

Undergraduate teaching on biological weapons and bioterrorism at medical schools in the UK and the Republic of Ireland: results of a cross-sectional study

Stephen T Green,¹ Lorenzo Cladi,² Paul Morris,¹ Donall Forde¹

To cite: Green ST, Cladi L, Morris P, *et al*.

Undergraduate teaching on biological weapons and bioterrorism at medical schools in the UK and the Republic of Ireland: results of a cross-sectional study. *BMJ Open* 2013;**3**:e002744. doi:10.1136/bmjopen-2013-002744

► Prepublication history for this paper is available online. To view these files please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2013-002744>).

Received 17 February 2013
Revised 26 April 2013
Accepted 29 April 2013

This final article is available for use under the terms of the Creative Commons Attribution Non-Commercial 2.0 Licence; see <http://bmjopen.bmj.com>

¹Infection and Tropical Medicine, Royal Hallamshire Hospital—Sheffield Teaching Hospitals, Sheffield, South Yorkshire, UK

²Politics, Languages and International Studies, University of Bath, Bath, Somerset, UK

Correspondence to

Dr Stephen Green;
idthphysician@hotmail.co.uk

ABSTRACT

Objective: To determine if individual undergraduate schools of medicine in the UK and the Republic of Ireland provide any teaching to medical students about biological weapons, bioterrorism, chemical weapons and weaponised radiation, if they perceive them to be relevant issues and if they figure them in their future plans.

Design: A cross-sectional study utilising an internet-based questionnaire sent to key figures responsible for leading on the planning and delivery of undergraduate medical teaching at all schools of medicine in the UK and Ireland.

Setting: All identified undergraduate schools of medicine in the UK and Ireland between August 2012 and December 2012.

Outcome measures: Numerical data and free text feedback about relevant aspects of undergraduate teaching.

Results: Of the 38 medical schools approached, 34 (28 in UK, 6 in Ireland) completed the questionnaire (89.47%). 4 (all in UK) chose not to complete it. 6/34 (17.65%) included some specific teaching on biological weapons and bioterrorism. 7/34 (20.59%) had staff with bioterrorism expertise (mainly in microbiological and syndromic aspects). 4/34 (11.76%) had plans to introduce some specific teaching on bioterrorism. Free text responses revealed that some felt that because key bodies (eg, UK's General Medical Council) did not request teaching on bioterrorism, then it should not be included, while others regarded this field of study as a postgraduate subject and not appropriate for undergraduates, or argued that the curriculum was too congested already. 4/34 (11.76%) included some specific teaching on chemical weapons, and 3/34 (8.82%) on weaponised radiation.

Conclusions: This study provides evidence that at the present time there is little teaching at the undergraduate level in the UK and Ireland on the subjects of biological weapons and bioterrorism, chemical weapons and weaponised radiation and signals that this situation is unlikely to change unless there were to be high-level policy guidance.

ARTICLE SUMMARY

Article focus

- Do undergraduate medical students in the UK and the Republic of Ireland currently receive any formal teaching on biological weapons and bioterrorism?
- What are the reasons for the approach taken?
- Do undergraduate medical schools in the UK and the Republic of Ireland have plans regarding future teaching and training to educate about biological weapons, bioterrorism and other aspects of weapons of mass destruction studies?

Key messages

- Medical schools in the UK and the Republic of Ireland currently spend little if any time on the teaching of this subject area to medical undergraduates.
- In general, they have few or no plans to increase the level of attention they will pay to these issues in the future.
- An absence of official advice is in part a major factor behind this stance.

Strengths and limitations of this study

- This is the first study in either the UK or the Republic of Ireland to look at this issue.
- The response rate was very high.
- Not all medical schools provided responses to all questions, and the reasons for this are not known.

INTRODUCTION

The United Nations has stated that ‘...terrorism continues to inflict pain and suffering on people’s lives all over the world’ and ‘...almost no week goes by without an act of terrorism taking place somewhere in the world’.¹

In the USA, following the 9/11 terrorist events of 2001, the Association of American Medical Colleges urged medical schools

across that country to ensure that medical students were taught about biological weapons and bioterrorism and how best to identify a potential terrorist attack.² The value of taking such steps was illustrated by the deliberate release of anthrax in the USA in late 2001.³ A number of US medical schools have since included such material into their curricula.^{4–8} In 2003, the European Union stated that ‘Health authorities and agencies have a crucial role here...’ and ‘...must...’ promote ‘...preparedness...’, ‘...create a capability for the detection and identification of biological and chemical agents that might be used in attacks...’ and ‘...familiarise clinicians with the syndromes to look out for’.⁹

