Mass casualty decontamination in the United States: an online survey of current practice

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Abstract

Mass casualty decontamination is a public health intervention that would be employed by emergency responders following a chemical, biological, or radiological incident. The decontamination of large numbers of casualties is currently most often performed with water to remove contaminants from the skin surface. An online survey was conducted to explore US fire departments' decontamination practices, and their preparedness for responding to incidents involving mass casualty decontamination.

Survey respondents were asked to provide details of various aspects of their decontamination procedures, including: expected response times to reach casualties, disrobing procedures, approaches to decontamination, characteristics of the decontamination showering process, provision for special populations and any actions taken following decontamination. The aim of the survey was to identify any differences in the way in which decontamination guidance is implemented across US States.

Results revealed that in line with current guidance, many US fire departments routinely use the "ladder-pipe system" (LPS) for conducting rapid, gross decontamination of casualties. The survey revealed significant variability in LPS construction, such as the position and number of fire hoses used. There was also variability in decontamination characteristics, such as water temperature and water pressure, detergent use, and shower duration.

The results presented in this paper provide important insights into the ways in which implementation of decontamination guidance can vary between US States. These inconsistencies are thought to reflect established 'perceived best-practice' and local adaptation of response plans to address practical and logistical constraints. These outcomes highlight the need for evidence-based, national guidelines for conducting mass casualty decontamination.

Introduction

The use of chemical, biological, radiological and nuclear (CBRN) material and weapons remains a global threat[1, 2]. Due to the adverse health consequences of chemical incidents, the US Government considers both deliberate and accidental release to be a serious threat to public health[3, 4]. National or regional guidelines are in place in the US and many other countries for responding to mass casualty incidents arising from exposure to CBRN materials[3, 5, 6]. One of the main interventions for reducing the risk posed by CBRN agents is decontamination. The aim of decontamination is to remove as much contaminant from the skin as possible, in order to prevent or minimise adverse health effects, and to reduce the risk of secondary contamination of other people and places. Decontamination can involve various steps, including disrobe, a shower with water, or dry decontamination with absorbent materials. While decontamination may be used in response to incidents involving biological and radiological materials, it is likely to be of most benefit during incidents involving chemical agents, since this type of exposure may be overt (it is immediately obvious that a release has occurred) and an immediate response is necessary in order to minimise injury and save lives[7]. Mass decontamination is described as, "the emergency removal of contamination quickly from large numbers of victims"[8]. .

Although there are gaps in the research literature to date, evidence suggests that rapid physical removal of a hazardous agent is the most important aspect of decontamination[1,9]. The act of disrobing has been shown to be a highly effective method for removing hazardous chemical contaminants from casualties and should be implemented at the earliest opportunity during incidents involving chemical agents [7, 10]. For incidents involving biological and radiological materials, a "wet strip flush" approach may be more effective, but the current survey focuses on response to chemical incidents, for which disrobing prior to showering has been shown to be most effective[7]. It is important that casualties disrobe prior to showering, as failure to do so could facilitate increased transfer of any contaminant on to the skin[7]. Disrobing should then be followed by gross decontamination, which is the use of standard equipment to provide a rapid yet structured decontamination process for large numbers of people. One recommended method for conducting gross decontamination is the Ladder-Pipe System (LPS). LPS decontamination involves positioning ladders and hoses from two or more fire tenders to create a shower corridor through which contaminated casualties are moved[11].

Guidance recommends that water in this shower corridor is delivered in high volume, but at relatively low pressures (see Figure 1 for an illustrative LPS corridor). Further, guidance recommends that instructions to casualties include the instruction to walk slowly through the corridor with their heads held back, arms extended and turning around in the centre of the corridor[12]. LPS decontamination may then be followed by secondary or technical decontamination in specialised mass decontamination units. The decision as to whether or not to carry out secondary decontamination will usually depend on the type and the extent of contamination[12].

Insert Figure 1 here.

Recent research involving specialised mass decontamination units has examined how different characteristics of the showering process can contribute to the effectiveness of decontamination. Findings show that in mass decontamination units, the optimal duration for shower-based decontamination is between 60 and 90 seconds and the recommended water temperature for decontamination is 35°C (95˚F)[13,14]. The use of detergent removes around 40% more contamination that water alone[7,15] and is recommended to optimise shower-based decontamination [7,12,16,17,18,19,20]. However, while research has examined the effectiveness of different showering characteristics using mass decontamination units, methods of gross decontamination have not undergone formal testing. In the conduct of gross decontamination, current guidance recommends that a high volume of water be delivered at a minimum of 60 pounds per square inch (psi) (4.14 bar) to ensure that hazardous agents are removed[11]. Weather is an environmental factor that may affect the behaviour of a toxic agent and will therefore impact on decontamination requirements. For example, strong wind, heavy rain, or temperatures below freezing may reduce the effects of a chemical agent[8]. Decontamination during cold or adverse weather may also increase the risk of hypothermia, particularly for vulnerable groups such as older people, young children and people with existing health conditions, and the decontamination process may need to be adapted accordingly; for example, implementing dry instead of wet decontamination and quickly providing casualties with temporary clothing and a place to shelter, in order to provide warmth and to address modesty concerns[3, 12].

