that the fire was not in their area. The intermittent alarm bells suggest that they should stay where they are and wait for instructions. Their patients have now seen that the smoke is reaching their ward. The pagers no longer seem to be working.

As the flames take hold, a more dangerous situation develops. Some of the supply pipes begin to rupture in the intense heat. From then on the flames are fed with an uncontrolled supply of oxygen. Some of the staff have been trained to cut the local supply system. This leaves them with very little time and no additional staff to support the breathing of their patients. Residual pressure will only last a few minutes at most.

Immediate Response

In the areas closest to the fires, staff begin to implement their evacuation plan. In the semi-light created by a limited supply of battery powered torches, staff move the patients from one area to another using 'horizontal evacuation' procedures. The aim is to place fire walls between the patients and the flames. This is made more difficult because few people are sure about the precise location of the fires. Vertical evacuation from one floor to another is a last resort and nobody is willing to make this decision. Evacuation is a slow process; it can take up to five minutes to move a single patient from their bed to a wheelchair. Further delays are created as staff try to move beds along corridors in opposite directions. There is little coordination as staff struggle to glean additional information from their colleagues.

Very few of the ambulant patients spontaneously make their way to a place of safety even when the flames approach their wards. Some begin to mill around in the corridors. Those individuals and groups who do decide to make their way out of the building, add to the confusion by using the main stairwells rather than the fire exits which are all well sign-posted.

Suddenly a blast destroys the side of the hospital. Subsequent investigations cannot determine the precise cause. Part of the domestic gas supply may have been ruptured by the oxygen 'enriched' fire. Patients and staff are trapped in the wreckage.

Some wards begin a vertical evacuation but the lifts are compromised. Nursing staff are beginning to suffer the physical fatigue of multiple patient transfers. Others are suffering from the effects of heat and smoke inhalation. Decision making and communication becomes increasingly disorganised. In areas of the hospital away from the fire and explosion other members of staff are waiting to be told what to do. Non-clinical workers are gathering in their assembly areas.

Secondary Response

Meanwhile, the emergency services are beginning to respond. Fire Service Control had been immediately alerted by the first call from the hospital switch board. Initially, there was little concern. Such alarms were commonplace and usually followed by a second call to confirm that it had been a false alert. The fire crews begin to mobilise. At 04.31 a small car bomb is detonated close to the main door of the Station. The blast destroys the door and causes a partial collapse. Several fire fighters are injured. It soon becomes clear that a similar device has been detonated at another local fire station. In the confusion, only one appliance can be manoeuvred through the wreckage. Police crews rush to both the fire station and to the hospital. Like the NYPD Emergency Service Units in the World Trade Centre they are well trained to respond to the emergencies, however, they have minimal protective and fire fighting equipment. Time passes as medical and fire fighting resources are brought in from other areas.

The media are initially alerted to the incident by phone calls from members of the public, including patients inside the hospital. Initially, the fire has only local interest. However, this quickly escalates when there are rumours of an explosion. There are unconfirmed reports of telephone calls warning about explosive devices placed close to five fire stations in the area. This information is passed to the emergency services. By this stage, however, concern over additional devices has already placed considerable constraints on the response to the hospital fire.

A limited number of security staff and clinicians begin to coordinate the evacuation using personal mobile phones, a small number of hospital radios and a system of 'runners'. Police support arrives quickly but their radios are incompatible with the remaining hospital communications systems. In consequence, some officers are exposed to needless risk as they check through areas of the hospital that have already been evacuated. It is clear that there have been many casualties. Some areas of the hospital are structurally unsafe. Others are in flames. Difficult decisions have to be made about where to allocate limited staff resources to support the evacuation.

Eventually, fire crews arrive from outside the local area. Their progress is hindered by the large numbers of private vehicles that obstruct the narrow approach roads to the hospital. In many cases, friends and relatives have received telephone calls from patients in the hospital. 24-hour news services have shown initial images taken with a patient's mobile phone. Many relatives have ignored the please from local radio stations to stay away and have rushed to the hospital. Even though they try to pull off to the side of the road to let the fire vehicles and ambulances reach the hospital, there is insufficient room to let them all through.

Aftermath

The police eventually establish a perimeter; the explosions at the fire stations created too much confusion for them to be certain where to place access control measures in the immediate aftermath of the fire. The roads are gradually cleared and the necessary resources begin to reach the hospital. However, the lack of preparation even for a relatively primitive,

conventional terrorist threat has cost the lives of many patients and staff. It has also created a fear that persists amongst all those who enter hospitals for months after the attack.