In the UK, it was clear following the London suicide bombings on 7 July 2005¹⁰ that the possibility of further terrorist incidents occurring at some time in the future existed, and the potential for any such incidents involving bioterrorism has been considered,^{11–12} although in 2007 a major survey questioned the current degree of preparedness of Accident and Emergency Departments in the UK for such events.¹³ In the Republic of Ireland, there has been high-level planning for dealing with the consequences of bioterrorism.¹⁴

In addition to the risk of bioterrorism, the potential for radiological terrorism such as polonium poisoning and nuclear ‘dirty bombs’^{15–16} and events such as the 1995 deliberate release of the chemical weapon sarin in the Tokyo subway (Japan),¹⁷ the 2003 discovery in London of the vegetable toxin ricin¹⁸ and the ricin-containing letters sent to the US president and others in 2013¹⁹ illustrate that risks exist in these areas too.

The United Nations takes weapons of mass destruction (WMD) very seriously,²⁰ and attention has already been drawn to existing deficiencies in the education of scientists, including life scientists, with respect to their background knowledge about and understanding of bioterrorism and biowarfare, and how the research into this field is undertaken and the results disseminated could impact upon this.²¹ In addition to their future work as clinicians, medical graduates will form at least a part of the research community working in this field. Accordingly, to establish whether issues related to WMD such as bioterrorism agents, radiation-based weapons and chemical weapons are currently being considered by those responsible for organising and delivering undergraduate medical teaching in the UK and Ireland, and if the degree programmes they offer currently include any time spent on these issues, a cross-sectional survey has been undertaken of all medical schools in the UK and the Republic of Ireland.

METHODS

A survey comprising nine questions was prepared using the ‘Survey Monkey’ web site, a tool which facilitates the construction of a questionnaire that can then easily be emailed to recipients.²² The questionnaire was designed for maximum clarity, and figure 1A, B shows the actual

original questionnaire, including its layout, that was sent to the recipients. The specific questions posed to the medical schools are both contained in the figures as well as being listed in the Results section. Respondents were not under any obligation to answer any or all of the questions, or to provide free text responses.

All individually listed schools of medicine providing undergraduate medical degree courses in the UK and the Republic of Ireland were identified by visiting the individual websites of all universities and Royal Colleges in the two countries, and establishing whether they offered such courses.

In August 2012, a hyperlink to the survey questionnaire was sent by email to the persons identified from the internet as being the Dean or equivalent person in charge of undergraduate medical teaching at each of the identified schools of medicine in the UK and the Republic of Ireland (totalling 38: 32 in the UK and 6 in Ireland). Depending upon whether or not replies were received, at least three emails were sent out to the identified contacts at each medical school. Emails were sent out from the NHS email box of one of the authors (STG). The emails invited the recipients to click on the hyperlink and to look at the questionnaire and to complete and return it. They were advised of the names, status and place of work of the researchers. They were advised that it was intended that the results would be published, and that they had the option to choose anonymity for the institution. A positive response from a respondent was, in itself, considered as the evidence of consent. The survey was terminated in mid-December 2012.

Question 1 (figure 1A) of the questionnaire gave undergraduate schools of medicine the choice of either identifying the name of the medical school or remaining anonymous. Beyond this, no assurances of anonymity were given.

Questions 2–7 (figure 1A,B) dealt with bioterrorism. Question 2 asked, in the present tense, if the organisation has included any specific teaching on bioterrorism. If the answer to question 2 was no, question 3 explored their future plans, asking if there were any plans in place to introduce such teaching. Questions 4 and 5 asked, in the present tense, if certain areas of knowledge were covered and if the organisation had specific teaching experience in place to deliver such teaching. Questions 5 and 6 were included to help establish whether a decision should be made in the future to include new teaching on bioterrorism, the necessary expertise was already present among the existing teaching staff. Opportunities were given within the questionnaire to provide free text replies, to allow for comments to be made by the participants if they should wish to do so. Such comments could, for example, provide insight into the reasoning and motives behind the answers given to the questions, and perhaps even provide wider insights which had not hitherto been recognised, or highlight if there had been any difficulty with interpreting and answering the questions.