The needs of a diverse population and in particular vulnerable groups must be considered during the decontamination process. Following the attacks of September 11, 2001, the National Organisation on Disability launched the Emergency Preparedness Initiative to ensure that emergency managers and first responders address disability concerns, and that people with disabilities are included in all levels of emergency planning, response, and recovery[17]. Guidance suggests that those with disabilities be allowed to retain any equipment which enables them to maintain independence and self-control[3]. Further, recent research has suggested that emergency responders can look to casualties to support each other to take key actions such as moving away from the source of contamination and initiating self-care decontamination procedures, helping those around them to do the same[22]. An effective communication strategy is needed to convey the importance of these steps as emergency responders help to manage contaminated casualties[23,24]. Guidance states that it may be challenging to communicate decontamination procedures with casualties who are Non-English speaking (NES) or Limited English Proficiency (LEP)[19,20,25]. Research suggests individuals who are NES/LEP are unlikely to follow instructions during a mass casualty event, possibly because they may have lower confidence in the communication they receive regarding appropriate actions to take[26]. Guidance recommends the inclusion of interpreters in the decontamination team, and for emergency responders to be fully trained in order to assist those who are NES and LEP[20,25].

This study explored decontamination practices and preparedness for chemical incidents in US fire departments via an online survey, in order to explore regional variations and consistency with current evidence and guidance for mass casualty decontamination. Survey questions related to: the response time to reach contaminated casualties, approaches to disrobing, the characteristics of the decontamination showering process, provision for vulnerable groups, and the management of casualties post-decontamination (See Supplementary File 1 for full survey). The study informed an on-going collaborative research programme conducted by University of Hertfordshire and Public Health England on behalf of Health and Human Services' Biomedical Advances Research and Development Authority (BARDA), which seeks to develop the evidence-base for effective emergency decontamination procedures.

Methods

Survey design

A 31 question online survey was created by researchers at Public Health England (PHE) and the University of Hertfordshire (UH). The survey was conducted using SelectSurvey.Net, hosted on PHE servers in the UK. This allowed data to be stored in accordance with the UK Data Protection Act 1998. As the survey was designed to capture information about current emergency decontamination practices, the survey was considered a form of service evaluation, and therefore not subject to research ethics approval. This position was confirmed by the PHE Research and Development Office.

Survey questions were designed to ensure clarity, brevity and avoid ambiguity to meet good practice in survey design. A combination of closed questions, multiple response, and open-ended response options were used to address a range of questions. Multiple response option questions were presented in a grid format, with the order of questions randomised within each grid to prevent response item ordering bias. Page conditions were used so that if, for example, a respondent reported that casualties would not be disrobed prior to decontamination, they would be directed to a subsequent set of questions and would not have to answer questions about pre-decontamination disrobing. Respondents were able to skip questions if they had insufficient information to respond.

Survey respondents were asked to report their level of experience concerning mass decontamination, including: whether they had ever been involved in a CBRN incident, the number of real-life incidents they had been involved in and the occurrence/ frequency of emergency preparedness drills and exercises in their locality. Three questions were asked to identify: the decontamination approach used by their fire department, the hose configurations they would use for Ladder-Pipe System decontamination, and the procedures they would use during cold weather. Two questions addressed the act of disrobing casualties during an incident response. The survey asked five specific questions about the decontamination showering process, which related to: the temperature of the water, the water pressure (in psi) the duration of showering, whether detergent would be routinely added to shower water and whether casualties would walk through the decontamination corridor alone or in groups. Further questions in the survey sought to collect data in key areas including: the response time to reach contaminated casualties and the provision for vulnerable populations during mass decontamination. The full set of survey questions can be seen in the supplementary File 1 accompanying this article.

Participants and procedure

A covering letter with a link to the online survey was circulated to members of the US InterAgency Board (IAB). The IAB is, "…a voluntary collaborative panel of emergency preparedness and response practitioners from a wide array of professional disciplines that represent all levels of government and the voluntary sector"[27]. The covering letter explained the purpose of the study and invited recipients to take part in the survey. Additional emergency responders were identified using snowball sampling; a non-probability sampling technique where respondents are asked to assist researchers in identifying other potential participants. The covering letter and survey link requested that IAB members circulate the survey to other colleagues among the emergency response community. Respondents were provided with PHE contact details should they have any further questions about the survey. Informed consent from survey respondents was collected via a question on the first screen of the survey, following an introduction to the aims of the survey, the time commitment involved and information on the way in which respondents' information would be processed and stored.

