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Evaluating basic training for prevention and response to biological incidents
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ABSTRACT
Biomedical scientists were critical of the response to the unprecedented 2014-16 Ebola crisis in West Africa, highlighting the relevance of teaching skills to respond to biological incidents. However, time dedicated to studying these topics in the Biomedical Science degree at De Montfort University was minimal and thus a group of academics and first responders designed training for human health science students on how to respond to biological incidents encompassing basic competences identified by the European Commission. Moreover, curriculum modifications were undertaken in the BSc Biomedical Science Programme in 2016/17 to ensure graduates received comprehensive knowledge regarding emerging diseases, public health and response to biological incidents. The syllabus of the module “Basic Microbiology” was comprehensively revised after expanding the module to 30 credits. The final year module “Medical Microbiology” was also modified to introduce novel training related to response to biological incidents using experience gained in the field during the Ebola outbreak. During this training, final year students (n=121) tailored an intervention programme to respond to an outbreak following an evidence-based public health methodology with 87.1% of the class indicating that they received appropriate knowledge to respond to biological incidents. This novel training could facilitate the acquisition of developed competences to respond to biological events to protect the public.

KEY WORDS: curriculum changes, medical preparedness, biological incidents, response.

1. INTRODUCTION
Biological incidents and outbreaks of infection are natural, accidental or deliberate (bioterrorism) events that involve the release and spread of biological agents or hazards (Brown et al., 2006). Large biological incidents can present an enormous challenge to the health care system and require highly skilled first responders and an appropriate and quick response to protect the public (Ebadi et al., 2015; Lansdowne et al., 2015). Thus, the unprecedented 2014-2016 Ebola epidemic in West Africa highlighted the relevance of implementing applicable, effective, well-coordinated and rapid international intervention responses to reduce the spread of the Ebola virus and protect human health (Bell et al., 2016). Moreover, the occurrence of biological incidents is becoming more prevalent globally. The European Union (EU) has faced recent large water and foodborne outbreaks such as those related to different species of Shiga-toxin-producing Escherichia coli infection in England and Germany (Frank et al., 2014; Launders et al., 2016). Lessons learnt from these events indicate that training on emerging diseases, medical preparedness, global public health and how to respond to biological incidents is increasingly needed to form future health care professionals.

However, literature reviews have shown that insufficient training is provided in Europe to face future crises, particularly amongst clinicians and other health professionals that would be part of the initial response (Djalali et al., 2016). Thus, an internet search for undergraduate degree courses more widely in the United Kingdom (UK) that include biological training, by combining key words such
as “Biological Incidents”, “Module”, “Undergraduate” and “Human Health Science” in the Google search engine did not yield hits for courses that directly address biological incident response as a topic. Thus, to the best of our knowledge, this training is lacking in undergraduate human health related courses in the UK. The search identified two short training courses, but they are offered as highly specific courses specially developed for the public health workforce and they consider a range of hazards including chemical, biological and radiological hazards (Cranfield University, 2017; Defence Academy of the United Kingdom, 2017).

In order to address this lack of training, a group of academics at De Montfort University (DMU, Leicester, UK) with support from EU researchers and academics from other universities (University of Alcalá, Spain) and first responders (biomedical scientists) during the Ebola outbreak in Sierra Leone are developing a training initiative to respond to biological and chemical incidents specifically designed for undergraduate human health science students. Prior to developing this training, we identified and developed basic competences and related skills to train these students following the competences identified by the European Commission (Djalali et al., 2016). Djalali et al. (2016) developed a series of domains with different core competences specifically designed for medical responders to react to chemical, biological, radiological or nuclear emergencies in an EU project entitled Threat Identification and Emergency Response (TIER). Taking into account these domains, we created basic competences for undergraduate human health students and distributed them into six domains (Peña-Fernández et al., 2016): identification of the risk and risk analysis; toxicological effect of biological agents; planning and organisation of an intervention programme; environmental planning; communication and information management; safety and personal protective equipment; societal and ethical reflections. To facilitate the acquisition of these competences, we are creating a series of research-led workshops (training sessions) in which students need to tailor an appropriate and relevant intervention response to protect the public.

