Rosabel Roig-Vila (Ed.)

Investigación en docencia universitaria

Diseñando el futuro a partir de la innovación educativa
Investigación en docencia universitaria. Diseñando el futuro a partir de la innovación educativa

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Implementation of chemical incident training in human health programmes

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ABSTRACT

The release of chemicals or chemical incidents can have dramatic consequences on human health and the environment. Health care professionals can provide invaluable help to respond to these events but appropriate training is limited in human health degrees in the European Union. Academics from De Montfort University (DMU, UK) and the University of Alcalá (UAH, Spain) are developing training to provide basic skills to future professionals to respond to chemical incidents. We comprehensively modified a successful previous training programme tested with pharmacists at UAH and created two research-led workshops with different levels of difficulty for the 2016/17 course at DMU: basic for Medical Science bachelor degree students; the other more specialised for Advanced Biomedical Science Master’s students. The basic training consisted of selecting public health interventions to control urban environmental contamination. Master’s students developed a complete plan to respond to a chemical incident including remediation of the environment using the novel recovery tools developed by Public Health England (UK). All undergraduate students highlighted that they learnt how to identify public health interventions to protect the public and 84% of the Master’s students reported that they learnt how to tailor an appropriate recovery programme. The research-led workshops, methods and tools used facilitated the acquisition of skills to respond to future minor scale chemical incidents.

KEY WORDS: chemical incidents, training, decontamination, environmental recovery.

1. INTRODUCTION

Chemicals are necessary for the economy and human progress. However, the release of chemicals or chemical incidents (accidental, natural or deliberate) can have dramatic consequences on human health and the environment (Duarte-Davidson et al., 2014; Young et al., 2015). Environments affected by chemicals can increase the morbidity and mortality of associated populations and they require interventions to protect public health (Wyke et al., 2014). Incidents involving chemical agents are infrequent but the probability of them happening is increasing due to advances in technology and a threat from terrorism (Carter and Amlôt, 2016). Recent examples of chemical incidents include the Toledo tyre landfill fire in Spain in 2016, which resulted in an increase of cancer risk for the local population due to an increase in the airborne levels of polycyclic aromatic hydrocarbons (Nadal et al., 2016). Deliberate incidents include the recent use of chemical warfare agents in Syria (Hakeem and Jabri, 2015; Zarocostas, 2017).

Health care professionals can provide invaluable help to respond to chemical incidents. However these events can significantly impact health care systems, resources and capabilities (Shumate et al., 2017; Hsu et al., 2017). Different studies have identified national weaknesses in dealing with these events (Duarte-Davidson et al., 2014) such as a lack of appropriate preparedness, capability, capacity
and/or resources of the emergency medical services in different countries: Finland (Jama and Kuisma, 2016), The Netherlands (Mortelmans et al., 2017) or various states in the United States (Belsky et al., 2016). Thus, emergency response planning and the establishment of an appropriate network of experts to respond adequately and quickly to these events is urgently required, as rapid, well-co-ordinated responses will minimise morbidity and mortality in the affected population (Jama and Kuisma, 2016).

Experts or first responders to chemical incidents should receive appropriate and specialised training (Madar et al., 2017), however literature reviews have shown that insufficient training is provided in Europe to address future crises (Djalali et al., 2016). Similarly, this training is lacking elsewhere in undergraduate courses in the UK. Thus, we undertook a web-based, non-systematic search for chemical response training in human health undergraduate programmes in the UK, by combining key words such as “Chemical Incident”, “Module”, “Undergraduate”, “Recovery and Remediation” and “Human Health Degree” using the Google™ search engine. To the best of our knowledge, there are no undergraduate courses in the UK that directly address this topic. However some training at postgraduate level is starting to be provided by a few universities although they are mostly related to a specific type of incident, discipline or targeted for the workforce. There are postgraduate courses that provide training on chemical incident management from an environmental point of view (University of Birmingham, 2017), and another related to epidemiology and health protection (University of Nottingham, 2017). Cardiff Metropolitan University (2017) also offers Master’s level training in the management of public health emergencies but it is highly specialised for particular events such as marine disasters.