Results

The survey elicited a relatively low sample size. A total of 68 emergency response professionals responded to the survey, however only 42 completed the survey, with 26 skipping one or more questions. Of the 68 participants, 49 identified their location (see Figure 2) with at least one response coming from each of 21 different US States. Thirty four participants identified the city to which their fire department was located; according the 2010 US Census[28], 31 of these cities are classified as an urban area (≥ 50,000 people), whilst 3 are classified as an urban cluster area (at least 2,500 and less than 50,000 people). Fifty two survey respondents disclosed their emergency response role, with responses indicating varying levels of experience in emergency preparedness and response. Eleven respondents indicated that they were directly involved in decontamination, CBRN, and/or hazmat at an operational level. Two respondents reported that they were responsible for producing guidance on the subject. Almost half of the respondents who completed the survey (n = 23) held leadership positions at the senior level, such as Director or Chief. Overall, respondent's job roles indicated that they were well qualified to describe the emergency response procedures in their locality.

Insert Figure 2 here.

Response time to contaminated casualties

Twenty five respondents estimated the time between receiving a 911 call and the arrival of fire tenders at the incident scene. The estimated response times during peak traffic ranged from 3 to 15mins (Mean response time (M) = 8.01mins), while the estimated response times during non-peak traffic ranged from 3 to 12mins (M = 5.36 mins). Twenty respondents estimated the time between arrival of fire tenders at the scene and the start of emergency decontamination. The estimated time between arrival of fire engines and decontamination of the first casualty ranged from 20 seconds to 20 minutes (M = 5.65 minutes), with five of 20 respondents providing estimates of 2 minutes or less. Twenty eight respondents estimated the time allowed between disrobing and beginning emergency decontamination, with times ranging from 0 - 60 minutes (M = 6.29 minutes).

Removal of contaminated clothing

The majority of respondents (64%) reported that in a real incident involving a chemical contaminant, casualties would be instructed to disrobe prior to showering (see Figure 3). Respondents were asked to specify at what point during the decontamination process they would ask casualties to disrobe. This open-ended question revealed that nearly half of the respondents (13/28) said that casualties would be asked to disrobe immediately. Other responses included: “response would be situation/incident dependent” (n = 11); “casualties would be instructed to disrobe after gross decontamination” (n = 3); and “unsure” (n = 1).

Respondents were asked what they would do if casualties were unwilling to disrobe. The question allowed respondents to select more than one option from several strategies; responses are presented in Table 1. The most commonly selected procedure (n = 18) was to “offer a privacy corridor”. The 7 respondents who selected “Other” were asked to specify the alternative strategies they would use, with responses including: “several of the above”; “situational”, and “separated into a different refuge area (control until decontamination can be metered or quality assurance measures are verified)”.

Insert Figure 3 here.

Insert Table 1 here.

Methods of decontamination

Thirty-six of 51 respondents confirmed the Ladder-Pipe System (LPS) is the preferred approach for decontaminating multiple casualties affected by a chemical incident. A number of different or additional approaches were reported including: “technical decontamination”, “reactive skin decontamination lotion (RSDL)”, “multiple decontamination shower tents”, and “outdoor plumbing and fixtures around military hospitals to quickly set up mass decontamination lines for community and military support”.

Characteristics of the LPS decontamination

Respondents were asked to describe the hose and nozzle arrangement employed during LPS decontamination and to provide details about water temperature and pressure used, shower duration, and instructions provided to affected casualties. Twenty five of the 36 respondents who used the LPS approach answered these questions.

Configuration of hoses/nozzles

Respondents were asked to specify the configuration of hoses and nozzles they would use to carry out LPS. The questions in this section allowed respondents to select more than one option from several strategies. The most common response reported by 19 of the 25 respondents was the use of three positions; hoses mounted to fire tenders either side of the decontamination corridor and overhead hoses. Two respondents indicated that only side mounted hoses were used whilst 7 respondents stated that some other configuration was used. Respondents reported a variety of different brands and types of shower nozzles used at each hose position including Turbo Master, Hy-D, Akron Fog Nozzles, and Task Force Tips.

Control of water temperature

The majority of the respondents (20/25; 80%) said they were unable to control the temperature of the shower water. Only 3 respondents (12%) stated that temperature control was possible (see Figure 4). The respondents who said they were unable to control the water temperature were asked the approximate hydrant temperature on the coldest and hottest days of the year. Ten respondents estimated the hydrant temperature on the coldest and hottest days of the year, with temperatures ranging from 30 - 76°F (-1.1 – 24.4˚C) for the coldest day, and 50 - 79°F (10 – 26.1˚C) for the hottest day.

Water pressure

The respondents were asked to estimate the water pressure used to decontaminate casualties. Ten of 25 respondents estimated the water pressure used, with responses ranging from 30 to 150 psi (M = 66 psi) (2.07 – 10.3 bar (M = 4.6 bar)). Factors influencing decisions about water pressure included satisfactory spray pattern, corridor length and adequate 'fog'. Nine respondents did not know the water pressure used for decontamination.