This novel training to prepare students to tackle biological incidents was initially tested with students enrolled in the BSc Biomedical Science (BMS) degree programme at DMU due to their relevance as first responders. Thus, biomedical scientists were critical personnel or first responders to react appropriately to the Ebola outbreak in West Africa (Moschos, 2015). Early diagnosis is pivotal to contain the spread of a biological hazard (e.g. the Ebola virus) and for patient care, hence the relevance of a diagnostic or laboratory team in any plan to face a biological incident. The DMU BMS curriculum is delivered over three years (levels 4 to 6). However, dedicated time to study emerging diseases and medical preparedness, which are critical to respond to biological incidents, was minimal and limited to two 15 credit modules focused on general/medical microbiology (level 4 and 6 modules). The syllabuses for this programme are accessible through the DMU website (2016). We have implemented a series of changes in the curriculum, specifically around the syllabus of the two aforementioned modules. A description of these changes is provided below.

The objectives of this paper are: a) to determine if the novel training created met its immediate goals to impart knowledge and basic skills to initially address biological incidents; b) to identify the strengths and weaknesses of the training; c) to assess the impact on students following changes in the curriculum.

2. METHODS
A series of important modifications were undertaken in the BMS programme in 2016/17 to ensure that our graduates received comprehensive knowledge to respond to outbreaks of infection (or other
biological incidents). The syllabus of the level 4 module “Basic Microbiology” was comprehensively revisited after expanding this module to 30 credits. Important new topics were introduced in this first year module related to viral infectious diseases, helminths and fungi. The final year BMS module “Medical Microbiology” (level 6) was also intensively modified to introduce lectures in relation to water- and foodborne emerging diseases (e.g. *Cyclospora*, microsporidia), neglected diseases that can impact large groups of individuals around the world (e.g. Chagas disease) and the specific novel training to respond to biological incidents. To make these changes to the curriculum we took into account the subject-specific threshold standards described by the Quality Assurance Agency for Higher Education (QAA, 2015).

The novel training programme was designed and created following experience from the field in Makeni, Sierra Leone during the Ebola outbreak in West Africa in 2015-16. Thus, our teaching group was enhanced with biomedical scientists and virologists that were deployed during the UK response to the West African Ebola epidemic to work in the Public Health England (PHE) managed laboratories in Sierra Leone (Peña-Fernández and Choi, 2016). These first responders also received comprehensive training from the Novel and Dangerous Pathogens Training group at PHE, Porton Down, UK (Logue et al., 2017).

2.1. Context and participants

This was a qualitative and quantitative study carried out from October 2016 to May 2017. Participants involved in this study were undergraduate students enrolled in the compulsory modules Basic Microbiology and Medical Microbiology of the BMS degree programme at DMU. This programme is accredited by the UK Institute of Biomedical Science. A total of 196 students were enrolled in the first year and 121 were studying in their final year.

2.2. Instruments

To evaluate the curriculum changes implemented in both modules to improve students’ awareness of emerging infectious diseases and the relevance of responding to biological incidents, we collected general feedback through the interim module level feedback survey. This survey required of all undergraduate modules in the programme and is aimed at gathering student perceptions of various aspects of module delivery and content using a Likert scale and free form response questions. The ‘interim module level feedback survey’ is made available to students through the Blackboard virtual learning environment and is administered approximately halfway through a module to enable early feedback and as necessary a pro-active response to module-related issues. This interim module survey has the capacity to include module–specific questions as well as generic questions and thus provided a convenient tool to gain feedback across the cohort regarding the novel training.