(a)

Undergraduate medical teaching on bioterrorism

1. What medical school/university faculty of medicine are you representing? (if you wish the institution to remain anonymous, please either state as such or leave blank)

2. Does the undergraduate medical curriculum at your university include any specific teaching on bioterrorism?

Yes
 No

3. If no - are there any plans to introduce any specific teaching on bioterrorism?

Yes
 No

4. If yes - are the following areas of knowledge covered?

Policies and planning for bioterrorism and suspected bioterrorism
 The microbiological and laboratory aspects of bioterrorism
 Recognising clinical syndromes associated with bioterrorism
 Health and safety in the hospital around caring for possible cases of bioterrorism
 Public Health issues around bioterrorism
 Legal and police issues in bioterrorism
 Ethical issues in bioterrorism
 Public relations regarding bioterrorism
 The imparting of information to the public regarding bioterrorism and suspected bioterrorism

Other (please specify):

5. If yes - does your university have specific teaching expertise available relating to bioterrorism?

Yes
 No

(b)

6. If yes - in what areas of expertise?

Policies and planning for bioterrorism and suspected bioterrorism
 The microbiological and laboratory aspects of bioterrorism
 Recognising clinical syndromes associated with bioterrorism
 Health and safety in the hospital around caring for possible cases of bioterrorism
 Public Health issues around bioterrorism
 Legal and police issues in bioterrorism
 Ethical issues in bioterrorism
 Public relations regarding bioterrorism
 The imparting of information to the public regarding bioterrorism and suspected bioterrorism

Other (please specify):

7. If there is not currently any undergraduate teaching on bioterrorism to medical students/student doctors at your university, please explain why is this so?

8. Does the undergraduate medical curriculum at your university include any specific teaching on chemical weapons, and their effect(s) on human health?

Yes
 No

9. Does the undergraduate medical curriculum at your university include any specific teaching on radiation used for the purposes of aggression (e.g. nuclear bombs, dirty bombs), and its effect(s) of human health?

Yes
 No

Powered by [SurveyMonkey](#)
Check out our [glossary](#) for more terms and definitions!

Figure 1 (A) Part 1 of original questionnaire emailed to undergraduate schools of medicine. (B) Part 2 of original questionnaire emailed to undergraduate schools of medicine.

Question 8 (figure 1B) asked about chemical weapons and question 9 explored the issue of radiation utilised for the purposes of aggression.

With respect to piloting, given that the aim of the piloting process is to detect any flaws in the questioning and to correct these prior to the main survey being started, the questionnaire was first tested on a small group of colleagues, which confirmed that it was clearly written in plain English, and was comprehensible.

This approach was preferred to going through a formal pilot study as

- ▶ The objective of the survey was to obtain, if possible, completed questionnaires from all medical schools;
- ▶ The overall target group (of medical schools) was small;
- ▶ If a subgroup was to be subjected to a pilot study, and those participants were then excluded from the main study, this would have left an even smaller—and incomplete—dataset.

Formal ethical approval was not considered necessary and therefore not sought. This was because the survey was considered to be more akin to a service review, with no experimentation being involved, no sponsorship being involved and no patients being involved or approached. The sample under study was made up of large mature well-resourced organisations, rather than individual people.

RESULTS

Breakdown of respondents

Of a total of 38 undergraduate schools of medicine who were contacted, 34 (89.47%) completed the questionnaire. A total of 28 were from the UK and 6 from the Republic of Ireland. A total of 32 respondents provided the name of their organisation. Of the remaining 6, 2 completed the questionnaire, but chose to remain anonymous. Accordingly, there were 4 medical schools

(all in the UK) which did not provide any information for the study. The detailed breakdown is in [table 1](#).

Because of subsequently receiving further information, one undergraduate school of medicine asked for its original response to be withdrawn and replaced with a revised response, which was achieved.

Responses to questions relating to bioterrorism

These responses relate to questions 2–6 listed in the original questionnaire illustrated in [figure 1A,B](#). The following data were obtained from the 34 respondents.

Some respondents chose not to answer all the questions.

1. 'Does the undergraduate medical curriculum at your university include any specific teaching on bioterrorism?' A total of 6/34 (17.64%) replied yes, 28/34 (82.36%) replied no and 0/34 (0%) provided no answer.
2. 'If no—are there any plans to introduce any specific teaching on bioterrorism?' A total of 4/34 (11.76%) replied yes, 25/34 (73.53%) replied no and 5/34 (14.71%) provided no answer.
3. 'If yes—are the following areas of knowledge covered?' A total of 11/34 (32.35%) provided answers and 23/34 (67.65%) provided no answers to the following questions:

Table 1 Undergraduate Schools of Medicine approached breakdown of responders and non-responders

