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Emergency preparedness, resilience and response to a biological outbreak

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Received 4 September 2019
Revised 25 October 2019
Accepted 3 November 2019
Published Online First

ABSTRACT

Major disease outbreaks continue to be a significant risk to public health, with pandemic influenza or an emerging infectious disease outbreak at the top of the UK National Risk Register. The risk of deliberate release of a biological agent is lower but remains possible and may only be recognised after casualties seek medical attention. In this context the emergency preparedness, resilience and response (EPRR) process protects the public from high consequence infectious diseases, other infectious disease outbreaks and biological agent release. The core elements of the EPRR response are recognition of an outbreak, isolation of patients, appropriate personal protective equipment for medical staff and actions to minimise further disease spread. The paper discusses how high-threat agents may be recognised by clinicians, the initial actions to be taken on presentation and how the public health system is notified and responds. It draws on the national pandemic influenza plans to describe the wider response to a major disease outbreak and discusses training requirements and the potential role of the military.

Key messages

- ⇒ Clinicians are likely to be the first to recognise a biological event.
- ⇒ This may be an unusual infectious disease or a cluster of patients presenting with similar symptoms and signs over a short period.
- ⇒ The core elements of the emergency preparedness, resilience and response (EPRR) are recognition, isolation of patients, appropriate personal protective equipment for medical staff and actions to minimise further disease spread.
- ⇒ Regular training in infectious disease management is essential for all EPRR responders.
- ⇒ A large outbreak or pandemic would have significant effects on society, extending beyond healthcare.
- ⇒ The military has a role in providing specialist capabilities and additional support to the NHS.

INTRODUCTION

This paper describes the healthcare emergency preparedness, resilience and response (EPRR) to a high consequence infectious disease (HCID), other infectious disease outbreak or biological agent release. In this context the EPRR process seeks to protect the public by recognising an outbreak, identifying the pathogen or toxin, implementing control measures and minimising further disease spread.

A disease outbreak exists when occurrences of the disease exceed what would normally be expected within a defined population. Recent examples include recurrent Ebola virus disease (EVD) and monkeypox in West and Central Africa, Middle East respiratory syndrome (MERS) reported in 27 countries, and plague in Madagascar. Monkeypox, MERS and EVD have been reported in the UK. A global influenza pandemic or an emerging infectious disease outbreak remains at the top of the UK National Risk Register.[1]

In the UK, the deliberate release of a biological agent is assessed to be less likely than conventional and low sophistication terrorist attacks.[2] However it remains a threat and may be difficult to initially recognise especially as common pathogens may be used as the crude biological weapon. *Salmonella typhimurium* was distributed in Oregon in 1984 in an attempt to disrupt local elections; 10 restaurants were contaminated, infecting 751 patients.[3]

The challenge for clinicians is the early recognition of an outbreak since initial cases of an infection may not immediately be recognised as presenting a wider risk to the community.

DEFINITIONS

HCIDs are diseases that pose a significant public health risk and are characterised by the following:

- An acute infectious disease.
- Typically with a high case fatality rate.
- Possibly not having effective prophylaxis or treatment.
- Often difficult to recognise and detect rapidly.
- Ability to spread in the community and within healthcare settings.
- Requiring an enhanced individual, population and system response to ensure they are managed effectively, efficiently and safely.

Public Health England (PHE) divides HCIDs by method of transmission in order to guide enhanced infection prevention and control (IPC) measures (Table 1).[4]

Emerging infectious diseases are infections with a recent, or potential, increased incidence in humans. They are considered to be persistent if they become a significant cause of morbidity and include HCIDs such as MERS.

Biological agents that have potential for deliberate release are classified as either live agents (bacteria, viruses, parasites, fungi) or toxins. Historically specific diseases such as anthrax, smallpox, tularaemia, brucellosis, glanders and plague have been researched and developed into biological

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To cite: Welby-Everard P, Quantick O, Green A. *BMJ Military* 2020;**166**:37–41.