Moreover, chemical incidents require a complete intervention programme that also considers the decontamination and restoration of the impacted environment(s) (Wyke et al., 2014). Environmental recovery and restoration is critical to protect human health but specific guidelines to help responders to develop an effective response to restore the environment to pre-incident status in the aftermath of a chemical event have been created only recently (Peña-Fernández et al., 2014; Wyke et al., 2014). Thus, Public Health England (PHE) has developed novel methodology and guidance to recover environments affected by chemicals that can be found in the UK Recovery Handbook for Chemical Incidents (Wyke-Sanders et al., 2012).

In order to address the lack of training in undergraduate human health programmes, academics from De Montfort University (DMU, Leicester, UK) are developing novel teaching strategies to provide training in emergency response, public health and environmental decontamination/restoration in the aftermath of a chemical incident in collaboration with the University of Alcalá (Spain). This novel training was implemented in two taught programmes related to human health this current academic course (2016/17) at DMU: the BMedSci Medical Science degree and the MSc. in Advanced Biomedical Science. To create this training programme we followed previous successful experience at UAH to create novel training (Peña-Fernández et al., 2015). Moreover, we developed basic competences that any health care professional should acquire to respond to chemical incidents to protect human health including: planning and organisation of an intervention programme; communication of risks; protective equipment; and societal and ethical considerations (Peña-Fernández et al., 2016). These basic competences created by our group were based on the core competences that medical first responders should have to face chemical, biological, radiological and nuclear (CBRN) incidents identified by the European Commission for CBRN Threat Identification and Emergency Response known as TIER (Djalali et al., 2016). Finally, we also included basic competences related to environmental toxicology and risk assessment (e.g. identification of the risk and risk analysis; toxicological effect of the chemical...
substances) (Peña-Fernández et al., 2016), as these are key skills and capabilities required to develop an appropriate response to any event involving chemicals.

The objectives of this paper are: a) to determine if the two novel training exercises are successful in providing knowledge and basic skills to respond to chemical incidents; and b) to identify areas of the training that require further development to create more robust basic training that can be adopted in any human health degree.

2. METHODS

We developed novel teaching content and training to deliver the basic competences especially created for future health care professionals to respond to minor scale chemical incidents (Peña-Fernández et al., 2016). To do this, we followed the structure of a previous short educational course created at UAH in 2013/14 to train postgraduate pharmacists in environmental toxicology and environmental recovery of areas impacted by chemicals (Peña-Fernández et al., 2015). We followed this UAH-devised training programme since it produced high levels of student satisfaction and engagement (>88%).

2.1. Context and participants

Our study was carried out from October 2016 to May 2017 at DMU. Participants involved in this study were undergraduate and postgraduate students enrolled in the compulsory level 5 module “Evidence Based Medicine” in the BMedSci degree in Medical Science and the level 7 module “Advanced Topics in Biomedical Science” of the MSc Advanced Biomedical Science programme. The MSc is currently being comprehensively reviewed to be accredited by the UK Institute of Biomedical Sciences. A total of 41 BMedSci students were enrolled in the level 5 module and 9 students in the level 7 module.

2.2. Instruments

We used a qualitative and quantitative approach to determine the effectiveness of both training programmes in facilitating the acquisition of the desired basic competences. The performance and engagement of the class in each workshop was used to gain an understanding of the level of comprehension of the novel training and teaching sessions implemented in both modules. Moreover, we used two validated feedback-questionnaires using the Likert scale (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree) in conjunction with open-questions (free-response), to collect comprehensive information about both teaching initiatives as well as the resources and practical exercises performed. Questionnaires can measure the degree of satisfaction of the teaching and learning processes (Peña-Fernández et al., 2015). Ethical approval was provided by the Research Ethics Committee at DMU (Ref. 1729) and written approval from participants was obtained prior to completion of the questionnaires. Students’ feedback would also be used to appropriately modify the training if required.