Shower duration

The respondents were asked to specify how long they would let casualties spend in the shower. Twenty of the 25 respondents (80%) gave numerical estimations of the duration of decontamination, ranging from 5-10 seconds to 10 minutes, with half of the respondents stating that shower duration would be between 30 and 60 seconds (10/20; 50%). A further 4 respondents (20%) stated that shower duration would be 2 minutes; 3 respondents (15%) greater than 5 minutes (5 – 10 minutes), and 3 respondents (15%) stated that shower duration would be less than 30 seconds (5 – 20 secs).

Detergent use

Ten out of 25 respondents (40%) stated that they were unable to add detergent to the water dispensed from the fire hoses during Ladder-Pipe decontamination. A comparable 11 respondents (44%) said that they were able to carry out this process. Four respondents (16%) selected 'Don't know' (see Figure 5). Follow up questions explored the type and concentration of detergents, if used. Only 3 respondents referenced specific brands (Dawn, n = 2, Johnson' Baby Shampoo, n = 1), while 4 respondents provided generic information such as 'Class A foams' and 'dish soap'. No indication of the concentration of detergent used was provided.

Cold weather considerations

Eleven of 25 respondents confirmed that they would employ LPS decontamination, even under cold weather conditions. Fifteen of 25 respondents identified other measures including: “using tents with warm air and a warm water supply”; “dry decontamination”; “providing protection from the cold environment”, and “using nearby facilities such as nearby building lobbies”.

Management of casualties through the decontamination process

Nineteen of 25 respondents (76%) reported that they have no fixed rules for how casualties would walk through the shower corridor. Five respondents (20%) reported that casualties would walk through the shower individually, and one respondent (4%) reported that they didn’t know whether casualties would be asked to walk through the process individually or in groups. Eight out of 25 respondents (32%) reported that they would use a bull horn or other type of PA system to direct casualties through the decontamination process. Seven respondents (28%) gave details of the instructions which they would provide to casualties during the decontamination process. The most commonly reported instructions included: asking casualties to walk slowly through the decontamination corridor; extend arms, and turn occasionally.

Provision for vulnerable groups

Survey respondents were asked to elaborate their procedures for managing casualties with additional or special needs during mass decontamination, specifically during disrobe and rerobe. Groups who may have special needs during decontamination, include those with mental or physical health conditions, children, non-ambulatory casualties and those who require supportive aids such as wheelchairs, prosthetic limbs and assistance animals. Respondents were asked how they would manage groups who are unable to undress/redress themselves due to physical and/or mental health conditions (see Table 2). The most commonly selected approach was, ‘have a member of their team disrobe them and rerobe them at the other end’ (n = 21). Those who selected ‘Other’ (n = 8) were asked to specify the approach they used. Responses included: “depends on the situation”, “any of the above may be applicable”, “male and female hazardous materials technicians are available inside the decontamination tent to assist”, and “generate a by-pass lane / privacy corridor and/or tarp the tent interior to create support space”.

Insert Table 2 here.

Respondents were asked if parents/guardians were allowed to carry young children through the decontamination shower. Of 48 responses to this question, 41 respondents stated that parents would be allowed to carry young children through decontamination, with only 2 respondents suggesting that this is not permitted. In addition, respondents were asked to identify their procedures for the management of casualties who are unable to walk (non-ambulatory) during decontamination (see Table 3). The most common option was, ‘allocate a designated decontamination area and crew specifically to deal with non-ambulatory casualties’ (n = 34). ‘Other’ responses included: “dependent on agent”; “level of exposure”; “onset of symptoms”; “available staff”; “number of casualties requiring decontamination”; “ask victims to assist and provide extra time in the decontamination shower area for the group to reduce contamination as much as possible for all involved”, and “assist non-ambulatory casualties with responders in PPE”. When asked if they would allow those with physical impairments to take supportive aids through the decontamination procedure, the majority of respondents indicated that guide dogs (74%), walking sticks (79%), wheelchairs (74%), prosthetic limbs (79%) and glasses (84%) were all permitted to pass through decontamination with casualties.

Insert Table 3 here.

Post-decontamination care

The majority of respondents (22/28; 79%) would provide temporary clothing packs to casualties following emergency decontamination. Only 4 respondents (14%) said ‘no’, while the remaining 2 respondents (7%) said they did not know. When asked whether the emergency department of a local hospital would be prepared to accept casualties who had only undergone LPS decontamination, 16 of 25 respondents (64%) answered ‘yes’. However, 7 respondents (28%) said the emergency department would be prepared to accept casualties, ‘only after more thorough/technical decontamination’. Two respondents (8%) said they did not know.