	Number	Names/location of medical schools
Total number of medical schools approached in UK and Republic of Ireland	38	32 in the UK (England, Wales, Scotland and Northern Ireland) 6 in the Republic of Ireland
Completed questionnaire and provided name—out of 32 UK medical schools approached	26 of 32	Aberdeen (Scotland) Birmingham (England) Bristol (England) Cardiff (Wales) Dundee (Scotland) Durham (England) East Anglia (Norwich, England) Edinburgh (Scotland) Glasgow (Scotland) Hull York (England) Keele (Stoke-on-Trent, England) Leeds (England) Leicester (England) London—Guy's, King's and Thomas' (England) London—Imperial College London (England) London—St Georges, London (England) London—University College London (England) Manchester (England) Newcastle-upon-Tyne (England) Nottingham (England) Oxford (England) Peninsular (Exeter and Plymouth, England) Sheffield (England) Southampton (England) Swansea (Wales) Warwick (Coventry, England)
Completed questionnaire anonymously	2 of 32	N/A
Either responded anonymously, or chose not to complete questionnaire	6 of 32	Brighton and Sussex (England) Belfast (Northern Ireland) Cambridge (England) Liverpool (England) London—Barts and the London (England) St Andrews (Scotland)
Completed questionnaire and provided name—out of 6 Republic of Ireland medical schools approached	6 of 6	University College Cork University College Dublin Royal College of Surgeons in Ireland (Dublin) Trinity College Dublin National University of Ireland, Galway University of Limerick

- ▶ Policies and planning for bioterrorism and suspected bioterrorism—1/11 replied yes.
 - ▶ The microbiological and laboratory aspects of bioterrorism—7/11 replied yes.
 - ▶ Recognising clinical syndromes associated with bioterrorism—8/11 replied yes.
 - ▶ Health and safety in the hospital around caring for possible cases of bioterrorism—5/11 replied yes.
 - ▶ Public health issues around bioterrorism—2/11 replied yes.
 - ▶ Legal and police issues in bioterrorism—1/11 replied yes.
 - ▶ Ethical issues in bioterrorism—3/11 replied yes.
 - ▶ Public relations regarding bioterrorism—0/11 replied yes.
 - ▶ The imparting of information to the public regarding bioterrorism and suspected bioterrorism—1/11 replied yes.
 - ▶ Other declared areas of expertise—3/11 replied yes (there were three free text responses, indicating that teaching on torture and various relevant microorganisms and clinical syndromes was provided—these are listed in box 1).
5. 'If yes—does your medical school have specific teaching expertise available related to bioterrorism?' A total of 7/34 (20.59%) replied yes, 8/34 (23.53%) replied no and 19/34 (55.88%) provided no answer.
6. 'If yes—in what areas of expertise?' A total of 7/34 (20.59%) provided answers and 27/34 (79.41%) provided no answers to the following questions:
- ▶ Policies and planning for bioterrorism and suspected bioterrorism—3/7 replied yes.
 - ▶ The microbiological and laboratory aspects of bioterrorism—5/7 replied yes.
 - ▶ Recognising clinical syndromes associated with bioterrorism—4/7 replied yes.
 - ▶ Health and safety in the hospital around caring for possible cases of bioterrorism—2/7 replied yes.
 - ▶ Public health issues around bioterrorism—1/7 replied yes.
 - ▶ Legal and police issues in bioterrorism—1/7 replied yes.
 - ▶ Ethical issues in bioterrorism—2/7 replied yes.
 - ▶ Public relations regarding bioterrorism—1/7 replied yes.
 - ▶ The imparting of information to the public regarding bioterrorism and suspected bioterrorism—2/7 replied yes.
 - ▶ Other declared areas of expertise—0/7 replied yes.

Free text responses relating to bioterrorism

These responses relate to question 7 listed in the original questionnaire illustrated in figure 1B, which states that 'If there is not currently any undergraduate teaching on bioterrorism to medical students/student doctors at your university, please explain why this is so'.

28/34 (82.35%) respondents provided free text responses, the full list of which is in box 1.

Chemical weapons and radiation used for the purposes of aggression

These responses relate to questions 8–9 listed in the original questionnaire illustrated in figure 1B.

1. 'Does the undergraduate medical curriculum at your university include any specific teaching on chemical weapons, and their effect(s) on human health?'

Box 1 Complete list of free text replies to the question "If there is not currently any undergraduate teaching on bioterrorism to medical students/student doctors at your university, please explain why this is so"

"Curriculum is full..."—"Less important in an overcrowded undergrad curriculum..."