Parliament initially responds to these events by using the military to secure NHS direct care facilities. Eventually, they are replaced by civilian security companies. However, the continual need to check the credentials of patients and care workers undoubtedly costs more lives as emergency services are delayed by security procedures. The attack has a fundamental impact on the nature of healthcare provision in this country.

Notes on the Scenario

This scenario is a work of fiction. It can, therefore, be argued that previous paragraphs are unnecessarily alarmist. Healthcare providers have more immediate concerns than a nebulous terrorist threat. However, the intention here is to avoid the 'failures of imagination' that leads to systemic vulnerabilities in critical infrastructure. The methods of attack described in the previous paragraphs are narrowly based on those in London and Madrid. They require little specialist knowledge and minimal coordination; mainly because they focus on soft targets. The response is informed by a recent study of previous hospital evacuations during non-terrorist incidents (Johnson, 2005).

Credibility and Sophistication of the Terrorist Threat

How easy would it be for a terrorist group to create such mayhem? Gaining access to a hospital is remarkably easy. A terrorist could pose as a visitor and hide himself in a toilet until it was time to plant devices. He or she could pose as an agency nurse or care assistant. It is a common experience for the nurse in charge of a shift to be confronted by someone wearing a uniform and speaking heavily accented English having been sent to the wrong ward or simply not knowing where to go. Which senior staff nurse anxious to hand over would dream of checking the contents of an Agency HCA's duffel bag? The commitment and training required to gain authorised and almost unrestricted access to most healthcare facilities is far less than was required by those involved in the 9/11 attacks.

There is a chance that such an attack would be discovered before it was launched. Previous attacks have shown, however, that we cannot rely on the intelligence and police services to detect all terrorist conspiracies. Hospital security has improved greatly improved in recent years. However, they often lack the specialist training to detect and prevent coordinated terrorist attacks from being launched. Limited numbers of security staff are also often stretched to the limit during night and weekend shifts. They tend to be concentrated in areas such as Accident and Emergency departments where their attention must be distributed across a host of other issues.

Closed circuit surveillance systems can be used to detect suspicious activity. However, the coverage and quality of these systems varies immensely. Systems that are installed in legacy buildings often have many 'blind spots'. Above all, the provision of this equipment far exceeds the resources that are available to monitor the video feeds. It is likely that this equipment will only be useful in explaining what happened *after* an attack has already taken place.

Our scenario is based around a relatively simple coordinated attack using conventional weapons that could easily be improvised with minimal technical knowledge. Some aspects would, however, require additional planning and limited 'inside' knowledge. For example, would it be difficult to interrupt the main power supply and disable stand-by generators? It would be relatively easy to force access to most NHS generator rooms. However, these pieces of plant are complex and very commonly connected to computer managed automatic switching devices that detect a drop in mains voltage. Once inside these facilities there are often detailed instructions on how to both connect and isolate the power supplies on printed task cards. Ironically there are intended to help personnel during accidental emergencies.

Fire protection systems have also become more sophisticated in recent years. However, they still offer limited protection in healthcare institutions. There is a reluctance to install them in areas where water damage has serious consequences for healthcare provision. Accidental discharge is a significant risk for patient records in either paper or electronic form not to mention the costs associated with replacing sensitive electro-mechanical equipment. Many areas of legacy buildings are difficult to protect using water based sprinkler systems. Automatic systems are activated when the temperature of the fusible element of the sprinkler head exceeds the pre-set temperature rating of the sprinkler head. This normally occurs in hospital buildings when the temperature is at least 150° F. Combined with the uneven distribution of sprinkler heads, this allows considerable opportunities for distributed, multiple coordinated fire sources to gain hold in a hospital building. The reliance on these systems can also create further vulnerabilities. For example, the US National Fire Protection Agency describes various provisions whereby non-flame retardant materials can be retained in healthcare institutions only if those areas are covered by sprinkler systems (O'Connor, 2002). Such practices would make these systems a potential target for terrorist actions. As with secondary power systems, they are typically vulnerable to a host of attacks, especially where they rely on air or water pressure tanks and electrical pumping equipment. As mentioned, our scenario is deliberately kept as simple as possible. In consequence, we make no assumptions about any attack on these systems.