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Table 1 High consequence infectious diseases[4]

Contact precautions	Airborne precautions
► Argentine haemorrhagic fever (Junin virus).	► Andes virus infection (hantavirus).
► Bolivian haemorrhagic fever (Machupo virus).	► Avian influenza A H7N9 and H5N1.
► Crimean-Congo haemorrhagic fever.	► Avian influenza A H5N6 and H7N7.
► Ebola virus disease.	► Middle East respiratory syndrome.
► Lassa fever.	► Monkeypox.
► Lujo virus disease.	► Nipah virus infection.
► Marburg virus disease.	► Pneumonic plague (*Yersinia pestis*).
► Severe fever with thrombocytopaenia syndrome.	► Severe acute respiratory syndrome.

weapons, but common pathogens such as salmonella also have the potential for deliberate release. Live agents may be disseminated through food and water supplies, vectors, aerosols or powders.

Toxins of biological origin, which have previously been developed as weapons, such as botulinum toxin and ricin, are not self-replicating and do not present a risk of transmission. However, due to their high lethality, they require an emergency response to identify the source and protect the public from further exposure to the agent.

Infection caused by the deliberate release of a live agent is likely to be difficult to distinguish from a naturally occurring outbreak due to their incubation period and covert nature of distribution.

PRESENTATION

The patient's history, clinical features and situational circumstances may raise suspicion that an individual case needs to be reported and appropriate IPC measures taken. An early response to an infectious disease outbreak depends on clinicians recognising unusual illnesses and reporting single cases.

The first indication of a deliberate release is likely to be when casualties seek medical attention. PHE recommends that clinicians remain *'alert to the unusual, the unexpected, and the case that just doesn't fit'* (Box 1).[5]

Many high-risk pathogens present with non-specific *'flu-like'* prodromal symptoms deteriorating to sepsis, but diagnosis of a specific pathogen or agent is unlikely to be possible until laboratory results are available. Classic symptoms may not always be present and suspicion should take into account the history and wider situation; relapsed EVD has presented as acute meningitis rather than with haemorrhagic symptoms.[6]

A detailed travel history should be taken for any patient presenting with fever and their occupation, hobbies, animal exposure and current family health considered. Recent unusual events and clusters of similar patients may suggest exposure from a specific incident or source.

INITIAL RESPONSE

HAZMAT/CBRNe

The incubation period, from the time of exposure to the onset of symptoms, for infectious diseases and live agents is days to weeks. It is therefore unlikely that an outbreak or deliberate release would require an immediate Hazardous Materials or Chemical, Biological, Radiological, Nuclear and explosives (HAZMAT/CBRNe) approach. Even toxin exposures, such as ricin or botulinum, are likely to go unnoticed until medical teams recognise patients presenting with similar breathing difficulties.

Box 1 Indicators of a potential deliberate biological agent release[5]

⇒ An unusual illness (sudden death, critical illness or death from pneumonia of a previously healthy adult).
⇒ An unusual number of patients with the same symptoms.
⇒ An illness unusual for the time of year (summer *'flu'*).
⇒ An illness unusual for the patient's age group (*'chickenpox'* in a middle-aged adult).
⇒ An illness in an unusual patient (cutaneous anthrax in a patient with no history of contact with animals, animal hides or products).
⇒ An illness acquired in an unusual place (tularaemia in the UK).
⇒ Unusual clinical signs (eg, mediastinal widening on CXR; sudden onset of symmetrical flaccid paralysis).
⇒ An unusual progression of an illness (lack of response to usually effective antibiotics; *'chickenpox'* rash predominant on extremities).
⇒ Any confirmed case of smallpox, plague, pulmonary anthrax, glanders, tularaemia, Venezuelan equine encephalitis or viral haemorrhagic fever without history of travel to an endemic area.

The trigger for action will be clinicians identifying a cluster of disease cases.

The exception to this would be an overt attack using powder, such as anthrax, when the incident should be managed in line with the Joint Emergency Services Interoperability Principles (JESIP) and the NHS Initial Operational Response.[7] In this situation potentially exposed individuals would require decontamination, observation for symptoms and possibly prophylaxis.