2.3. Process

We comprehensively modified our preliminary training (Peña-Fernández et al., 2015) for postgraduate pharmacists and created two research-led workshops (training) with different degrees of difficulty for the 2016/17 course at DMU: one basic and lasting 3 hours for undergraduate students enrolled in the Medical Science degree (BMedSci); the other more specialised and lasting 2 hours for Master’s students attending the MSc. Advanced Biomedical Science programme (MScBMS). To create robust training, a range of new lectures and seminars with different levels of difficulty were also introduced.
on global public health, evidence-based public health, basic environmental toxicology/decontamination and basic response to chemical incidents. Postgraduate students also received comprehensive information about risk assessment, development of appropriate and effective environmental decontamination and recovery responses and response/preparedness to chemical incidents. Brief detail of each of the research-led workshops (training) is provided below.

The basic training, tested with undergraduate students, consisted of developing a complete public health intervention plan to reduce the emissions of lead (Pb) and minimise its presence in urban environments. Lead was selected as the US Centers for Disease Control and Prevention has recommended preventing exposure of children to this metal (CDC, 2011). There is no known safe blood Pb level in children and its exposure can affect nearly every system in the body, particularly the brain and nervous system. Second year BMedSci students enrolled in the module “Evidence Based Medicine” (n=41), working in small teams to encourage participation, developed an intervention programme to prevent exposure of children to Pb in an urban environment in the UK following the steps of evidence-based public health (EBPH; Brownson et al., 1999). EBPH was used as it is a methodology that can facilitate the development of applicable interventions (Jacobs et al., 2012). To inform their decisions, students were provided with information about the toxicology of Pb and a series of articles and reports on previous public health interventions that have been implemented to tackle the environmental problem of this metal (Kim et al., 2015; Leech et al., 2016). Thus, previous successful interventions reported in the literature, such as the ban of use of Pb compounds in gasoline (Kim et al., 2015) were shown to students and discussed during the first hour of the workshop. Once they had identified some public health interventions to tackle the urban environment affected by Pb, the results were pooled and students critiqued the interventions proposed by the different groups. We used this approach to clarify erroneous knowledge or misinformation.

Master’s degree students (n=7) developed a complete protection and remediation response to address the different phases of the chemical incident response (Sandström et al., 2014): preparedness and situation assessment; exposure assessment; acute health effects; long term health effects; and recovery phase. These postgraduate students were provided with a case scenario of a chemical spill impacting a shoreline similar to that described by Peña-Fernández et al. (2015) but with comprehensive modifications to involve two different environments: food production systems and open waters. The chemical spill was related to pharmaceutical drugs that have been described as contaminants of emerging concern on the watch list of substances to monitor in water (Decision 2015/495/EU). Students followed the novel PHE recovery methodology described in the UK Recovery Handbook for Chemical Incidents (Wyke-Sanders et al., 2012) to develop a protection and remedial response for the case scenario proposed. This methodology helps the user to select appropriate protection and recovery options as a function of the physicochemical properties of the contaminant(s) and the characteristics of the environment affected (Wyke-Sanders et al., 2012; Peña-Fernández et al., 2014; Wyke et al., 2014). To facilitate the work, students worked in pairs and to overcome time constraints, students used the new on-line resource “Chemical Recovery Navigation Tool” (CRNT; PHE, 2015), a web-based resource that follows the same methodology and guidance described by Wyke-Sanders et al. (2012) in the above recovery handbook. The physicochemical properties of the pharmaceutical drugs were provided to students in a workbook and they used a template to record their plan (one student controlled the CRNT and the other recorded decisions). Prior to this workshop, postgraduate students received two specialised lectures: one related to environmental toxicology and how to implement a basic risk...
assessment study following the risk assessment methodology developed by the US Environmental Protection Agency (US EPA, 1989); the second lecture was about the importance of remediating environments affected by chemicals using real response situations implemented after serious chemical disasters [the Bhopal incident (Broughton, 2005); the Minamata disaster (Akito et al., 2014); the Aznalcóllar mine spill (Martín Peinado et al., 2015)] and an introduction to the CRNT tool from PHE. Students described their intervention plan to tackle both environments affected and criticise them to select the most applicable.

3. RESULTS

The results obtained in the feedback-questionnaires used to analyse the novel training implemented in BMedSci (with a 63.4% response rate) and MScBMS (100% response rate) are described in Table 1. Some BMedSci participants that only partially completed the questionnaire were not taken into account.