Credibility of the Hospital Response and Evacuation Strategy

Many of the adverse consequences described in our scenario stem from a mismatch between the flexible and unpredictable nature of coordinated terrorist attacks and the existing 'defend in place' evacuation strategies of horizontal evacuation. In preparing this paper, we have simulated a number of evacuation scenarios using computer generated models of NHS facilities using current evacuation practices. This is illustrated in Figure 1. The intention behind these tools is to show what might happen to mean evacuation times using a range of different staff to patient ratios. It can also be used to analyse the impact of those ratios for wards catering for different patient profiles. Proposed changes in the physical layout of healthcare buildings can also be assessed. Table 1 illustrates the mean evacuation times for a single ward with a day time staff using horizontal procedures to move patients to a place of safety. The various times are recorded for different profiles of ambulant and non-ambulant patients. Each figure is the mean result obtained over ten runs in each condition using Monte Carlo techniques (Johnson, 2005). These simulators are calibrated using observations both from evacuation drills and from previous fires. Table 2 shows the experimental results obtained from evacuation drills within a single NHS hospital for the amount of time required to prepare different types of patient for evacuation in one ward.

Input from all three of these sources, drills, real incidents and simulation, has informed the development of the scenario that was introduced in the previous section. For example, we assume that fire protection systems are insufficient to prevent the spread of multiple independent fire sources. We also assume that legacy buildings will be have multiple paths through which smoke and toxic gases can affect building occupants who are remote from the seat of the fires. These observations on based on a hospital fire that was caused when smoking materials in a patient's bed led to the deaths of five patients (NFPA, 1994).

The scenario also assumes that the fire will feed on an oxygen rich environment as local distribution pipes are breached and staff do not isolate the various supply networks. These observations are based on various incidents including a hospital fire in New York (NFPA, 1993). Other similar incidents have been exacerbated by staff using wedges to keep fire doors open to help patients call for attention from busy nursing staff. Open doors assist ventilation in legacy buildings. Door can also be wedged open by busy staff as they clean rooms or distribute equipment and supplies.

Other aspects of the scenario were based on the results of full-scale evacuation drills. For instance, McCarthy and Gaucher (2004) describe an exercise in which a fire starts from an unguarded electrosurgical pencil. Staff members rapidly removed the blazing cover from the patient by throwing it on the floor and using a fire extinguisher. Other colleagues were informed of the fire. At this point, however, the staff running the simulation intervened to inform them that the fire had spread. A senior nurse began to coordinate the evacuation of operating room staff. There was initial confusion about the best way to transport the patients to a triage point. Partly as a result of this several adjacent rooms were evacuated at the same time causing temporary gridlock in the corridors. This evacuation drill simulated the movement of intubated patients using the operating room bed with a bag-valve mask. The exercise also required staff to move individuals with open incisions. Wounds were packed with sterile, saline-soaked laparotomy sponges and then covered with sterile drapes.

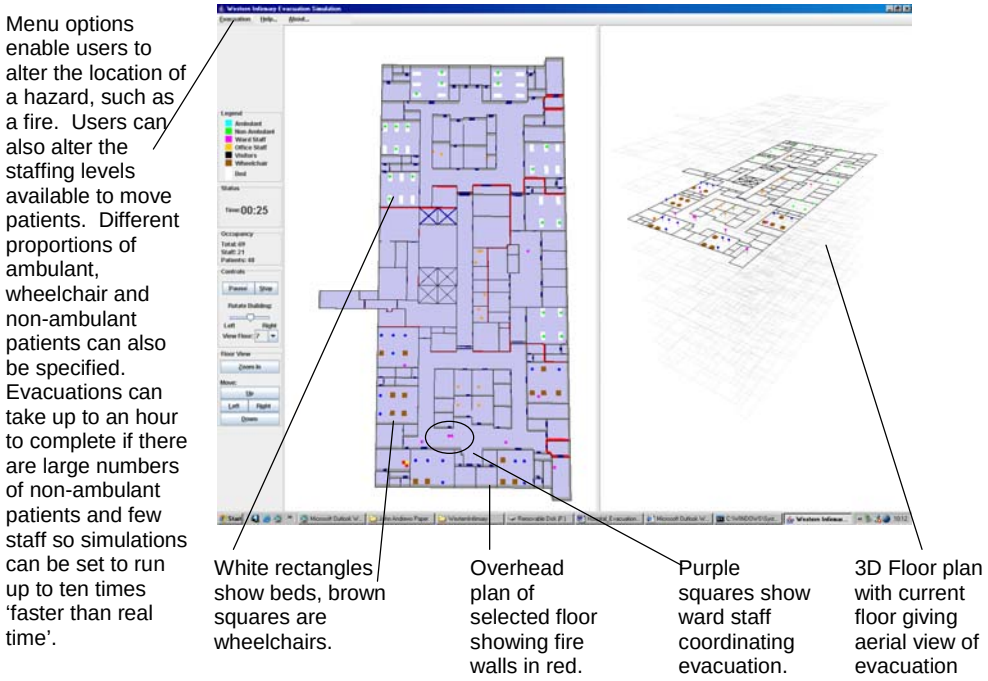

Figure 1: Interface to the Glasgow Hospital Evacuation Simulator (Johnson, 2005a)

