Institution: University of Hertfordshire		
Unit of Assessment: 3 - Allied Health Professions, Dentistry, Nursing and Pharmacy		
Title of case study: New US and UK government emergency response protocols for chemical incidents and terror attacks.		
Period when the underpinning research was undertaken: 2012-2018		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Robert Chilcott	Professor of Toxicology	Feb 2011 – present
Joanne Larner	Senior Research Fellow	Jan 2012 – present
Hazem Matar	Senior Research Fellow	Jan 2012 – present
Period when the claimed impact occurred: 2014 – 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact (indicative maximum 100 words)

In line with raised terrorism threat levels, the US and UK Governments have strengthened their emergency responses to chemical terrorism attacks to better protect civilians and save lives. Research by the Toxicology Research Group at the University of Hertfordshire (UH) into effective decontamination of casualties exposed to the deliberate or accidental release of toxic materials has shaped the US and UK Governments' de facto guidance for how all emergency services and civil contingency agencies should respond to chemical, biological, radiological and nuclear (CBRN) incidents. The new emergency protocols, based on six years of studies, guided the immediate response to the nerve agent attack in Salisbury and are now a key component of CBRN training for UK emergency personnel. Researchers adapted them for inclusion in a mobile app made available by the US Government to all first responders in the US. The protocols were cited in evidence given by UK Government departments and the security minister to House of Commons Select Committees as demonstration of the UK's preparedness for a CBRN incident.

2. Underpinning research (indicative maximum 500 words)

The Syrian Civil War highlighted the devastating impact that chemical warfare agents can have on civilian populations. But the 2018 'novichok' nerve agent attack in Salisbury on Sergei Skripal and his daughter Yulia, and the death of British citizen Dawn Sturgess, dispelled any complacency that chemical warfare agents are limited to politically unstable regions. Within this wider context, the US and UK Governments sought to determine the most clinically effective methods to treat survivors of chemical terrorism attacks, as well as accidents caused by toxic industrial chemicals.

Funded by the US Government's Biomedical Advanced Research and Development Authority (BARDA) under the Office of the Assistant Secretary for Preparedness and Response (ASPR), Professor Robert Chilcott and colleagues researched the most effective decontamination methods that first responders should use in a chemical terrorism attack or accident. The aim of the initial three-year $7.0m programme [**G1**] was to ensure that all casualties exposed to potentially hazardous chemicals receive the most effective treatment as quickly as possible.

UH research found that the common practice of showering clothed patients with high-volume water mist from fire engines as the primary method of decontamination should be avoided. Studies by Chilcott's team showed that this method can wash chemicals through to the skin, increasing contamination. They found that careful disrobing in combination with a dry decontamination process before showering removed 99 per cent of contaminants. Lab studies on the effects of water temperature, flow rate, detergents and delayed decontamination, combined with human volunteer studies in which dangerous contaminants were simulated, led to the development of the three-volume Primary Response Incident Management System (PRISM), authored by Chilcott's group and first published in 2015 (revised in 2018) by the US Government [**3.1**].

BARDA commissioned UH to carry out further research to evaluate the clinical and operational effectiveness of PRISM in order to fully optimise emergency responses. Under the $7.1m GO-AHEAD project (Guidance On All-Hazards Enhanced Action Decontamination) [**G2**], Chilcott's

group developed a user-friendly algorithm (called ASPIRE) for incorporation into a mobile app to ensure effective and proportionate responses from first responders. UH researchers designed a robust decision support tool for triggering immediate disrobing and/or mass decontamination processes at the scene of an incident and developed improved knowledge of how hair affects decontamination processes. A UH-led live exercise in Rhode Island, Operation Downpour, involving hundreds of volunteers, emergency service personnel and public health officers, demonstrated the effectiveness of the new 'disrobe and dry decontamination' procedure [**3.2**].

Concurrently, research by Chilcott's group, in collaboration with Public Health England, shaped new protocols in the UK for responding to CBRN incidents. The 2013 EDICTAS study [**G3**] (Emergency Decontamination In Clinical Treatments At Scene), funded by the Department of Health, identified the most appropriate methods for performing dry decontamination, using absorbent materials readily available within the NHS. It highlighted the need for specific instructions for first responders to ensure dry decontamination is carried out effectively [**3.3**]. Research also found that dry decontamination was ineffective against particulate contamination; wet decontamination should be used for non-liquid contaminants [**3.4**].