Discussion

The online survey presented in this paper describes a cross-section of current decontamination practices and preparedness for chemical incidents across 21 different US States. Responses to the survey indicate that decontamination practices differ substantially, suggesting that current protocols are not always consistent with current evidence and best-practice guidance. The survey focused on a number of different aspects of mass decontamination: response time to reach contaminated casualties; approaches to disrobing and decontamination; characteristics of the decontamination showering process and provision for special populations. These topics will be discussed here.

Response time to reach contaminated casualties

All respondents reported that they would reach contaminated casualties within 15 minutes of receiving a 911 call, and that response times could be as little as 3 minutes. However, there was wide variability in the length of time between fire tenders arriving at the scene and the first casualty being decontaminated, with estimations ranging between 20 seconds and 20 minutes. This emphasises the need to quickly initiate disrobing of casualties, as this is an effective step which can be taken soon after emergency responders arrive at the incident scene [7]. It may be that the respondents assumed that the decision to decontaminate would already have been made in this scenario, and may also have made the assumption that initial decontamination could be conducted with on vehicle water reservoirs and hoses, rather than with a full LPS configuration in place. However, this is speculative, so we acknowledge that these times might be unrealistic, and further investigation is required.

Approaches to disrobing and decontamination

Most of the respondents stated that they would ask casualties to disrobe prior to showering, with just over half stating that they would ask casualties to disrobe as soon as possible. However, a proportion of respondents stated that they would *not* ask casualties to disrobe prior to showering. Disrobing has been shown to be one of the most effective steps to reduce exposure to a contaminant and to maximise this protective effect, disrobing should occur as soon as possible following potential contamination[10]. While a large number of respondents acknowledged the importance of rapid disrobing, this was not universally recognised.

When asked what actions they would take if casualties were unwilling to disrobe, most respondents stated that they would either offer a privacy corridor or provide further explanation about the benefits of disrobing (or both). However, half of the respondents stated that they would allow casualties to proceed through the decontamination process fully clothed. Allowing casualties to undergo decontamination whilst fully clothed could increase the transfer of contaminants through the clothing, leading to greater contamination of the skin[7].

The majority of respondents stated that they would employ the LPS method of decontamination, as recommended in current guidance [3,11, 12]. The most common hose configuration for LPS was to use hoses mounted to the side of fire tenders, as well as a hose suspended from a ladder attached to an aerial truck. The type of nozzle attachments generating the shower spray was shown to vary amongst respondents with no clear indication of preferred models or spray pattern. The majority of respondents recognised that it might be necessary to adapt LPS decontamination systems during cold weather, with suggested adaptations including using tents with warm air and warm water, or carrying out dry decontamination instead. However, some respondents stated that they would carry out the same method of decontamination during cold or adverse weather. Current guidance suggests that in cold environments, it might be necessary to avoid water-based decontamination, to minimise the likelihood of cold weather injuries[3]. This is particularly the case when decontaminating vulnerable groups, such as older adults or children, who are at increased risk of adverse effects from the cold.

Characteristics of the decontamination showering process

The majority of respondents stated that they were unable to control the temperature of the water used for decontamination. There were a wide range of different water pressures reportedly used for decontamination but over half of the respondents were unclear as to the pressure employed. Approximately a quarter of respondents stated that the pressure they would use would be around or below 60 psi (4.14 bar), the minimum recommended water pressure for decontamination[11]. The majority of participants (14 of 25) were either unable to add detergent to the water dispensed from fire hoses, or did not know if this was possible, and were therefore unable to follow the recommendation of decontaminating casualties using detergent[16,17,18,19,20.] Only 3 respondents made reference to specific brands of detergent appropriate for the decontamination of casualties, and no indication of the concentration of detergent used was provided. Respondents reported a wide range in shower duration, ranging from 5 seconds to 10 minutes. Half of respondents reported that shower duration would be between 30 and 60 seconds, below the recommended shower duration of 60 and 90 seconds identified in controlled studies of emergency decontamination[13, 14].

Only a quarter of respondents reported that they would provide instructions to casualties about how to progress through the decontamination process. Where details of specific instructions were given, these included asking participants to walk slowly through the decontamination corridor, turn occasionally, and extend arms; these instructions were therefore broadly in-line with current guidance, based on perceived best practice[12]. However, research into effectiveness of showering in mass decontamination units suggests that active washing will be important[14].

Provision for vulnerable populations

When asked how they would manage the decontamination of casualties who were unable to undress/re-dress themselves due to physical or mental health conditions, the majority of respondents stated that they would ask a member of their team to help the casualty to disrobe and rerobe. This was the most common way to manage non-ambulant casualties through the decontamination process. However, depending on the number of casualties with additional needs, these actions could put strain on responder resources, and may not be practical. Another option selected by respondents was to ask an able-bodied casualty to assist other casualties during disrobe and rerobe. Recent research suggests that casualties may be willing to help others during decontamination, provided they have received practical, health-focused information from emergency responders concerning the importance of undergoing decontamination[22,23,24.]. Guidance states that the decontamination team should include interpreters in order to assist casualties who are NES or LEP [20,25]. The survey did not ask questions specifically related to communication with non-English speaking casualties; further work is needed to explore the management of this vulnerable group during mass decontamination. The survey questions relating to vulnerable groups also did not distinguish between casualties who were non-ambulant due to pre-existing conditions, and casualties who had become non-ambulant as a result of the incident. It is likely that emergency responders might choose to manage these two groups differently, and this is therefore an aspect which requires further study.

