DEVELOPING TRAINING TO PREPARE HUMAN HEALTH SCIENCE STUDENTS TO FACE BIOLOGICAL INCIDENTS

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Abstract

Biological incidents involve the natural, accidental or deliberate release of biological agents that can lead to outbreaks or contamination of the environment with significant impact on human health. Outbreaks and intentional attacks (bioterrorism) present a significant challenge to the local healthcare infrastructure due to the large numbers of people affected. Biomedical and medical scientists can play a key role in collaborative response efforts to protect public health and reduce the spread of a biological hazard, as demonstrated during the recent international response to the West Africa Ebola outbreak in 2014-2015. Despite the UK playing a major role in the response in Sierra Leone, appropriate training in how best to respond to biological incidents is lacking in biomedical and medical science programmes taught in the UK. Therefore, a series of initiatives have been put in place at De Montfort University (DMU) to address this need. We have developed novel teaching sessions aimed at students studying in the UK following our experience as biomedical scientists at the Public Health England (PHE) mobile laboratories built in Sierra Leone during the Ebola outbreak, described in Peña-Fernández & Choi (2016) [1]. These sessions aim to facilitate the acquisition of key competences and skills to protect human health in the aftermath of a biological incident. We initially tested them with DMU medical science students in 2015/16 in which students developed intervention programmes during hypothetical scenarios of Ebola and Zika outbreaks in the UK, using evidence based medicine protocols. Following a high level of student satisfaction, we have made the following improvements that will be tested in 2016/17: 1) the possible creation of a practical element that includes developing a mock-mobile isolator, so students can learn how to work with this critical equipment to manage highly contagious clinical samples necessary to make a diagnosis; 2) the development of a new workshop in which final year students from both degrees will develop an intervention programme to deal with the emerging disease Crimean-Congo haemorrhagic fever that has recently threatened different EU countries such as Spain this summer 2016. Peer teaching and peer group interaction will be used to enhance students' revision of these topics and overcome current limitations of time in the delivery of these teaching sessions. Learning through peer-to-peer interaction has shown to improve student engagement and improve active learning. Students will also be provided with a workbook to help them with the development of this activity. A validated questionnaire has been developed to analyse whether these teaching sessions are successful in providing undergraduate students with the skills necessary to face future biological incidents. This article describes the novel teaching sessions developed so far that might be adopted in other related human health degrees to teach key competences necessaries in the aftermath of a biological incident to protect human health.

Keywords: Haemorrhagic virus, biological incidents training, field experience, evidence-based public health.

1 INTRODUCTION

Biological incidents and outbreaks are natural, accidental or deliberate events that involve the release of biological agents [2]. Serious biological incidents present an enormous challenge to the health care sector as they can affect a large number of people, overwhelming not only the medical personnel and other first responders, but also the health care system [3,4]. In addition, biological incidents can be geographically widespread affecting multiple countries [2], so often require national and international collaboration to avoid high levels of morbidity, mortality and public distress. Medical disaster responders and other health care responders require highly specialised training to quickly identify the biological hazard and access the relevant information to inform their decisions to respond to the biological incident [4]. However, although biological incidents have become increasingly prevalent [5], literature reviews have shown that insufficient training is provided in Europe to face future crises,

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particularly amongst clinicians and other health care professionals that would be part of the initial response [6].

To address this need, an innovative teaching group at De Montfort University (DMU) in the UK and at other European universities such as University of Alcalá (Madrid, Spain) in conjunction with virologists and biomedical scientists with experience from the field during the recent Ebola outbreak affecting West Africa are in the process of developing appropriate training for human health science students [7]. Although our teaching project it is at a very preliminary stage, we have initially developed novel classes to train students how best to respond to biological incidents and tested these with final year undergraduate students studying Biomedical and Medical Sciences at DMU [1]. This teaching experience received very positive feedback from the students and we are delivering the training during the academic course 2016/17 to the following three programmes: BSc Biomedical Science (Hons) and BMedSci Medical Science (Hons) degree programmes and the MSc. Advanced Biomedical Science.