Both the UK and US studies shaped protocols in the UK Government's revised specialist operational response (SOR) for CRBN incidents. Optimised methods for performing dry and wet decontamination were published (open access) in the Emergency Medicine Journal to increase the visibility of the new protocols to healthcare professionals [**3.5**]. The research highlighted challenges in treating non-ambulant casualties and found that further live exercises were required to assess the combined effectiveness of dry and wet decontamination for this at-risk patient group [**3.6**].

3. References to the research (indicative maximum of six references)

3.1 Chilcott RP, Larner J and Matar H (Eds) (2018), Primary Response Incident Scene Management: PRISM Guidance, Volumes 1, 2 and 3, Second Edition, Office of the Assistant Secretary for Preparedness and Response, Biomedical Advanced Research and Development Authority, Washington DC. https://medicalcountermeasures.gov/barda/cbrn/prism/
3.2 Chilcott RP, Larner J, Durrant A, Hughes P, Mahalingam D, Rivers S, Thomas E, Amer N, Barrett M, Matar H, Pinhal A, Jackson T, McCarthy-Barnett K, Reppucci J. Evaluation of US Federal Guidelines (Primary Response Incident Scene Management [PRISM]) for Mass Decontamination of Casualties During the Initial Operational Response to a Chemical Incident. Ann Emerg Med. 2019 Jun;73(6):671-684. http://doi.org/10.1016/j.annemergmed.2018.06.042.
3.3 Amlôt R, Carter H, Riddle L, Larner J, Chilcott RP. Volunteer trials of a novel improvised dry decontamination protocol for use during mass casualty incidents as part of the UK'S Initial Operational Response (IOR). PLoS One. 2017 Jun 16;12(6):e0179309. http://doi.org/10.1371/journal.pone.0179309.
3.4 Kassouf N, Syed S, Larner J, Amlôt R, Chilcott RP. Evaluation of absorbent materials for use as ad hoc dry decontaminants during mass casualty incidents as part of the UK's Initial Operational Response (IOR). PLoS One. 2017 Feb 2;12(2):e0170966. http://doi.org/10.1371/journal.pone.0170966.
3.5 Chilcott RP, Larner J, Matar H. UK's initial operational response and specialist operational response to CBRN and HazMat incidents: a primer on decontamination protocols for healthcare professionals. Emerg Med J. 2019 Feb;36(2):117-123. http://doi.org/10.1136/emermed-2018-207562. ***This paper was featured as a podcast on the Royal College of Emergency Medicine's e-learning platform and is in the top 5% of all research outputs scored by Altmetric.***
3.6 Chilcott RP, Mitchell H, Matar H. Optimization of Nonambulant Mass Casualty Decontamination Protocols as Part of an Initial or Specialist Operational Response to Chemical Incidents. Prehosp Emerg Care. 2019 Jan-Feb;23(1):32-43. http://doi.org/10.1080/10903127.2018.1469705.

G1 United States ASPR-BARDA: Grant no: HHS0100201200003C; $7,026,799; 2012 – 2015.
G2 United States ASPR-BARDA: Grant no: HHSO10020150016C; $7,108,597; 2015 – 2018.
G3 UK Department of Health: EDICTAS study; £104,847; Sept 2012 – March 2013.

4. Details of the impact (indicative maximum 750 words)

Research into effective decontamination of casualties exposed to the release of toxic materials has shaped policy and practice in the UK and US on responding to CBRN incidents. This programme of work was awarded *Research Project of the Year: STEM* in the Times Higher Education Awards (2018), which recognises '*innovative research in STEM subjects that has a far-reaching impact*'.

Establishing new US policy guidance for CBRN responses

The PRISM guidance [**3.1**], written by Chilcott and colleagues and published by the US government, was the first evidence-based US federal guidance for responding to terrorist incidents or accidents that lead to the exposure of mass casualties to hazardous materials. According to BARDA: "*Effective decontamination is the best way to protect health against chemical exposure and is the only generic medical countermeasure available against multiple chemical threats. However, there was no standard, scientifically supported practice for performing it in the United States before BARDA asked the University of Hertfordshire to undertake rigorous studies"* [**5.1**].

BARDA has recommended PRISM for use by the entire US first responder community of over a million people (Fire Departments, Emergency Medical Services and Police) and it underpins the development of Tribal, County, State and Federal Government policies for chemical response management. PRISM is key to *"saving lives and improving our response capabilities for both terrorism and accidental chemical release"*, according to BARDA, noting its *"widespread and significant impact on societal preparedness"* in the United States [**5.1**].