The majority of respondents stated that they would allow various different types of service equipment, including guide dogs, walking sticks, wheelchairs, prosthetic limbs and glasses to be taken through the decontamination shower; this is in-line with recommendations in decontamination guidance[3]. Only a small minority stated that they would not allow this equipment to go through the decontamination shower. Whilst allowing service equipment to be taken through the shower is likely to enable casualties to progress through decontamination more independently, consideration should be given to equipment which cannot go through the showering process (e.g. some types of prosthetic limbs). In such cases, casualties should be decontaminated as non-ambulant casualties[3].

Implications

Reported decontamination procedures varied substantially between different survey respondents. In certain aspects, such as initiating disrobe as quickly as possible, employing an LPS method of decontamination, and provision of rerobe packs to casualties following decontamination, responses were broadly in-line with guidance and evidence for decontamination practices. However, in several aspects of decontamination, most notably characteristics of the decontamination shower (shower duration, shower temperature, and shower pressure), responses varied and were often not consistent with current guidance. Failure to adhere to recommended decontamination processes could result in casualties receiving less than effective decontamination, and possibly experiencing more adverse effects or injury. The variability in the responses presented here may be a result of the fact that there are several national guidance documents for mass decontamination, which are not always consistent with each other. Some of these guidance documents are based on evidence from research, while others are based on perceived best practice. The findings from the survey reported here therefore suggest that there is a need to ensure that decontamination guidance documents are consistent across US States, and updated routinely with the developing evidence-base in this area.

Study limitations

There are two main limitations to this study. First, snowball sampling was used to reach respondents; this method is dependent on participants forwarding the survey on to others. The population of interest was emergency response personnel with either experience of or training in the management of CBRN incidents; such responders are likely to have busy and demanding roles, which may have impacted their ability and willingness to complete the survey. However, the variability in response in a relatively small sample could be indicative of wider variability in decontamination practices, or at least variability within the bounds of the responses of the current sample, emphasising the need for evidence-based, national-level guidance. A second limitation is that the survey is based on self-report data. While we acknowledge that self-reported data can be biased, this represents the most efficient method to capture responder experiences and understanding of decontamination methods. Whilst the responses may be subject to some bias, it is likely the responses reflect 'perceived best-practice' and local adaptation of response plans to address practical and logistical constraints.

Future work

There is currently no standard procedure for carrying out gross decontamination, and this is reflected in the fact that responses varied so much between participants. Future work is needed to identify optimum procedures for carrying out gross decontamination. Guidance should then be updated and standardised based on evidence from research, rather than relying on perceived best practice.

Conflicts of Interest

None declared.

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Table 1. *If casualties are unwilling to disrobe, how would you respond?* NB. Respondents could select as many options as applicable.

Procedure	No. of times selected
Allow casualties to proceed through the decontamination procedure fully clothed	**14**
Refuse to decontaminate until they disrobe	**1**
Explain the importance of disrobing in order to encourage them to disrobe	**15**
Offer a 'privacy corridor'	**18**
Other*	**7**

* See text for 'Other' strategies.

Table 2. *How do you manage groups who are unable to undress/redress themselves due to physical and/or mental health conditions?* NB. Respondents could select as many options as applicable.

Procedure	No. of times selected
Allow them to proceed through the decontamination procedure fully clothed	**11**
Have a member of your team disrobe them and re-robe them at the other end	**21**
Request help from an able-bodied casualty to assist with the disrobe process	**12**
Other*	**8**

* See text for 'Other' strategies.

Table 3. *What would you do if presented with casualties who are unable to walk (non-ambulatory) during the decontamination procedure?* NB. Respondents could select as many options as applicable.

Procedure	No. of times selected
Prioritize the decontamination of ambulatory over non-ambulatory casualties	**12**
Allocate a designated decontamination area and crew specifically to deal with non-ambulatory casualties	**34**
Send non-ambulatory casualties to hospital without decontamination	**2**
Other*	**11**

* See text for 'Other' strategies.