With a view to improving the course further, we have considered the introduction of a practical element based on working with an isolator, which is an essential piece of protective equipment for handling biological agents such as Ebola virus. Working with an isolator would facilitate the acquisition of core competences that any medical or biomedical scientist should have in responding to biological incidents identified by Peña-Fernández et al. (2016) [7]. Specific competences that would easily be taught through using an isolator include 1.) safety and personal protective equipment (*e.g.* demonstrate an understanding in principles and methods of safety, personal security and integrity of medical/biomedical scientists that are dealing with a biological agent), and 2.) planning and organisation of an intervention programme (*e.g.* demonstrate proficiency in identifying basic consumables and resources that would be necessary in laboratories that are working in response to stop the spread of highly contagious microorganisms). Owing to the fact that access to appropriate isolators may be challenging due to cost, availability, and the large number of students enrolled in these programmes, the use of a mock-isolator may be useful. In this report, we present information to develop a mock-isolator using commonly found materials, based on our previous experiences of designing, building and using a mock-isolator to demonstrate staff at an Ebola Treatment Centre (ETC) in Sierra Leone (West Africa) how to manage highly contagious clinical specimens in order to diagnose Ebola and other fatal diseases. By developing this resource, students will participate in their own learning as well as learning how to work with this critical equipment to manage contagious human samples necessary to make a diagnosis as part of the response to any biological incident or outbreak.

Other improvements include the creation of two new workshops, one designed for final year undergraduate students (enrolled in both programmes, *i.e.* BSc and BMedSci) and one for postgraduate students, in which they need to develop an intervention programme to deal with the emerging disease Crimean-Congo haemorrhagic fever that has affected Spain recently and threatened different European Union (EU) countries [8,9].

Here, we summarize the work-flow in the Ebola Diagnostic Lab and the staff training presentation we gave, describing the mock-isolator in more detail so any academic can adapt it to include in their teaching. Finally, we describe how this can be applied to teaching students in the UK.

2 WORKING IN AN ISOLATOR AT THE EBOLA MOBILE LABORATORY

Ebola virus is transmitted directly by contact with patient bodily fluids such as blood [10], and indirectly by contact with objects or surfaces contaminated with Ebola virus [11]. Thus, all the clinical samples (blood, sputum, semen, vaginal swabs and breast milk) used to diagnose Ebola and other infectious diseases such as malaria that were received at the Ebola diagnostic laboratory at the ETC were in three sealed containers to avoid exposing laboratory personnel to potentially infectious material. In the laboratory, the outer container was removed following bleach-treatment, but the other two containers were not opened until they were inside a flexible film isolator (Figure 1). The isolator is a useful tool to prevent direct contact with bodily fluids or clinical samples when managing and preparing them for diagnosis, and its use was necessary to prevent exposure of laboratory personnel as they wore surgical scrubs rather than the extensive personal protective equipment (PPE) worn by the staff who came into contact with potentially infected patients.

Figure 1. *The real isolator. The pass box is shown to the right, and the sleeved gloves are shown.*

The sample was fully opened in the isolator and a small volume was chemically inactivated with a viral lysis buffer. Once this step had been completed, it was safe to pass the inactivated sample back out of the isolator for downstream processing which involved heat treatment, nucleic acid extraction, purification and amplification by quantitative polymerase chain reaction (Figure 2). All containers were disinfected with 5000 ppm sodium hypochlorite upon entry and exit of the isolator as this disinfectant has been described as successful with the Ebola virus [11]. The isolator consisted of two chambers: a large main work area, and a smaller pass box. Two doors were present, one from the outside into the pass box, and one from the pass box into the main work area. Both doors were to remain closed while working in the isolator and only opened to pass materials into or out of the isolator, and then only one door was to be opened at a time. Two *marigold* rubber gloves in heavy-duty plastic sleeves were present in one side of the isolator, and laboratory personnel placed their already gloved hands into these sleeves to gain access to the main work area. A final latex glove was applied to the outside of the rubber glove before commencing lab work. At the beginning of the day, it was necessary to integrity-check each isolator and patch any holes. At the end of the day, it was necessary to fully decontaminate the isolator.