As part of US Government efforts to publicise the guidance to its agencies the Assistant Secretary for Preparedness and Response at the US Department of Health and Human Services (HHS), cited the UH studies extensively in an interview with *Homeland Preparedness News* in March 2018. He said: *"Dousing someone fully clothed with a fire hose, which is a common practice, potentially pushes chemicals into the skin causing greater harm. Emergency planners and first responders need to know about the studies and the resulting PRISM guidance, so they can incorporate the proven approach into their emergency plans and exercises"* [**5.2**].

In 2019, both PRISM and the ASPIRE decision support tool were made available online to all services in the US, including being incorporated into the Chemical Hazards Emergency Medical Management (CHEMM) web-based resource, managed by HHS and the US National Library of Medicine (NLM) [**5.3**]. The University of Hertfordshire team also worked with NLM to incorporate PRISM and APSIRE into the WISER mobile and desktop app (Wireless Information System for Emergency Responders). This app was downloaded 128,787 times in its first five months, including many organisational downloads that then make the app available to individual employees [**5.3**]. In an interview with Infection Control Today the director of BARDA said: *"Building on the first ground-breaking studies and guidance, we now have a larger body of scientific evidence that is incorporated into the latest guidance, and we have made it even easier for responders to use in preparing for disasters and on the scene in an emergency."*

Speaking to *Nature* in 2019, the deputy director for BARDA said he hoped that governments and first responders elsewhere, especially in the Middle East, will use the guidelines, pointing out that videos of chemical weapons attacks in Syria suggested that people lacked the basic information needed to quickly decontaminate themselves. The article also quoted the Director of Policy at New York-based Physicians for Human Rights, which advises frontline health workers in the Middle East on chemical attacks, as saying that the guidance will be helpful for responders in war zones [**5.2**].

Establishing new UK policy guidance for CBRN responses

Findings from the UH-led EDICTAS study were translated into new protocols for improvised decontamination by first responders at the scene of a chemical incident. This formed the basis of the Home Office's *Initial Operational Response (IOR) to a CBRN incident* [**5.4**].

Prior to the publication of this guidance in July 2015, initial responders were trained to stand off and wait for specialist responders to arrive, which, according to the IOR report, was "n*ormally*

considerably later than the optimal time for saving life." The guidance states: *"The IOR provides the process by which all responders first on the scene of a contamination incident can follow a number of steps to safely save lives during the most critical early stages of the incident."* [**5.4**]

The IOR was a key part of wider guidance published in September 2016: *Responding to a CBRN(e) event: Joint operating principles for the emergency services* [**5.5**]. It includes the IOR, the Specialist Operational Response (for specialist units arriving after first responders) and the transition between the two phases. UH research underpinned the document's guidelines on effective decontamination. The guidance was published by JESIP (Joint Emergency Services Interoperability Principles), which is run by the emergency services (police, fire and ambulance) with support and oversight from three government departments. Chilcott was the lead scientist on the Home Office-led working group that authored the guidance.

According to JESIP, the guidance was published to respond to the need for a *"dynamic and joint approach"* by the emergency services and other agencies and to *"create a faster, more agile, flexible, scalable and interoperable response"* [**5.5**]. These decontamination protocols also appear throughout PHE's 2018 handbook for public health and health protection professionals: *CBRN incidents: clinical management and health protection* [**5.6**].

A Home Office official said Chilcott's research *"has been fundamental not only in the area of mass decontamination but also in the ability of local emergency (services) to effectively respond to individual chemical assaults using corrosive materials"* [**5.7**]. The official said the Minister for Security referred directly to Chilcott's research when giving oral evidence (Sept 2016) to the House of Commons Select Committee on Science and Technology during its inquiry into UK responses to CBRN events. Earlier, in May 2016, the Home Office, in written evidence to the same inquiry, highlighted the evidence-based nature of its CBRN response protocols, noting "*University of Hertfordshire scientists*" are *"having a major impact on how we decontaminate casualties"* [**5.7**].

As an indication of the scenarios in which these new CBRN emergency response protocols are applied in practice, the guidelines were followed in the aftermath of the 'novichok' nerve agent attack in Salisbury in 2018. This is confirmed in a published letter (May 11, 2018) by the Minister of State for Security and Economic Crime to the Chair of the Science and Technology Select Committee in which he writes: "…*the capabilities held at readiness for a CBRN incident were employed as they were the most appropriate capabilities to respond to the circumstances."* [**5.8**] The protocols would also have been followed in August 2017 when a 'chemical cloud' drifted from out at sea onto a beach in East Sussex, resulting in 150 people seeking medical treatment, as well as in chemical attack practice drills in the UK (as context, the London Fire Commissioner publicly announced an increase in such drills in January 2017).