"It's not seen as a priority..."—"Pressure of other core areas..."—"Not seen as core..."

"Is this more of a postgraduate teaching subject?"

"It is not part of GMC requirements"—"Our curriculum covers the requirements of Tomorrow's Doctors 2009..." "It is not part of the GMC curriculum Tomorrows Doctors, and is not a common and important problem in the UK..."

"Recognition of infections that could arise through bioterrorism is not specifically covered at the undergraduate level..."—"...will be covered for students attached to the Infectious Diseases unit (IDU). This is currently a student selected attachment and only about half the year receive teaching on the IDU..."

"Whilst there is a theoretical possibility of a number of biological agents being used by terrorist groups, in reality the number of cases is tiny, and even of these few attempts most have failed. The chances therefore of a doctor having to deal with a case are vanishingly small. We do include possible terrorist use of Anthrax as a plenary topic..."

"Junior doctors would not be expected to cope with suspected cases unsupported..."

"To date this has not been considered in any substantial way..."—"Largely an oversight—it has featured in Year 1 PBL but not in a structured way and this survey has prompted us to review this"—"We have not been advised to include this teaching by our regulators or other bodies but we would be happy to be contacted to discuss implementation if it was deemed necessary..."—"This is a subject which I have often reflected upon but until now did not consider it as a valid component of our curriculum..."

"...it is naive and counterproductive to expect it to cover all aspects of importance within medicine..."

"There is an optional module on bioterrorism, but not considered essential core teaching..."

"We have no curricular materials readily available for this and I don't believe any expert available who could produce those for us..."

"The first essential is to ensure we produce safe and empathic doctors. I am not sure how many bioterrorist attacks we have experienced in the last 10 years, but in terms of medical problems I suspect it is extremely rare..."

A total of 4/34 (11.76%) replied yes, 30/34 (88.24%) replied no and 0/34 (0%) provided no answer

2. 'Does the undergraduate medical curriculum at your university include any specific teaching on radiation used for the purposes of aggression (eg, nuclear bombs, dirty bombs), and its effect(s) of human health?' A total of 3/34 (8.82%) replied yes, 30/34 (88.24%) replied no and 1/34 (2.94%) provided no answer.

DISCUSSION

It is clear from these results that few undergraduate medical students in the UK and the Republic of Ireland currently receive any teaching about biological weapons and bioterrorism. There may be some similarities to the situation that has already been recognised at the United Nations level with respect to the wider scientific research community, namely that there are widespread deficiencies in the education of scientists, including life scientists, with respect to their background knowledge about and understanding of bioterrorism and biowarfare and how scientific research into this field might lead to adverse consequences.²¹

The importance of recognising such diseases in the field has been acknowledged in the UK. For example, in 2001, a UK Parliament document stated that 'Some diseases occur so infrequently in nature that the appearance of just one case may be suggestive of deliberate release' and went on to say that 'UK clinicians are also being alerted to watch out for tell-tale symptoms and presentations'.²³

This is because if genuine instances of bioterrorism are not identified as soon as possible, valuable time is lost that might help to ensure that the overall impact of such incidents is minimised and possible repeat events prevented.

However, the first place where persons suffering from the effects of biological weapons are likely to interact with doctors is in accident and emergency departments or primary care, and the doctors who initially encounter such persons in those settings may be likely to be relatively junior or may have spent only a short time training within specialist hospital settings.¹³ Furthermore, there is currently little evidence of any research in the literature exploring whether or not more senior doctors have had any training in this field since qualifying.

Accordingly, if one was to wish to ensure that the highest possible proportion of qualified doctors working in the UK or the Republic of Ireland have acquired at least a basic knowledge of biological weapons, bioterrorism and related matters by the time they start working as doctors with the public and to avoid a knowledge vacuum in this area, the only way this could be guaranteed would be for there to be some teaching incorporated into the undergraduate curriculum.

Leaving such training entirely to the postgraduate stages, unless it is mandatory and robustly enforced, means that a significant number of medical graduates may never

receive any training about biological weapons and bioterrorism, which in turn may seriously hamper their abilities to recognise such events for what they are as early as they might be and alert the appropriate authorities. There exists evidence from British accident and emergency departments that postgraduate training and preparedness in this field is currently not as strong as it could be.¹³

Unlike in the USA, to date, very little research has been undertaken on this subject in the UK and Ireland, and the teams are very grateful to those colleagues at the 34 medical schools (34/38—89.47%—of those approached) who completed the questionnaire, whether identifiable or anonymous. We have no knowledge as to why four of the organisations approached did not wish to participate.