Infectious disease presentations

A potential HCID does not require decontamination, but enhanced IPC measures will be required. Routine IPC behaviours and practices, such as hand washing, should be followed and specific actions taken depending on the potential disease and mode of transmission. These may include isolation (in a negative pressure room if airborne pathogen), enhanced personal protective equipment (PPE) such as FFP3 face masks, restriction of visitors and masking of the patient. Individual guidance exists for viral haemorrhagic fever (VHF), MERS, avian influenza, Nipah virus, monkeypox and pneumonic plague.[4]

For any cases of suspected infectious disease, staff should employ a *'talk but don't touch'* approach while establishing the initial risk. The guidance for VHF presenting to the emergency department requires that the patient should immediately be isolated in a side room with hand washing facilities, a private bathroom or commode, and an adjacent space for donning and removing PPE with a clean-dirty segregation. Further assessment and clinical care should then be provided in appropriate PPE, a malaria test conducted and the local infection consultant (infectious diseases, virology or microbiology) contacted.[8] The principles of isolation, avoiding unprotected physical contact and early discussion with an infection consultant should be applied to all infectious diseases.

Confined waiting areas and delays in initial assessment may expose others to a contagious patient. Any areas that the patient may have contaminated while waiting to be assessed should be closed off and cleaned appropriately. Members of the public or staff who may have had contact with the patient should be

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identified and assessed for risk of exposure following the Advisory Committee on Dangerous Pathogens guidelines and with infection consultant guidance.[9]

Notification and patient transfer

Suspected or confirmed cases of any HCID, other possible outbreak or deliberate release event should be discussed without delay with the local infection consultant and the local health protection team (HPT) duty office.[10–13]

PHE's Imported Fever Service (IFS) can be contacted by hospital doctors following consultation with an infection consultant. It provides advice on the *'management of febrile patients, infection control and public health interventions'*, with diagnostic tests carried out by the Rare and Imported Pathogens Laboratory. Once an HCID has been confirmed by IFS, the patient should be transferred to a designated HCID treatment centre with a high-level isolation unit (HLIU). IFS may occasionally recommend the transfer of a highly probable HCID before results are available.[14]

The following are the principal contact HCID treatment centres in the UK:

- Royal Free Hospital, London.
- Newcastle Royal Victoria Infirmary.

Additionally there are four interim airborne HCID centres providing adult and paediatric services from six NHS trusts:

- Guy's and St Thomas' NHS Foundation Trust (adult and paediatrics).
- Royal Free London NHS Trust (adults) with Imperial College NHS Trust (paediatrics).
- Royal Liverpool and Broadgate University Hospitals NHS Trust (adults) with Alder Hey Children's NHS Foundation Trust (paediatrics).
- Newcastle upon Tyne Hospitals NHS Foundation Trust (adults and paediatrics).

Public health response

Under the Civil Contingencies Act 2004, PHE provides public health EPRR leadership, advice and expertise. The local HPT will take the lead in initial epidemiological investigation, establish the nature of a potential outbreak and the threat to public health.[15]

The HPT consultant in communicable disease control may declare an outbreak for any incident in which:

- Two or more people experiencing a similar illness are linked.
- There is a greater than expected rate of infection.
- A single case for certain rare diseases has occurred.
- There is a suspected, anticipated or actual event involving microbial or chemical contamination of food or water.

The level of response will depend on an initial dynamic risk assessment conducted by the HPT, and an outbreak control team (OCT) urgently established if an outbreak is characterised by the following:

- Immediate or continuing significant risk to the health of the population.
- One or more cases of a serious communicable disease.
- A large number of cases.
- Cases identified over a large geographical area suggesting a dispersed source.
- Significant public, political or reputational interest.[16]

The OCT will determine the National Incident Response Plan level, engage other agencies and establish the appropriate management level. PHE operates at one of two levels of response: standard or enhanced, which relates to the requirement for either local or national leadership.[17]

Control measures:

- Treatment: PHE has published clinical guidelines for the immediate management of a wide range of infectious diseases and biological agents.[5 18]
- Prophylaxis and vaccination: In some cases the use of prophylactic antibiotics or vaccination may be directed by PHE. Patient group directions have been developed to support the distribution of prophylaxis for suspected or confirmed exposure to plague, tularaemia or anthrax.[19]
- Reserve stocks: UK national reserve stocks of antibiotics are held at strategic locations and include antibiotics for both treatment and prophylaxis. Access to the national reserve can be requested by NHS organisations, on PHE recommendation by calling the NHS England EPRR duty officer.
- Self-care: Not all infectious diseases that have potential to develop into epidemics would require universal hospital treatment. The National Pandemic Flu Service, once activated, uses an algorithm to authorise the individual issue of antiviral medication through the 111 telephone service or internet. This can then be collected from designated collection points, usually based on local pharmacies.

THE NATIONAL RESPONSE: PANDEMIC INFLUENZA PLANNING

Pandemic influenza is at the top of the UK National Risk Register and is the only infectious disease for which there has been extensive contingency planning. The general principles of these plans provide a framework for managing an outbreak of any pathogen with significant disease transmission, morbidity, mortality and long-lasting consequences.

A widespread outbreak would require major incident plans to be initiated across the health and emergency sectors. Local resilience forum will coordinate the response from the emergency services, local authorities, NHS and other involved stakeholders, in line with JESIP.[20]

Civil Contingencies Act 2004 tier 1 and 2 providers are required to hold detailed plans for how they would respond to an influenza pandemic. These plans are made against the *'reasonable worst case'* (RWC) scenario based on modelling of previous influenza epidemics. The RWC assumes up to 50% of the population will become ill and up to 4% will require hospitalisation for an average of six days, 25% of which would need level 3 critical care for 10 days.[21]

A severe pandemic would have pan-societal consequences effecting the provision of critical services and infrastructure. In this event, the cross-governmental response is focused on maintaining business as usual. The National Pandemic Influenza Strategy does not plan for the UK Government to close borders, stop mass gatherings or impose controls on public transport, as epidemiological modelling does not show any significant disease control benefit.[22]

Unlike influenza, an epidemic of a novel emergent disease would be additionally complicated by lack of foundational research knowledge, rapid diagnostics and treatment protocols.

Communications

A large HCID outbreak will generate considerable media interest which can rapidly lead to speculations becoming represented as fact. It is crucial that a definitive voice, with a unified message, is kept by all healthcare providers during the outbreak. PHE will provide accurate information and continual contact with providers, and all forms of media, in order to coordinate the central message.

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Normal personal data protection rules apply to these communications unless there is a material public risk, in which case public protection is paramount.

Secondary care

In a large-scale epidemic individual isolation may no longer be possible, and cohorting of patients in dedicated wards would be required.

As numbers increase critical care provision may not meet clinical need. As part of planned escalation measures, trusts may need to use surgical recovery suites and anaesthetic machines to provide additional critical care capability. This will call for prioritisation and cancellation of elective surgeries.

The staffing of this capability will require personnel to be drawn from other clinical areas. NHS trusts should maintain an awareness of recently retired staff who may be prepared to provide service during the epidemic.

The resource-constrained environment is likely to raise difficult ethical issues regarding allocation of patients to limited resources. The widest ranging of these would be made at the Cabinet level and may include the use of reverse triage or expectant category. Individual patient decisions should be discussed through local ethics committees.

Primary care

Clinical commissioning groups are category 2 responders under the Civil Contingencies Act 2004 and are required to support the NHS and the wider health response.

In a low-impact outbreak, primary care would aim to continue normal service delivery. As demand increases non-urgent care and non-clinical activities would likely be suspended. General practitioners would need to prioritise high-risk patients and those requiring a higher level of care at home. Preplanned mutual support systems, such as practice buddying, may need to be activated and the use of retired medical staff considered.

At times of very limited hospital capacity, pandemic-specific clinical assessment tools may be used to prioritise patients. These set a *'higher bar'* for hospital admission to ensure that only the severely unwell, likely to respond to treatment, are actually conveyed to hospital.[23]

Ambulance services

Consideration may be given to expanding the role of ambulance staff in providing home assessment and coordinating with community care.