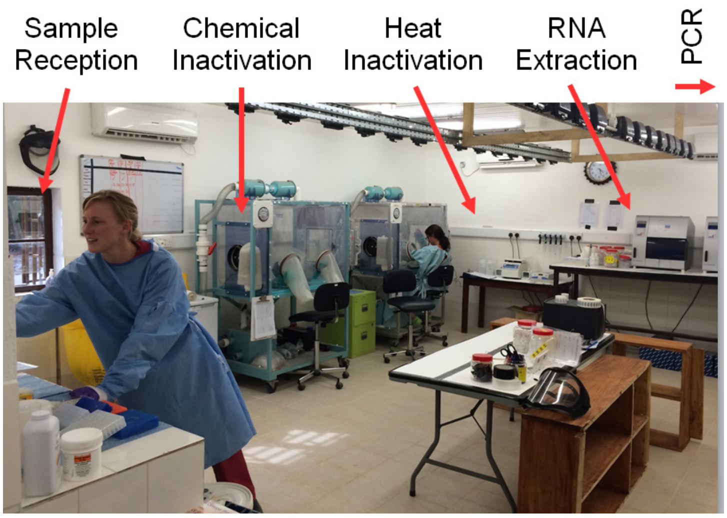

Figure 2. Picture that described the downstream processing for analysing EBOV in clinical samples at the Ebola laboratory (Peña-Fernández and Choi, 2016) [1].

2.1 *“Mateneh wants to learn”* training at the ETC in Makeni (Sierra Leone)

A range of local staff and personnel from different backgrounds worked at the ETCs built in Sierra Leone to cover work that was critical for the maintenance of the centre and to provide a good and robust public health service. Most of the local staff (*e.g.* people that worked at the laundry and the delivery of the samples, security, pharmacists, nurses, Ministry of Health laboratory technicians, Laboratory Liaison Officers, volunteers, etc.) had no previous experience working in a high containment laboratory, or with isolators. They were unfamiliar and curious with how the diagnostic laboratory processed the samples and diagnosed Ebola virus disease. In addition, whereas malaria diagnosis was performed rapidly and a result obtained quickly, Ebola diagnosis took several hours and people did not understand why. Moreover, some samples that arrived at the laboratory were inappropriately packaged for safe and efficient diagnosis, for example the presence of sharps in with the sample, or open or leaking sample containers. It was decided that the lab team should give a short presentation about how the Ebola mobile laboratory worked to process these highly contagious samples to inform the ETC’s non-lab staff and other health responders with three main aims:

- to inform them about the steps involved in Ebola diagnosis in the laboratory including the biosafety precautions that needed to be taken,
- to help people understand how long Ebola diagnosis took to manage expectations of the timing of results,
- to enable the people involved with sample collection to understand what happened to the sample, and why it needed to be packaged in a certain way, so they could provide appropriate samples in the future. This is critical to minimise the risks for the biomedical scientists working at the laboratory.

An educational programme for all workers at the Mateneh ETC near Makeni named “*Mateneh wants to learn*” was in existence, and in August 2015, the laboratory team gave a presentation as part of this seminar series.

The presentation described a step-by-step guide of how we diagnosed Ebola, emphasizing the safety requirements of the lab, and of the samples that entered the laboratory, and the timing of the different steps (Figures 3A and 3B).

Figure 3A and 3B. *The Ebola presentation and the audience.*

As described above, the audience consisted of physicians and nurses, as well as many workers who did not have a medical education, although through the seminar series, they learnt about the Ebola disease, the routes of infection, safety precautions and disinfection techniques, etc. We took into account the background level of knowledge of our audience and adapted the extent and complexity of our presentation accordingly. All the staff, both those with and without medical training, followed the presentation and were keen to learn more about our work, as evidenced by a good series of questions afterwards.

2.2 Development of the mock isolator for training purposes at the ETC

In order to better illustrate our work as biomedical scientists and demonstrate the use of the laboratory equipment, we wanted to go beyond a Powerpoint presentation and provide a practical demonstration using the laboratory technology. However, for safety reasons it was not possible to bring a real isolator out of the laboratory. Therefore, we decided to build a cardboard mock-isolator using materials we had readily available. The aim of the cardboard isolator was twofold: a) to demonstrate the individual steps we took to diagnose Ebola including the managing of the highly contagious clinical samples and the viral neutralisation; and b) to provide the audience with the opportunity to try it out for themselves, to gain experience working in an isolator, which can be a cramped working environment, with a decreased dexterity associated with working through multiple layers of gloves and procedures.

The cardboard isolator (Figure 4) contained all the important features of the real isolator, which had a main working box complete with gloves inbuilt into the flexible wall, and a smaller pass box that was attached with two doors [one from the outside into the pass box (door 1) and one from the pass box into the isolator (door 2)]. The cardboard isolator was smaller than the original one, due to constraints on the amount of materials available; however, we presented a reduced workflow with fewer samples to compensate.