To determine the effectiveness of the training implemented in Medical Microbiology in facilitating the acquisition of the basic competences created to respond to these incidents, we used qualitative and quantitative methods. Thus, we analysed the students’ performance during the research-led workshop (training) and their level of interaction and engagement in this activity. Moreover, we distributed a validated feedback-questionnaire to evaluate the level of student satisfaction and interest in this novel teaching initiative as well as on the resources and workshops performed. The questionnaire had a series of questions related to the training and its context in the module for which each student could select a different degree of agreement (Likert scale). The questionnaire also contained open-questions (free-response) so the students could comment on their overall experience and suggest future
improvements. Students were informed about the project and that the anonymous data provided could be used in a study, so written approval from participants was obtained. The use of feedback-questionnaires is an appropriate tool to measure the degree of satisfaction of the teaching and learning processes (Peña-Fernández et al., 2015). The students’ feedback would also be used to make appropriate modifications to this training. Ethical approval was provided by the Research Ethics Committee at De Montfort University (Ref. 1729).

2.3. Process

The novel training consisted of two teaching approaches (totalling 3 hours): one mainly theoretical and the other predominantly practical. Briefly, students were provided with a 2 hour lecture regarding emerging diseases and an overview of the international response to tackle the Ebola pandemic in West Africa. The research-led workshop (practical part, 1 hour long) consisted of the development of an intervention programme for an outbreak scenario related with a potential emerging pathogen that can affect the UK. The chosen case scenario was related to the Crimean-Congo haemorrhagic fever virus which is currently threatening countries in Western Europe (England et al., 2016). Moreover, this haemorrhagic fever virus is spreading globally affecting different countries such as Africa, Asia and Europe, so students could gain an understanding of the relevance of global public health. The workshop was delivered over two sessions due to the large number of students (n=121), but the same methods were followed in both sessions. Within each session, students were additionally and randomly divided into small groups (maximum 10 students per group) to encourage participation and because team-based learning has been shown to facilitate acquisition of knowledge (Emke et al., 2016). Each mini group followed an evidence-based public health methodology (Brownson et al., 1999) to develop an appropriate intervention plan to respond to the proposed scenario, a plan that had to have a range of measures for protection, preparedness and intervention. To overcome time constraints of the practical element (1 hour), students were provided with scientific papers and information to inform their decisions to develop their plan at least one week before the session so they could prioritise programme options. Groups showed their intervention programme to the classroom by selecting a presenter or “peer teacher” in each group (Benè KL. and Bergus G., 2014). Each peer teacher provided a rationale for each measure considered and discussed why their intervention was appropriate and effective in addressing the proposed scenario. In this session, active participation and reasoning were sought from students by formulating questions; all students participated in selecting the most effective intervention for the scenario, responses that were used to identify the level of understanding of the workshop. This methodology was useful to clarify erroneous knowledge or misinformation. More information about the preliminary teaching materials created can be found elsewhere (Peña-Fernández and Choi, 2016; Peña-Fernández et al., 2017).

3. RESULTS

In relation to the modifications made in both modules in the BSc Biomedical Science programme students reported high levels of satisfaction in both modules through interim module level feedback. 39 (20% response rate) students completed the interim module level feedback survey for Basic Microbiology and 27 (22% response rate) for Medical Microbiology. Only 2.7% and 7.4% of the students indicated that they were not enjoying the modules of Basic and Medical Microbiology, respectively. Up to 82% of participants in this survey indicated that academics made Medical Microbiology interesting.
Table 1. Responses (%) to the feedback-questionnaire to evaluate the novel training implemented in Medical Microbiology (BMS, DMU) to face biological incidents.