Table 1. Responses to the feedback-questionnaire to evaluate novel chemical incident training implemented at DMU in undergraduate ["Evidence based Medicine" (BMedSci)] and postgraduate ["Advanced Topics in Biomedical Science" (MScBMS)] courses. Survey results are shown as a percentage of all responses.

<table>
<thead>
<tr>
<th>Programme</th>
<th>Content was relevant to the module</th>
<th>Duration of the workshop was appropriate</th>
<th>Enjoyed the exercise</th>
<th>Workshop was easy to understand</th>
<th>Learnt how to protect children from environmental contaminants</th>
<th>Gained an appropriate knowledge of public health prevention and preparedness against a chemical incident</th>
<th>Learnt how to establish basic interventions to protect human health in the aftermath of a chemical incident</th>
<th>Satisfied with the workshop provided</th>
<th>Recommend the incorporation of similar training within the BMS programme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>Disagree</td>
<td>Neither agree nor disagree</td>
<td>Agree</td>
<td>Strongly agree</td>
<td>Strongly disagree</td>
<td>Disagree</td>
<td>Neither agree nor disagree</td>
<td>Agree</td>
</tr>
<tr>
<td>BMedSci</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>76.9</td>
<td>23.1</td>
<td>7.7</td>
<td>38.5</td>
<td>30.7</td>
<td>23.1</td>
</tr>
<tr>
<td>MScBMS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16.7</td>
<td>66.6</td>
</tr>
<tr>
<td>BMedSci</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>61.5</td>
<td>38.5</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>MScBMS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>33.3</td>
<td>50</td>
</tr>
<tr>
<td>BMedSci</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>84.6</td>
<td>15.4</td>
<td>0</td>
<td>0</td>
<td>83.3</td>
<td>16.7</td>
</tr>
<tr>
<td>MScBMS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>83.3</td>
<td>16.7</td>
<td>0</td>
<td>16.7</td>
<td>83.3</td>
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<tr>
<td>BMedSci</td>
<td>0</td>
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<td>0</td>
<td>84.6</td>
<td>15.4</td>
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<tr>
<td>MScBMS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
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<td>0</td>
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<tr>
<td>BMedSci</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15.4</td>
<td>61.5</td>
<td>16.7</td>
<td>61.5</td>
<td>23.1</td>
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<tr>
<td>MScBMS</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16.7</td>
<td>50</td>
<td>0</td>
<td>16.7</td>
<td>50</td>
<td>33.3</td>
</tr>
</tbody>
</table>
Students also recorded some limitations in both training exercises in the free-response questions, mostly related to the amount of information that they needed to process to tailor an intervention in a short time. The BMedSci students also requested more discussion and the use of videos to have a better understanding of environmental toxicology. Limitations highlighted by postgraduate students were similarly related to the amount of information that they needed to process in a short time to develop their plans and the difficulty of the PHE recovery terms.

4. DISCUSSION AND CONCLUSIONS

The basic training implemented in “Evidence Based Medicine” to increase awareness of public health, environmental toxicology and learning how to protect the public against environmental contaminants by implementing basic public health interventions was shown to be effective. Thus, all the participants indicated acquisition of knowledge on how to protect children from environmental contaminants (Table 1); a more detailed analysis of the feedback questionnaire showed that 92.3% of participants were able to establish some public health interventions to tackle environments affected by Pb (7.7% neither agreed nor disagreed, 76.9% agreed and 15.4% strongly agreed; data not provided in Table 1). A similar percentage of students indicated that they understood how to carry out an EBPH study to identify public health interventions.

Moreover, this training seemed to successfully facilitate the acquisition of important transversal competences that are only acquired during scientific research activity such as communication (students were required to communicate their conclusions or intervention plan and the reasons that support them in a clear and unambiguous way), critical thinking (students were requested to apply the acquired knowledge), research/literature searching, team work and problem solving (solve problems in new surroundings related to their study area); skills that are required for effective decision-making (Ribeiro et al., 2016).

Participants showed a high degree of engagement and interaction when discussing the evidence to develop some interventions; in particular, students were concerned about the presence of Pb found in paints used in playground structures in urban parks in the UK (Turner et al., 2016). It is important to highlight that some participants worked in childcare and some had young siblings and relatives.