Number of Non-Ambulant Patients	**Number of Ambulant Patients**	**Mean Evacuation time in seconds (Min:Sec)**	**Standard Deviation in seconds (Min:Sec)**
30	0	2643 (44:03)	257 (4:17)
25	5	1749 (29:09)	205 (3:25)
20	10	1439 (23:59)	189 (3:09)
15	15	1105 (18:25)	86 (1:26)
10	20	801 (13:21)	75 (1:15)
5	25	707 (11:47)	64 (1:04)
0	30	470 (7:50)	54 (0:54)

Table 1: Evacuation Times for Day Staff of 6 Nurses (10 Runs for Each Patient Distribution)

	Patient Category	Minimum delay (Seconds)	Maximum delay (Seconds)
1	Immobile patients who could not be moved from their beds (depending on associated instrumentation).	180	900
2	Immobile patients who could be moved from their beds but	180	900

	only with considerable difficulty and an associated delay (eg to a wheelchair)		
3	Immobile patients who could be moved with relative ease given the assistance of one or more members of staff.	60	180
4	Mobile patients able to move on their own with some staff directions (accounting for telling them what is about to happen).	30	90

Table 2: Initial Preparation Times for Patient Evacuation

The scenario presented in the previous section is also informed by some of the 'systemic' problems that have been uncovered in hospital evacuation exercises. For example, McCarthy and Gaucher (2004) describe how the hospital paging system played a central role in coordinating the emergency response. During the exercises, it emerged that many announcements could not be heard. Staff then had to either contact the desk issuing the calls or leave their posts to seek further clarification. It also emerged that no one was sure what would happen if it were to be damaged. As a result of these exercises, changes were made in the way that messages were sent around the hospital. A messenger position was opened and plans were made to distribute walkie-talkies in case the existing communications infrastructure was compromised during an adverse event.

Discussion

The motivation behind this article is to make hospital managers think about preparedness in their own organisations. The 'risk based' approach advocated in the NHS (2001) encourages staff to focus time and training resources on the relatively high numbers of isolated, low intensity fires that occur throughout the health service each year. There is an assumption that the emergency services will arrive in time to combat larger, more serious incidents. Techniques such as 'horizontal evacuation' assume that external agencies will eventually intervene to either put out a fire or move patients to another place of safety. However, we believe that it is time to question these assumptions. Hurricane Katrina has already shown that natural disasters can delay prompt intervention from external agencies. New Orleans University Hospital and Charity Hospital were forced to develop complex vertical evacuation strategies as their lifts failed and they areas began to flood (Johnson, 2005a). Similarly, the previous scenario describes ways in which coordinated terrorist actions might expose the vulnerabilities in NHS evacuation strategy. The deliberate use of multiple explosive or incendiary devices combined with targeted attacks on a small number of fire stations would have a catastrophic effect on most healthcare institutions.

When working in this area, it is difficult to avoid comparisons with the evacuation of the World Trade Center complex. Prior to the attack in 2001, the twin towers had been a target for terrorist attack in 1993. This explosion had forced a revision of evacuation support. Luminous markers were placed in the emergency stairwells. Additional hand-rails were provided. The attack also motivated the building operators and emergency services to alter their evacuation policy. So many occupants were injured during the evacuation following the 1993 bombing that standard operating procedures were re-written. The new policy adopted the principle of 'defend in place'. Occupants were told to remain in their offices, stay low and await the arrival of emergency personnel. When the aircraft hit the World Trade Center, this was the policy that people were to follow. FDNY dispatchers told occupants of the North Tower who were both below and above the impact point to follow this procedure. The first NYFD chiefs on site immediately rescinded this policy and ordered an evacuation of the North Tower. However, this information was not conveyed to all of the telephone operators who were receiving calls for advice from the occupants. Some chose to remain and wait for the fire crews and emergency service units from NYPD. Others chose to leave. The key lesson here is that if we rely on 'defend in place' and horizontal evacuation techniques then we cannot expect hospital staff and patients to develop more flexible responses to the

unpredictable threats posed by coordinated terrorist action or environmental disasters (Johnson, 2005).