<table>
<thead>
<tr>
<th>Response</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content was relevant to the module</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>48.4</td>
<td>51.6</td>
</tr>
<tr>
<td>Duration of the workshop was appropriate</td>
<td>0</td>
<td>3.2</td>
<td>3.2</td>
<td>51.7</td>
<td>41.9</td>
</tr>
<tr>
<td>Enjoyed the exercise</td>
<td>0</td>
<td>3.2</td>
<td>19.3</td>
<td>45.2</td>
<td>32.3</td>
</tr>
<tr>
<td>Workshop was easy to understand</td>
<td>0</td>
<td>9.7</td>
<td>3.2</td>
<td>41.9</td>
<td>45.2</td>
</tr>
<tr>
<td>Materials provided helped me to complete the case scenario</td>
<td>0</td>
<td>6.4</td>
<td>9.7</td>
<td>38.7</td>
<td>45.2</td>
</tr>
<tr>
<td>Gained an appropriate knowledge of public health prevention and preparedness against a biological incident</td>
<td>0</td>
<td>3.2</td>
<td>9.7</td>
<td>54.8</td>
<td>32.3</td>
</tr>
<tr>
<td>Learnt how to investigate an outbreak</td>
<td>0</td>
<td>3.3</td>
<td>20</td>
<td>56.7</td>
<td>20</td>
</tr>
<tr>
<td>Learnt how to establish basic interventions to protect human health in the aftermath of a biological incident</td>
<td>0</td>
<td>3.3</td>
<td>6.7</td>
<td>66.7</td>
<td>23.3</td>
</tr>
<tr>
<td>Satisfied with the workshop provided</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>56.7</td>
<td>33.3</td>
</tr>
<tr>
<td>Knowledge learnt in this training will help me in my future career</td>
<td>6.7</td>
<td>3.3</td>
<td>30</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Recommend the incorporation of similar training within the BMS programme</td>
<td>0</td>
<td>0</td>
<td>26.7</td>
<td>43.3</td>
<td>30</td>
</tr>
</tbody>
</table>

We also compared student satisfaction with the last academic year. The most significant increase was observed in the Basic Microbiology module that showed a significant increase of student satisfaction from 20% in the 2015/16 academic year to 64% in the current academic session. Students reported that “the topics are very interesting to learn about”.

The results obtained in the feedback questionnaire used to analyse the novel training implemented in Medical Microbiology are described in Table 1 above. Only 62 out of the 121 students completed the questionnaire appropriately (51% response rate), and only these latter questionnaires were used in this study. Questionnaires that were only partially completed were discarded.

A more detailed analysis of the feedback questionnaire and particularly the free-response questions gave the following results: most students commented on “a very good workshop” or “very interesting session”: limitations highlighted by students in this section of the questionnaire were related to the short time to tailor the intervention plan and the large number of articles provided to inform their decisions (although this was not recorded in the fixed questions as only 3.2% of the participants indicated disagreement with the duration of the project, Table 1).

Comments or suggestions to improve the training reported by students involved dividing the session to deliver it as shorter duration sessions or in two sessions rather than one. Other comments...
cluded the use of more pictures, photographs or videos when describing the international response implemented in Sierra Leone in the theoretical part of the training.

4. DISCUSSION AND CONCLUSIONS

Despite the need to evaluate final module level feedback in both modules (which will be available by the end of May 2017) and the very low rate of response in these module surveys, we consider that the small curriculum changes undertaken have increased the level of engagement and satisfaction of our students. This could be attributed to numerous factors including the novelty of some of the sessions (e.g. regarding the UK response during the Ebola outbreak in West Africa) and the incorporation of more topics and further sessions that have been translated into an increase of students’ knowledge in microbiology, parasitology and global public health. Thus, we have detected an increase of student participation and engagement in some of the novel sessions incorporated such as those dedicated to emerging parasites (e.g. free-living amoebas) or when discussing the relevance of responding to biological incidents, even though they are occurring and impacting other countries/populations far from the UK or the EU. Moreover, students showed high levels of interest during the lectures related to responses to previous biological incidents and they were concerned about bioterrorism when this was described and discussed. This is in agreement with other authors that have reported high levels of engagement and interest in these topics (Gershon et al., 2004; Pollard et al., 2015). However, further analysis will be needed, especially to determine if changes undertaken in the first year module will be translated into having more knowledgeable students in the final year module of Medical Microbiology in two years’ time.

The research-led workshop or training, for its part, was well-received by BMS students, as evidenced by their favourable evaluation. Participants showed high levels of engagement as shown in Table 1: 77.4% of students enjoyed the research-led workshop (45.2% agreed & 32.3% strongly agreed), only 3.2% reported that they did not enjoy it. This could be attributed to the novelty of the teaching session and/or topic, the use of the classroom during the training or because a small percentage of students found the workshop difficult. Thus, some students (9.7%) highlighted that the workshop was difficult to understand (Table 1). We consider that one of the major challenges facing students during this training was to extract information from the literature to inform their decisions when tailoring the plan, a factor that could explain the above percentages reported in Table 1. This could be easily addressed by providing more time to complete the practical part of the workshop, a solution that was also pointed out by the participants in the free-open questions.