Duplicate responses seem unlikely. Virtually, all schools of medicine that chose to respond were happy to provide the name of their organisation, and only two chose to remain anonymous. Given that situation, even if there were to be any duplicate responses, their overall impact on the results would be small.

The issue of whether or not there could have been any ambiguity in the questionnaire leading to confusion among respondents must be considered.

Questions 1, 2, 7, 8 and 9 are very clear in their intent and virtually all respondents provided answers.

In the case of question 3, five respondents gave no answer, which, given the clarity of the wording of the question, suggests that, at the time of answering, they did not know if there were any plans in place, an option which was not given to them, while they had elected not to make further enquiries within their own medical school in order to establish if there were any such plans in place or not—as if they had, one would have anticipated that they would have been able to provide a yes-or-no answer. It is not known why respondents would not have sought to establish the internal situation within their own organisation more clearly rather than failing to provide an answer.

Eleven respondents provided answers to question 4, which is of interest as only six had stated in question 2 that they provided some specific teaching on bioterrorism and just four had answered in question 3 that there were plans in place to introduce some teaching. These are two main interpretations for this. First, it is possible that when they came to question 4, while some respondents may have recognised that their own institutions actually did provide some teaching that was relevant to the specific areas listed, it was not currently considered to be part of any specific teaching on bioterrorism, but was instead a component of other areas of teaching, for example, the clinical syndrome caused by anthrax and/or the microbiological aspects of anthrax might be taught as part of mainstream clinical medicine. Second, it is possible that some respondents answering question 4 were answering having given a yes answer either to question 2 ('Does the undergraduate medical curriculum at your university include any specific teaching on bioterrorism?') or to question 3 ('If no (to question 2)—are there any plans to introduce any specific teaching on bioterrorism?'). That said, and whatever

answers had been given to questions 2 and 3, only 11 respondents had subsequently chosen to provide an answer, and the answers given indicate that at the present time only a small minority of the UK and Ireland's medical schools currently cover any of the specific areas of knowledge enquired about.

Questions 5 and 6 attempted to establish if medical schools had appropriately qualified persons on their staff to deliver teaching on biological weapons and bioterrorism. Whatever be their prior answers, only seven respondents answered in the affirmative that they had such persons on their staff, and only seven gave any information regarding the specific academic areas in which their organisations did possess such expertise. It is possible that some respondents did not possess adequate knowledge about the range of activities within their own organisations to be able to provide answers regarding the information requested—if this was the case with some, it is not known why they chose not to seek out the necessary information. Also, it is possible that some medical schools currently possess absolutely no expertise whatsoever in some, and even all, of the specific areas enquired about. Furthermore, it should be borne in mind that even if an individual medical school did not currently provide any teaching about biological weapons and bioterrorism to its undergraduate students, and even if they had no plans at the present time to introduce any, this does not necessarily mean that there would not be any persons among their staff who do possess knowledge of the relevant areas. Overall, it seems clear that most UK and Irish medical schools currently do not possess high levels of expertise in these fields of study among their staff.

Of relevance to this work is understanding why topics relevant to biological weapons and bioterrorism are not currently taught, and the free text responses provide some insights into the possible reasons why this might be the case. Free text responses from the UK make it clear that one of the major reasons for not including bioterrorism in their courses is because it is not included in 'Tomorrow's Doctors', the 2009 recommendations of the UK's General Medical Council (GMC) for what should be included in degree courses.²⁴ Of note is that other documents of relevance emanating from the UK or Irish governments and quangos, the European Union, the United Nations and papers describing North American experience are not mentioned in the free text responses, the implication of this being that it may be possible that other documents looking at this same issue but from different perspectives might not have been considered. Other reasons given for not incorporating these topics into courses include the relative rarity of such events, a lack of time and a view that it is a postgraduate subject and not appropriate for undergraduates. Some responses state that they plan to look again at whether or not the subject should be included.

The results of this survey reveal that at the moment most UK and Irish medical schools spend relatively little time teaching medical students about this area of

knowledge, and many do not provide any teaching at all. Furthermore, any period of time that is allocated to teaching would cover mainly the clinical and laboratory elements, rather than contextualising this area of health-care needs by providing teaching on the ethical, social, legal and political dimensions. Furthermore, many medical schools stated that they did not have members of staff with particular expertise in fields associated with the use of biological weapons and bioterrorism, a finding that has clear implications not only for teaching but also for research in this field.