Social care

The social care sector encompasses statutory, voluntary and private organisations, as well as the informal network of carers who provide support to family and friends. The aim would be to maintain crucial services by redeploying staff from non-essential services and the temporary reallocation of resources from those with lower care needs to those in higher need.

RECOVERY

The OCT will declare an outbreak over once there is no longer a threat to public health requiring investigation and control measures. This is normally twice the incubation period of the pathogen from the last known case. During the West African Ebola outbreak, countries were declared *'Ebola free'* after 42 days since the last reported case; EVD's incubation period is 2–21 days. Heightened surveillance continues in the following period and this does not signal the end of the emergency as recovery measures will continue to be required.

Business continuity planning is central to all major incident plans, with the intention of maintaining normal services for as much of the incident period as possible. The initial recovery phase should include periods of staff rest and provide an opportunity to regroup in case of another wave of the epidemic. The restoration of business as usual, including catching up on routine activities, such as cancelled elective surgeries, may take many months or longer.[24]

Structured debriefing and audit should be conducted at all levels of response as part of the postincident review. The lessons identified must then be incorporated into future resilience plans that will be tested by future collaborative exercises and real-life responses.

For a pandemic or major outbreak, unlike discrete HAZMAT/CBRNe incidents, the long-term consequences will be profound and extend well beyond the immediate health-related effects. Systemic vulnerabilities will be exposed and those systems with the least capacity for resilience will be affected worst and for longest.

Training and exercises

NHS core EPRR standards require all providers to maintain plans for a range of eventualities including pandemic influenza, infectious disease outbreaks and provision of mass countermeasures. They must ensure staff remain competent in their role in these scenarios and conduct an annual tabletop exercise, and every three years a live exercise and a command postexercise.[25]

PHE provides a range of one-day *'Off the Shelf Exercises'* including scenarios for botulinum neurotoxin, pandemic influenza and VHF.[26]

EPRR leads are responsible for ensuring that sufficient numbers of staff are trained in recognition of potential high-threat presentations and the immediate actions to be taken, and have received appropriate training in IPC. In the emergency department and other acute areas, this should include the donning and doffing of appropriate protection for VHF and FFP3 face masks.

The national response to pandemic influenza was exercised across the UK in Exercise Cygnus in 2016.

Military assistance

Under specific Memoranda of Understanding, the Ministry of Defence provides ongoing specialist capabilities to support the Department of Health and Social Care. This includes provision of the air transportable isolator and a team to move high-risk patients to one of the HLIUs. Deployments within the UK since 2012 have included transporting cases of Crimean-Congo haemorrhagic fever and EVD.[27]

When the NHS has exceeded its capacity or requires specific capabilities, it may request military support. The military aid to the civil authorities (MACA) requires ministerial approval, except in very exceptional circumstances where there is an urgent need to protect life. Many Defence Medical Services (DMS) clinical staff are routinely embedded within NHS organisations. Authorisation of medical MACA will consider the effect of redeploying these staff on the clinical capability within their host NHS organisations.[28]

Potential DMS support to serious outbreaks may include providing clinical support and patient transportation. However, given the scale of a pandemic, it is likely that the major MACA efforts would be directed to logistics and security. This would provide significant challenges for military primary and public

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health staff, with units deploying into potentially infected local populations.

CONCLUSIONS

Clinicians working in primary care and acute settings are likely to be the first to recognise an unusual clinical presentation. Maintaining a degree of suspicion and raising concern early through the local infection consultant and HPT speed the EPRR response. The core elements of response are recognition, isolation of patients, appropriate PPE for medical staff and early epidemiology in order to minimise transmission and further infection. Disease outbreak and HAZMAT/CBRNe responses are integrated with NHS organisations' major incident plans. Staff working in category 1 and 2 EPRR responders should be aware of their roles and have appropriate training to respond. A national epidemic or global pandemic would have a significant impact across society and require difficult resourcing decisions for healthcare providers. The military has a potential role in providing specialist capabilities and additional support to the NHS throughout the response.

Contributors PW-E wrote the initial draft of the paper, with revisions and additions made by OQ and AG.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Not required

Provenance and peer review Commissioned; internally peer reviewed.

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