Students unanimously agreed that the content of this training was relevant to the module (48.4% agreed and 51.6% strongly agreed) although students demanded more time to complete the case scenario. The high level of engagement in this training session was also highlighted by the fact that most participants (73.3% agreed/strongly agreed; 26.7% neither agree/disagree; 0% disagree) would recommend the incorporation of similar training and/or initiatives within their programme (Table 1).

The training, although limited in time, was effective in facilitating the acquisition of some of the basic competences/skills required by future health care professionals to respond to biological incidents developed by our group (Peña-Fernández et al., 2016), particularly those related with the following domains: planning and organisation of an intervention programme; communication and information management; safety and personal protective equipment and societal and ethical reflections. Thus, 90% of students felt “confident” with being able to implement a basic intervention plan to protect humans in the aftermath of a biological incident or an outbreak of infection (54.8% agreed & 32.3%
strongly agreed; Table 1). Students also indicated that they gained public health knowledge and were able to understand the UK response and preparedness to biological incidents. This is highlighted by the fact that 87.1% of students have indicated that they received appropriate knowledge of public health prevention and how to respond to biological incidents (54.8% agreed & 32.3% strongly agreed; Table 1). Our results are in agreement with other authors that have demonstrated that even very short courses (3 hours) can improve knowledge, attitude and skills regarding biological incidents (Gershon et al., 2004; Parrish et al., 2005).

Moreover, the training described could also facilitate the acquisition of relevant transversal competences for biomedical science students such as critical thinking, research skills (e.g. analysing and understanding research articles), communication and teamwork, evidence-based skills, etc. The possible success of this training in delivering transversal competences has been also observed when we implemented similar training with Medical Science students in the 2016/17 academic course (Peña-Fernández et al., 2017).

Regarding the methods and materials used, evidence-based public health (EBPH) has shown to be effective in facilitating students to develop their plan. EBPH could also facilitate students to become more efficient responders that rely on evidence in order to protect the public in the aftermath of a biological incident, although more studies are needed to fully understand the possible beneficial role of introducing this methodology in this training. Additionally, EBPH can facilitate the development of applicable, appropriate and effective interventions (Jacobs et al., 2012). Therefore, any intervention plan to tackle any biological incident should rely on the evidence rather than on the basis of political or other factors.

The use of peer-teachers when discussing each group plan and working in teams has also provided a dynamic learning environment that resulted in a high degree of acceptance by students (almost 90% agreed/strongly agreed; Table 1). Students also indicated that enough materials and resources were provided to complete the exercise (38.7% agreed & 45.2% strongly agreed; Table 1).

Finally, the introduction of the experience from first-hand biomedical scientist responders during the 2014-2016 Ebola outbreak and the lessons learned during the international response to this large biological incident has also been shown to facilitate and enhance students’ learning and interest. This has been highlighted by students in the interim module level feedback survey as well as in the free-response questions, in which students demanded more related lectures/tutorials with this topic and showing more photographs and information about the response provided at the PHE Ebola laboratories in Sierra Leone.

In conclusion and on the basis of our experience thus far, the training created could facilitate the acquisition of basic competences to respond to biological events to protect the public. To our knowledge, this is the first report that describes an attempt to introduce basic training to respond to biological incidents in a biomedical science programme. We believe that the effectiveness of this training was due to a combination of different disciplines (microbiology, epidemiology, medical preparedness, evidence based public health, behavioural science) and collaboration with first responders as no single discipline can manage the complex issues raised in a major biological incident. The methods and training reported here could be easily adapted and introduced into other health science programmes as a short training or brief educational programme on responding to biological incidents. Basic training for undergraduate human health students to respond to these crises has become very relevant in current society to protect the public.
5. REFERENCES


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