Figure 1: Image of a typical Ladder-Pipe System (LPS) decontamination corridor

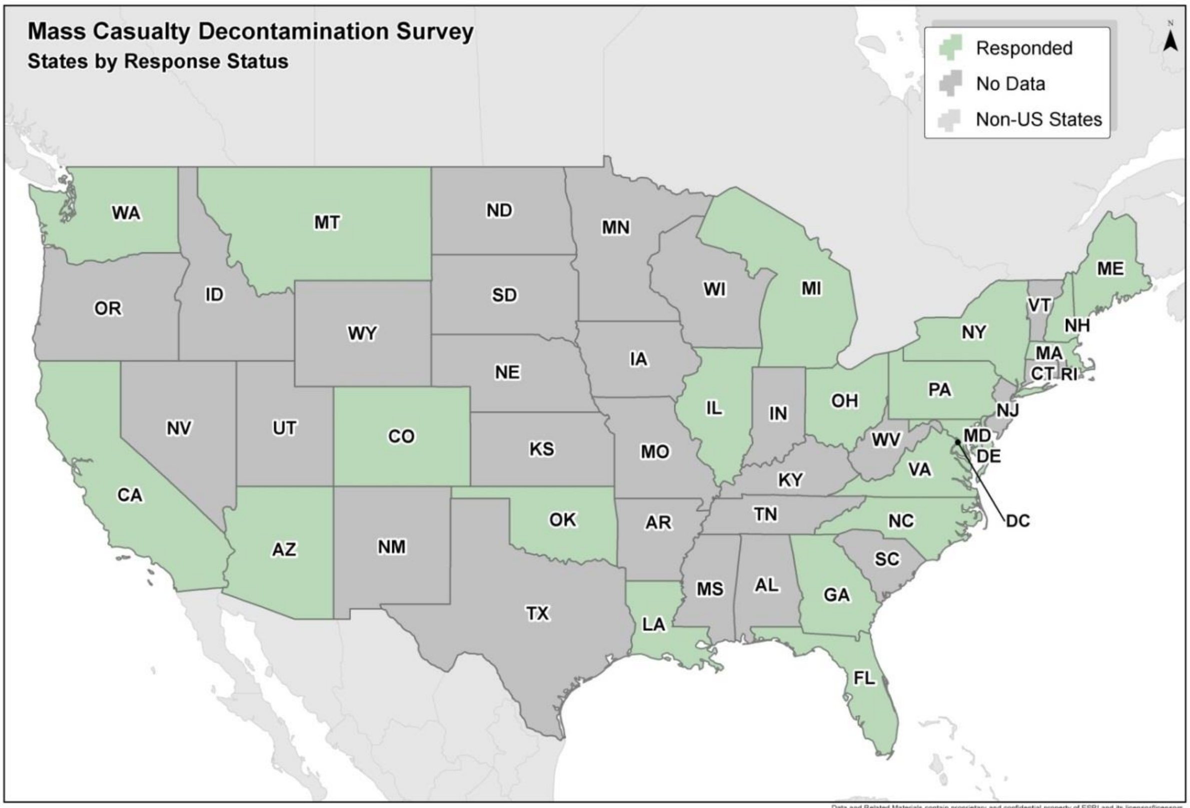

Figure 2: Locations of emergency response professionals who responded to the survey.

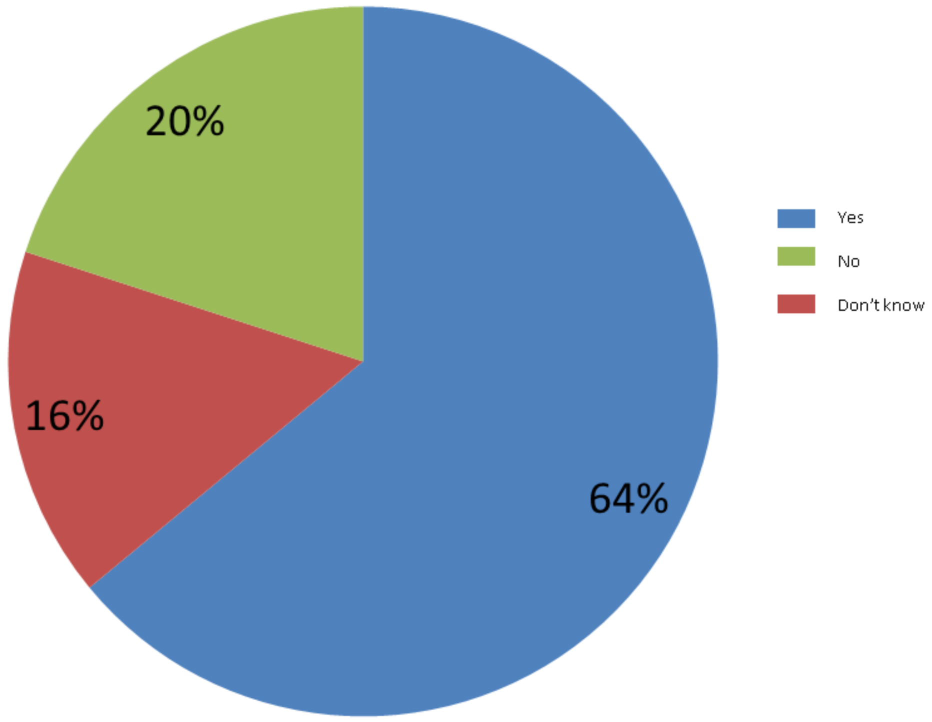

Figure 3: Percentage of responders who would ask casualties to disrobe prior to showering.