*Figure 4. The mock isolator used in Sierra Leone for teaching /demonstrating purposes.
The pass box is shown to the left.*

The cardboard isolator consisted of one big and one small cardboard box. The lid of the smaller box served as door 1, whereas door 2 was constructed (Figure 4). Windows were cut into the boxes and covered with transparent plastic sheets obtained from un-used waste bags to represent the transparent flexible film lining of the real isolator. One side of the big cardboard box was left open, to allow the audience to follow the work steps during the presentation. On the opposite site, where the operator sits, plastic candy jar lids were inserted into the plastic sheet, and used to install long gloves, which reached into the cardboard isolator.

Needless to say, we used fake samples in the presentation! For demonstration, we reduced the workflow in the isolator to the most important steps: bringing the sample into the isolator, removing the container and decontamination, transferring the sample into a new tube, and chemically inactivating the sample. After presenting the workflow, the audience had the opportunity to try pipetting in the cardboard isolator.

To retain the clarity of the demonstration, we did not demonstrate the maintenance of the isolator like the integrity checks and decontamination; however, the model would also be useful for such purposes.

2.3 Potential teaching applicability of the mock isolator

We consider that working with isolators should form part of any training to face biological incidents. There are two possibilities for use of isolators in teaching students in the UK. First, real isolators could be used to demonstrate the important features to the students. However, real isolators are not readily available, and are expensive. In addition, it is only possible for one person to use an isolator at any one time. The use of mock-isolators is able to address these issues. In addition, if the students are tasked with designing and building one themselves using readily available materials, they will be engaged in kinaesthetic learning, and be actively thinking about how biological samples would be processed in the real isolator, and the biosafety procedures that need to be in place.

3 CRIMEAN-CONGO HAEMORRAGIC FEVER WORKSHOP

We have developed a new specialised workshop on biological hazards and emergency planning, totalling 2 hours, consisting of two teaching approaches: one mainly theoretical and the other predominantly practical (Figure 5). The main learning objectives of this session were:

- To describe what is a biological hazard
- To learn what biosafety levels are
- To understand the differences between an outbreak of infection and bioterrorism
- To learn how to assessing human health risks in the aftermath of a biological incident
- To understand methods to protect human health against these events such as surveillance and epidemiology
- To learn key steps to prepare and response to biological incidents

The theoretical session was basic to make it generally accessible; active participation and reasoning was sought from the students by formulating questions and analysis. The session was finalised with a short overview of the emerging disease Crimean-Congo haemorrhagic fever which has recently killed two people (including a health care worker) in Spain and that can threat West Europe citizens because of their ways of transmission and infection. The practical part, consisted of the development of a public health intervention programme to protect UK citizens following previous experiences in developing novel training and adopting different pedagogies as highlighted previously by Peña-Fernández and Choi (2016) [1]. The learning objectives and some of the slides used in the practical workshop can be found in Figure 6. Students were divided into small groups of 4 or 5 members and were asked to design an appropriate intervention programme following the decision making process of evidence-based public health [12] to tailor their response. To overcome time constraints of this workshop (2 hours), students were provided with 5 comprehensive articles from the literature that contain appropriate information to develop an appropriate intervention.