Furthermore, it is clear that although UK medical schools have considerable freedom to decide what to include within their undergraduate medical curricula, at present many do not appear to look too far beyond 'Tomorrow's Doctors', the 2009 recommendations of the UK's GMC,²⁴ which currently do not give any consideration to any aspect of terrorism although, interestingly, some medical schools stated in their free text responses that they had been prompted by this survey to look again at the issue.

In the Republic of Ireland, the submitted responses reveal that of the six medical schools, two included quite substantial teaching on biological weapons and bioterrorism but the others do not do so. At least one Irish medical school stated in their free text responses that they had been prompted by receiving this survey to look at this issue.

The world is not becoming a safer place—Harrison and Wolf²⁵ have calculated that between 1870 and 2001, the frequency of wars between states increased steadily by 2% a year on average, and in the 1990s the frequency of wars between states rose by 36% per year, while since 9/11 terrorist attacks have continued to be common and widespread around the world.²⁶ While Parliament in the UK in 2001 expressed concern over the potential for a terrorist attack using biological weapons,²⁴ and in 2003 the Chief Medical Officer for England and Wales endorsed the need to ensure that the country possessed effective means to address the risks associated with biological agents,¹² the United Nations still felt it important to repeat similar warnings in 2012.²⁷ Given that UK and Irish medical schools do not just train doctors for the UK and Ireland, maintaining a broad international perspective would seem important.

As things stand, while acknowledging the many demands placed on undergraduate schools of medicine when it comes to formulating an effective curriculum, in the biological weaponry and bioterrorism field, many medical schools in the UK and the Republic of Ireland are not currently contributing significantly to the formal knowledge acquisition process among their undergraduates. Accordingly, if concerns still exist at the national governmental and supragovernmental levels, it may be wise for this matter to be revisited and examined by the relevant agencies, such as the GMC and the HSE (Ireland),¹⁴ and any gaps in teaching skills, research activity and funding that cause concern identified and remedied.

Furthermore, in 2003, the Chief Medical Officer for England and Wales also highlighted the importance of ensuring that the country has the means to deal effectively with the risks posed by chemical and radiation hazards,¹² and the widespread absence of teaching time spent on weaponised chemicals and the use of radiation as a weapon suggest that the situation may be similar to bioterrorism, although more work would be needed to establish the present overall situation.

With respect to the strengths of this work, this is the first study in either the UK or the Republic of Ireland to look at this issue, and the response rate was very high. The main limitation is that not all medical schools provided responses to all the questions posed, and the reasons for this are currently not known.

The survey provides sufficient data to indicate that more in-depth studies are warranted to establish more clearly if it is in the best interests of the public and patients for clinicians to be receiving at least some teaching about biological weapons and other WMD at undergraduate level, or if keeping the current system of leaving such training until the postgraduate stages of training is the most effective option. In addition, while many researchers joining the WMD research community (of whom a proportion will be medically-trained clinicians) enter it at the Masters and Doctorate levels, the aforementioned high-level concerns reported regarding the existing deficiencies in the education of researchers with respect to their background knowledge about and the understanding of bioterrorism and biowarfare, and how the research into this field is undertaken and the results disseminated²¹ indicate that research designed to determine the best stages in researchers' careers to introduce more training about and deeper insights into the broader issues surrounding WMD, as well as to monitor the efficacy of such training, would be valuable. For example, it may be that earlier, improved and augmented training of all medically trained individuals working within research teams engaged in studying WMD-related topics represents one way of improving on what is considered by some to be the currently unacceptable situation.

Contributors STG and LC originated the idea for the study and collected the data. All authors contributed to developing the ideas and the questionnaire and to the analysis and interpreting of the data. All authors contributed to the writing of the manuscript and gave final approval for the version submitted. STG is the Study guarantor.

Funding This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests All authors have completed the Unified Competing Interests form at http://www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous 3 years, no other relationships or activities that could appear to have influenced the submitted work.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The datasets used for the analysis are available from the corresponding author S T Green at ldphysician@hotmail.co.uk.