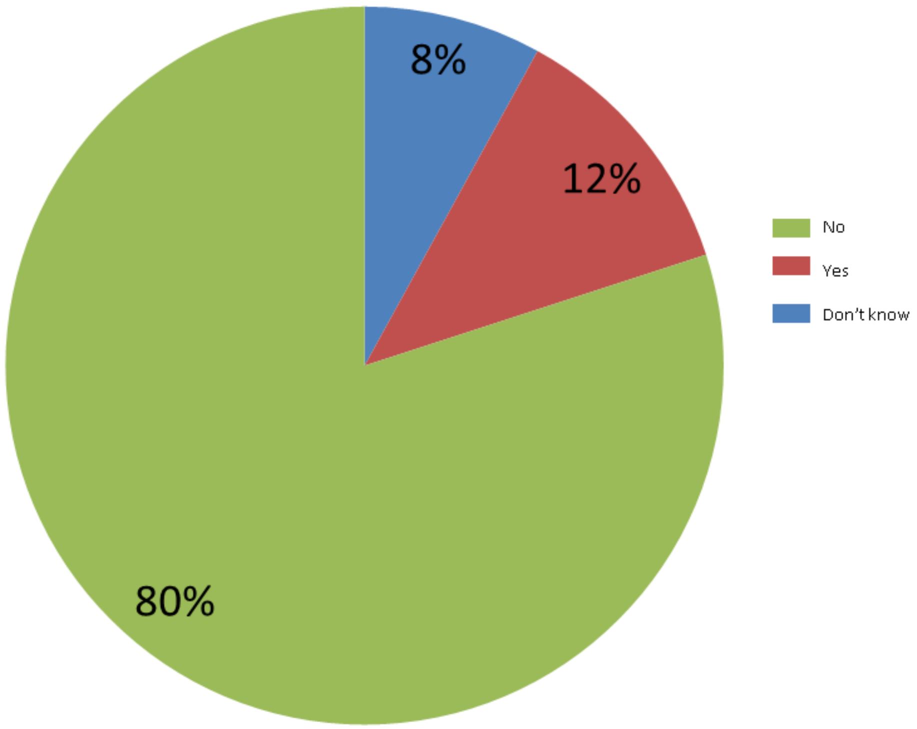

Figure 4: Percentage of responders who stated that they would be able to control the temperature of the shower water.

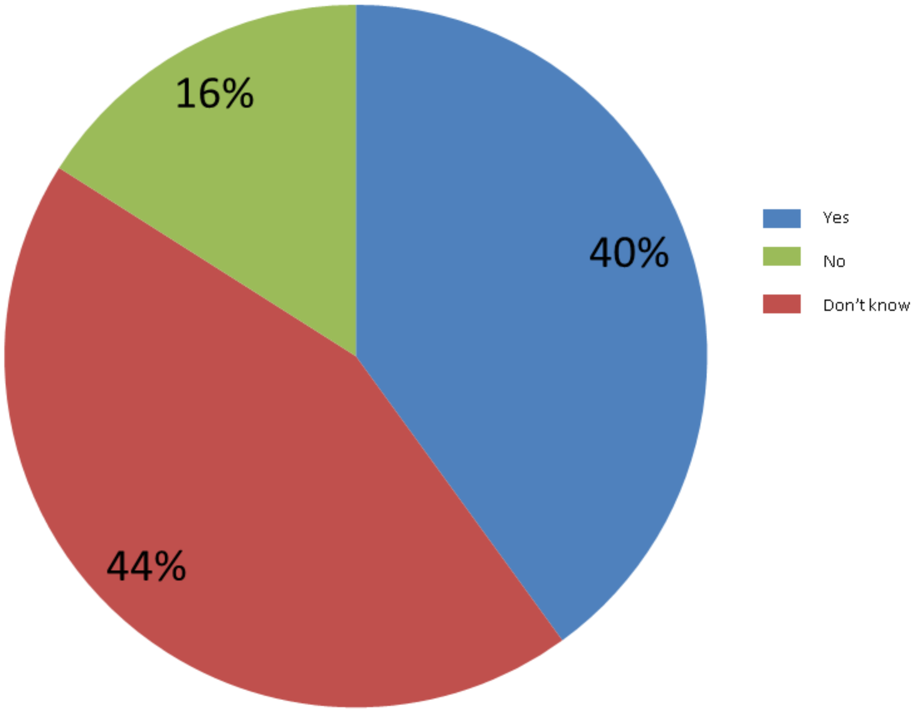

Figure 5: Percentage of responders who stated that they would be able to add detergent during decontamination.