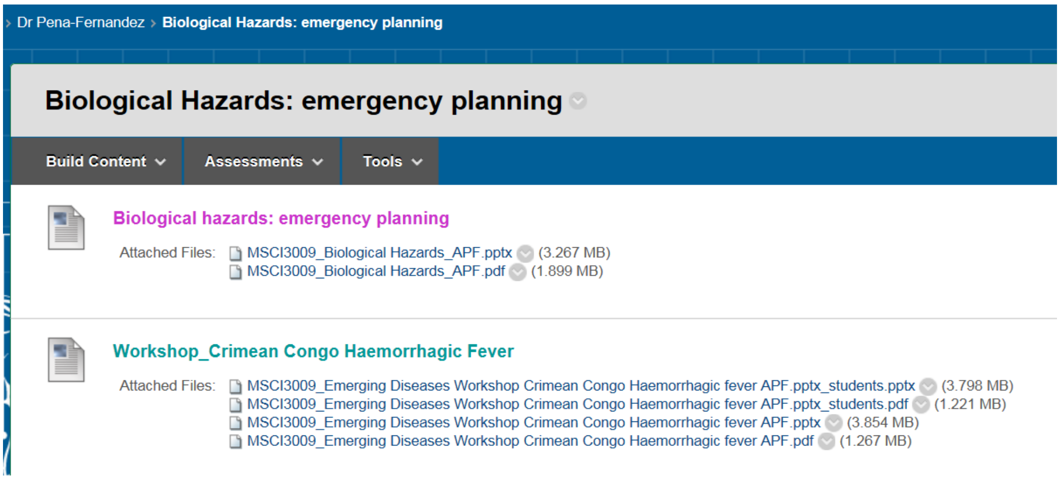

Figure 5. *Screen shot of one of the Blackboard Shell accessible for BMedSci students. Detail of both theoretical and practical teaching resources can be seen in the figure, materials that are freely accessible to DMU students enrolled in this programme.*

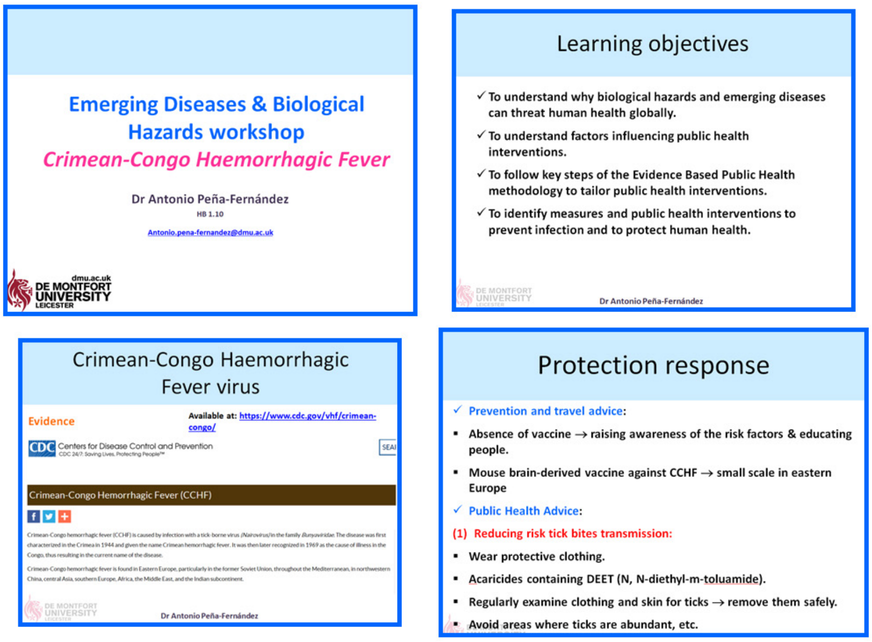

Figure 6. *This box presents summary views of the workshop and slides designed. Picture taken from the Centers for Disease Control and Prevention (CDC) website [13].*

This new training has been tested so far with final year BMedSci Medical Science students enrolled in the module "Clinical Perspectives II" this academic year 2016-17. During the pool of results, active participation and reasoning was sought from the students' groups by formulating questions and analysis, and an understanding of their intervention programme. A validated-feedback questionnaire has been distributed - ethics approval has been provided by the Research Ethics Committee at De Montfort University (Ref. 1729). The feedback questionnaire is a relevant tool to measure the degree of satisfaction of the teaching and learning processes [14]. The preliminary analysis of the survey has revealed a high level of student satisfaction although further analysis will be needed including the co-analysis of the learning experience after performing it in the other two programmes at DMU.

4 CONCLUSIONS

Recent biological incidents such as the Ebola outbreak in West Africa has highlighted the relevance of developing an appropriate international intervention respond to protect the public and minimise the impacts of these severe threats in their aftermath. Appropriate and quick responses will reduce the number of affected individuals, which can be only tailored if there is available infrastructure and equipment, and highly trained health care professionals. Biomedical and medical scientists and other human health graduates can be useful as first responders to biological incidents. Unfortunately, to our knowledge there is a lack of appropriate teaching in any programme in the European Union. Here, we have reported specific and basic training that can be easily incorporated in any university within the "European Higher Education Area" and other countries worldwide, after appropriate modifications or adaptations to their regulations and policies, as part of our teaching project to produce harmonised and adapted training in the EU on how to respond to biological incidents. Finally, further studies will be performed to evaluate the effectiveness and appropriateness of the developed training.

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