Changing approach of UK emergency responders to CBRN incidents

All emergency services in the UK are required to follow the Government's new CBRN response and decontamination protocols. The National Ambulance Resilience Unit (NARU), which works with all NHS Trusts in England, published two training videos in 2015, one for ambulance services and one for the wider NHS. Both featured interviews on the decontamination protocols with Chilcott. A DVD was circulated to all hospitals in England to support the rollout of the IOR [**5.9**].

In April 2015 NHS England's Emergency Preparedness, Resilience and Response (EPRR) team published: *Chemical incidents: Planning for the management of self-presenting patients in healthcare settings*. It included details of the IOR, informed by UH research, and the target audiences were NHS Chief Executives, Medical Directors, Directors of Nursing, NHS Trust Board Chairs and GPs [**5.9**]. In 2018 NHS England and NARU refreshed its IOR messaging through its *Remove, Remove, Remove* campaign. According to NARU, the poster and an aide memoire were designed to *"make core elements (of the IOR) quicker and easier to absorb, remember and apply, allowing first responders to significantly reduce harm to affected casualties"* [**5.9**].

NHS England's EPRR lead for London writes that Chilcott and his team *"have made a significant contribution to the development and implementation of NHS response procedures and guidance*

to a chemical incident - both in the form of leading the underpinning research efforts and as subject matter experts on relevant UK Government committees" [**5.9**].

PHE confirms the IOR *"regularly informs training and preparedness within acute healthcare settings"* and the optimisation of the SOR, based on UH research, is *"a key aspect of the training of, for example, Fire Service Mass Decontamination Instructors"* [**5.10**]. It says: *"Prof Chilcott's work has contributed to our training materials for emergency planning and response professionals. Our e-learning module on Decontamination includes this work and specifically references their publications. Further, we cite their work in training we are conducting with European partners for EU emergency response professionals"* [**5.10**]. As an indication of how widely the CBRN guidelines are informing training, modules on CBRN operational responses are publicised online by the College of Policing, NARU and local NHS trusts, fire services and police forces [**5.11**].

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Corroborating statement from BARDA.
5.2 Corroborating evidence via interviews with ASPR, published in Homeland Preparedness News, and BARDA, published in Nature:
https://homelandprepnews.com/countermeasures/27525-protecting-americans-includes-keeping-first-responders-safe-says-asprs-kadlec/
https://www.nature.com/articles/d41586-019-00646-4
5.3 PRISM and ASPIRE were incorporated into WISER 5.3 app in February 2019: https://wiser.nlm.nih.gov/whats_new_5_3.html - and publicised by the US Government: https://www.infectioncontroltoday.com/bioterrorism/new-hhs-sponsored-research-provides-new-tool-and-updated-guidance-mass-chemical; Corroborating email via NLM re WISER analytics.
5.4 Home Office's Initial Operational Response to a CBRN incident, 2015 (also on PDF): https://www.jesip.org.uk/uploads/media/pdf/CBRN%20JOPs/IOR_Guidance_V2_July_2015.pdf
5.5 Responding to a CBRN(e) event: Joint operating principles for the emergency services, 2016 https://www.jesip.org.uk/uploads/media/pdf/CBRN%20JOPs/JESIP_CBRN_E_JOPS_Document_On.pdf (see introduction for quotes cited in section 4 – also on PDF).
5.6 Gent N, & Milton R, editors. CBRN incidents: clinical management & health protection. 2nd ed. London: Public Health England; 2018 (also on PDF): https://www.gov.uk/government/publications/chemical-biological-radiological-and-nuclear-incidents-recognise-and-respond
5.7 Corroborating evidence relating to Home Office impact: corroborating statement from Home Office CBRN lead (see separate PDF); Home Office's written evidence to committee inquiry: http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/science-and-technology-committee/science-advice-for-chemical-biological-radiological-or-nuclear-emergencies/written/33593.html (see paragraph 15).
5.8 Letter from Security Minister to Chair of Science and Technology Select Committee relating to Salisbury CBRN response (also on PDF): https://www.parliament.uk/documents/commons-committees/science-technology/Correspondence/180511-Ben-Wallace-to-Norman%20Lamb-Salisbury-nerve-incident.pdf
5.9 Corroborating evidence relating to NHS England: corroborating statement from NHS England (see separate PDF); sample NARU video: https://naru.org.uk/videos/ior-nhs/; NHS England EPRR policy guidance: https://www.england.nhs.uk/ourwork/eprr/hm/;
5.10 Corroborating statement from Public Health England (separate PDF).
5.11 Report containing sample of emergency services training modules informed by UH research.