In relation to students’ satisfaction, 92.3% of BMedSci students (84.6% agreed & 7.7% strongly agreed; Table 1) were satisfied with the workshop but requested more time to complete the exercise to be able to analyse the supporting information more thoroughly to inform their decisions. None of the undergraduate students reported dissatisfaction with the workshop provided (Table 1). Despite the high level of satisfaction in the workshop provided, only 38.5% of the participants indicated that they enjoyed this workshop (61.5% neither agreed nor disagreed). This could be attributed to the novelty of the toxicology and public health topics, as the BMedSci programme is eminently focussed in clinical skills and more medical topics. Thus, up to 69.2% of students described the workshop as easy to understand (30.8% neither agreed nor disagreed) as indicated in Table 1. Interestingly, all participants indicated that the new content taught was relevant to the module (76.9% agreed, 23.1 strongly agreed; Table 1). We consider that this training could be appropriately adapted to make it more engaging to be introduced in any Medical Science programme.

Conversely, MSc students showed an appropriate understanding of the role of risk assessment as a tool to protect humans. Thus, students successfully identified the risks for humans in the case study proposed and suggested possible routes of exposure according to the physicochemical properties of the
They also developed appropriate protection and remediation interventions despite the short time available; students showed a full understanding of the case study proposed during the discussions of each plan. These qualitative observations are in agreement with the students’ feedback provided in the specific questionnaire. Thus, 83.3% of participants indicated that they learnt how to establish basic interventions to protect human health in the aftermath of a chemical incident (16.7% neither agreed nor disagreed; Table 1) and a similar proportion agreed with the statement that they learnt how to develop a recovery plan. Therefore, the novel training developed has been shown to facilitate the acquisition of the basic skills to respond to future small scale chemical incidents. Other authors have demonstrated that short courses (3 hours) can improve the knowledge, attitude and skills regarding unconventional weapons including chemical warfare (Parrish et al., 2005).

However, only 66.7% of the Master’s students indicated that the workshop was easy to understand (33.3% neither agreed nor disagreed, 50% agreed, 16.7% strongly agreed; Table 1). This could be attributed to the difficulty of students in understanding some of the recovery terms used in the PHE recovery tools, which are highly specific, as observed during the teaching session and reported in the open questions in the feedback questionnaire. The difficulty found by some students was not related to the CRNT as all participants indicated that it aided their learning and was easy to use to develop their intervention plan. We consider that the PHE recovery tools and resources are excellent tools that have facilitated the development of this novel training to prepare future health care professionals to respond to chemical incidents.

We also observed that MSc students had little knowledge of environmental toxicology. Toxicology as a subject is mainly offered in postgraduate programmes and only a few undergraduate degrees offer this discipline in their curricula. The introduction of aspects of toxicology and environmental sciences in human health science degrees should be considered, since toxicology provides valuable skills to protect the public against chemical hazards (Gundert-Remy et al., 2015; Wallace et al., 2016). Moreover, some environmental toxicology knowledge will be crucial to tailor appropriate, effective and applicable interventions and responses in the aftermath of a chemical incident. Thus, information about the toxicity of the chemical(s) involved is required for developing a recovery response (Wyke-Sanders et al., 2012; Wyke et al., 2014). A lack of information on the physico-chemical, toxicological and medical aspects of a chemical agent released in an event can affect the response system by challenging different capabilities such as the detection, decontamination, physical protection and treatment methods, resulting in the potential development of minimally effective interventions (Worek et al., 2016). Moreover, environmental and human monitoring are critical to provide objective information to make appropriate decisions in the aftermath of one of these incidents.

Despite the difficulty of some students in performing the research-led workshop previously described, the feedback has revealed high student satisfaction in our training (100%; Table 1). Also, 83.3% of students recommend the incorporation of chemical response training in their programme and all of them considered it relevant (Table 1).

In conclusion, the research-led workshops, methods and tools described in this paper can be considered a first attempt to develop and introduce basic training to human health students to respond to chemical incidents and environments impacted by chemical agents. Both novel training exercises have been shown, respectively, to facilitate the acquisition of skills to tailor public health interventions and a complete intervention plan, respectively to face future minor scale chemical incidents.
5. REFERENCES