The following paragraphs provide a number of additional points that should be considered by NHS managers as they consider the risks associated with future terrorist actions:

1. Every emergency contingency for which there is widely understood planning, postulates that fires and other disasters will be accidentally caused. The random and uncoordinated nature of these incidents can be used to justify many different NHS policies, including risk-based approaches to evacuation drills, horizontal evacuation techniques, piecemeal upgrades to non-fire resistant materials etc. However, many of these policies create the preconditions for major loss of life when faced with the risk of coordinated terrorist action. Most previous scenario modelling assumes hospitals will be the place where victims are cared for (US HRSA, 2005, US AHRQ 2004). There is little planning or foresight into risk control for direct terrorist attacks on healthcare institutions. Even conventional attacks create threats that are very different from the sporadic accidental fires that the NHS is preparing for.

2. Informal discussions with senior NHS managers have revealed that the threats described in our scenario are both credible and concerning. They are aware of the potential threat from terrorist action and feel unprepared to meet it. However, any adequate response would take resources away from primary care. This could only be justified by direct instructions from central government. Equally, however, it is possible to envisage a number of low-cost measures that hospitals could take to prepare for such adverse events. Many of these measures might also have the welcome benefit of preparing healthcare institutions for more common, minor fires. For example, everyone employed in patient care might be required to take part in simulated evacuation drills. This would move away from the risk-based approach mentioned above. Such innovation would be justified by the unpredictable nature of the hazards that face many civil organisations. These drills should consider what might happen if part of the communications infrastructure were to fail. They might also consider what would happen if defend in place techniques were insufficient to protect patient safety in the interval before emergency services arrived on site.

Although our focus has been on conventional weapons, our scenario has clear implications for other forms of attack. For example, most previous planning for bioterrorist incidents has focussed on the role of healthcare providers during triage, and decontamination. Few studies consider what might happen if healthcare institutions were themselves the target of the attack. They, therefore, fail to consider the consequences of key personnel being injured or infected. Again, we could take measures to prepare ourselves for such contingencies. For example, we can prepare search and rescue base of operations (SARBOs) similar to those that were used when healthcare institutions could not continue to function in central New Orleans.

Conclusions

The intention behind this paper is to provoke a debate. At present, the NHS favours a risk-based approach to evacuation and emergency planning. This enables trusts to focus training on those key individuals who are assumed to play the most important role during any likely evacuation. In consequence, few staff ever participate in evacuation exercises. The increasing use of agency staff and part time workers also erodes the knowledge base that enables teams to respond in flexible ways to unpredictable emergencies.

Most healthcare institutions base their risk assessments on the isolated hazards created by accidental fires. In consequence, emergency plans make a number of strong assumptions. For example, it is assumed that fire protection systems will put out or halt the progress of a

fire. It is assumed that communications systems, including pagers, PA systems and internal telephones will continue to support coordination. However, experience in previous accidental fires has shown that these assumptions cannot be sustained. Local networks have been destroyed by fire, mobile telecommunications networks have become overloaded by personal calls, PA systems have been inaudible over evacuation alarms. Legacy sprinkler systems have failed to prevent toxic smoke and gas from overwhelming patients and staff.

Assuming that the only hazards stem from isolated fires has also led to an unwarranted reliance on the 'defend in place' policies of horizontal evacuation. It is assumed that staff will be able to identify safe locations for patients to wait for the arrival of emergency services. These assumptions have already been challenged in a number of US states, which have already drafted laws banning the use of horizontal evacuation for certain classes of healthcare facility. They recognise the limitations of 'defend in place' strategies for anything other than simple, single accidental fire scenarios. Meanwhile in the UK, few managers have considered what might happen if multiple fires broke out at the same time in different areas of a building. Under such circumstances, it can become difficult for staff to identify the most appropriate location for them to move patients. Switchboard operators may not be able to provide key first responders with accurate information about the source of any potential hazards. Above all, horizontal evacuation techniques assume that emergency services will be able to reach the hospital before the safety of staff and patients is compromised. In most scenarios this assumption is justified. However, our scenario suggests ways in which this premise can be undermined through the use of conventional weapons.

Previous sections have argued that much current work focuses on the role of healthcare workers in the response to major terrorist incidents. They are seen as critical to an effective response following biological and nuclear attacks. However, the planning and training scenarios rarely consider what might happen if NHS infrastructure were itself the target of an attack. At present this infrastructure is incredibly vulnerable. Coordination across local and regional boundaries is seldom rehearsed. We can do little more than reiterate the opening comments from the 2003 Public Accounts Committee; "at a time of heightened risk of terrorist attacks, parts of the NHS are not well prepared to handle the emerging threats from nuclear, chemical, biological and radiological incidents". The scenario presented in this paper also, arguably, extends this critique to conventional incidents with minimal coordination.

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