REFERENCES

1. United Nations Action to Counter Terrorism. <http://www.un.org/terrorism/> (accessed 15 Apr 2013).
2. Association of American Medical Colleges. Training future physicians about weapons of mass destruction. <https://members.aamc.org/eweb/upload/Training%20Future%20Physicians%20About%20Weapons.pdf> (accessed 17 Feb 2013).
3. Bush LM, Abrams BH, Beall A, *et al*. Index case of fatal inhalational anthrax due to bioterrorism in the United States. *N Engl J Med* 2001;345:1607–10.
4. Emory University Department of Medicine, Paul Cantey's page. http://www.medicine.emory.edu/about_us/our_people/faculty-directory/cantey-paul.html (accessed 15 Apr 2013).
5. Texas A, M College of Medicine. <http://medicine.tamhsc.edu/academic-affairs/curriculum/model/2011-12-pdfs/phase2/Respiratory.pdf> (accessed 15 Apr 2013).
6. Baylor College of Medicine—Potential Bioterrorism Agents. <http://www.bcm.edu/molvir/overview> (accessed 15 Apr 2013).
7. UCLA David Geffen School of Medicine—Peter Katona's page. http://people.healthsciences.ucla.edu/institution/personnel?personnel_id=9107 (accessed 15 Apr 2013).
8. Smith S. Pitt's medical school integrates bioterrorism into curriculum. *EHS Today*. http://ehstoday.com/news/ehs_imp_12321 (accessed 17 Feb 2013).
9. European Union. The fight against bioterrorism. http://europa.eu/legislation_summaries/justice_freedom_security/fight_against_terrorism/c11576_en.htm (accessed 17 Feb 2013).
10. MacKenzie R, Redhead J, Wise D, *et al*. London bombings July 2005: the immediate pre-hospital medical response. *Resuscitation* 2005;66:IX–XII.
11. Alexander DA, Klein S. The challenge of preparation for a chemical, biological, radiological or nuclear terrorist attack. *J Postgrad Med* 2006;52:126–31.
12. Department of Health. Getting ahead of the curve—a strategy for combating infectious diseases (including other aspects of health protection). http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4060875.pdf (accessed 17 Feb 2013).
13. Anathallee M, Curphey A, Beeching N, *et al*. Emergency departments (EDs) in the United Kingdom (UK) are not prepared for emerging biological threats and bioterrorism. *J Infect* 2007;54:12–17.
14. Wall M. Bioterrorism infirmity planned in Ireland. Nuclear Threat Initiative. <http://www.nti.org/gsn/article/bioterrorism-infirmity-planned-in-ireland/> (accessed 17 Feb 2013).
15. Acton JM, Rogers MB, Zimmerman PD. Beyond the dirty bomb: re-thinking radiological terror. *Survival* 2007;49:151–68.
16. Medalia J. 'Dirty Bombs': Technical background, attack prevention and response, issues for congress. Congressional Research Service (USA). <http://www.fas.org/sgp/crs/nuke/R41890.pdf> (accessed 17 Feb 2013).
17. Okumura Y, Takasu N, Ishimatsu S, *et al*. Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med* 1996;28:129–35.
18. BBC. Terror police find deadly poison. <http://news.bbc.co.uk/1/hi/uk/2636099.stm> (accessed 17 Feb 2013).
19. CNN. FBI confirm letter to President, others contained ricin. <http://edition.cnn.com/2013/04/18/politics/tainted-letter-intercepted/index.html> (accessed 22 Apr 2013).
20. United Nations Office for Disarmament Affairs. http://www.un.org/disarmament/HomePage/about_us/aboutus.shtml (accessed 15 Apr 2013).
21. Working Paper 20, 7th Biological and Toxins Weapons Convention Review Conference. 2011. http://www.brad.ac.uk/bioethics/media/assis/bioethics/7RC_WP20.pdf (accessed 15 Apr 2013).
22. Survey Monkey. <http://www.surveymonkey.com/> (accessed 15 Apr 2013).
23. Parliamentary Office of Science and Technology. Bioterrorism—Postnote. <http://www.parliament.uk/documents/post/pn166.pdf> (accessed 17 Feb 2013).
24. General Medical Council. Tomorrow's Doctors. http://www.gmc-uk.org/TomorrowsDoctors_2009.pdf_39260971.pdf (accessed 17 Feb 2013).
25. Harrison M, Wolf N. The frequency of wars. *Econ Hist Rev* 2012;65:1055–76.
26. Muhlhausen DB, McNeil JB. *Terror trends: 40 years' data on international and domestic terrorism*. Heritage foundation. Special Report 93. <http://www.heritage.org/research/reports/2011/05/terror-trends-40-years-data-on-international-and-domestic-terrorism> (accessed 15 Apr 2013).
27. BBC. UN: More should be done to prevent bio-terrorism. <http://www.bbc.co.uk/news/technology-19745045> (accessed 17 Feb 2013).