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Nurses' and Medical Officers' Knowledge, Attitude, and Preparedness Toward Potential Bioterrorism Attacks

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Abstract

Terrorist attacks are increasingly becoming more lethal and less discriminate. The threat of bioterrorism is increasing daily. The ease of production and the broad availability of biological agents and technical know-how have led to a further spread of biological weapons and an increased desire among nations as well as terrorists to have them. Health professionals in emergency departments are expected to play crucial roles in the management of victims of bioterrorism when bioterrorism occurs. This study explored the knowledge, attitudes, and preparedness of emergency department nurses and medical officers (MOs) toward potential bioterrorist attacks in Ghana. This qualitative study utilized focus group discussions and semistructured interviews to explore the knowledge, attitudes, and preparedness of emergency department nurses and MOs toward potential bioterrorist attacks in Ghana. Data were subjected to a qualitative content analysis in which three main thematic categories were developed. These thematic categories are as follows: (a) differences in bioterrorism knowledge between emergency department nurses and emergency department MOs, (b) unprepared emergency department nurses and MOs for care during bioterrorism attacks, and (c) positive attitudes of emergency department nurses and MOs toward bioterrorism preparedness. Although emergency MOs had better knowledge of bioterrorism than their nursing counterparts, both groups of health professionals were unprepared to respond to any form of bioterrorism. Both nurses and MOs indicated the need for staff education and infrastructure readiness to be able to respond effectively to a bioterrorist attack. A well-prepared emergency department and health professionals against bioterrorism could prevent high casualty rates in a bioterrorist attack and also serve a dual purpose of dealing with other natural disasters when they occur.

Keywords

bioterrorism, preparedness, emergency, Ashanti, Ghana

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Introduction

The progress made in biotechnology and biochemistry has the potential of making biological weapons more potent than conventional and chemical weapons (Riedel, 2004). The ease of production and availability of various biological agents and technical know-how

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have led to a spread of biological weapons and an increased desire among nations as well as terrorists to have them (Cary, 2009; Riedel, 2004). Appropriate knowledge, positive attitudes, and preparedness of health professionals against bioterrorism in a lower middle-income country such as Ghana can help reduce casualty rates during an attack (Gera, Gupta, Verma, Singh, & Gupta, 2017). Although the threat of biological warfare seems remote to most countries (Das & Kataria, 2010), bioterrorist attacks such as September 11, 2001, anthrax attacks in the United States (Kearns et al., 2014; McFee, Leikin, & Kiernan, 2004; Murphy, 2004) and other available evidence shows that many countries, as well as terrorists, are rapidly acquiring biological weapons for future use against opponents (Cary, 2009). Terrorist attacks have frequently been reported in African countries such as Kenya, Nigeria, Tanzania, and Egypt. These terrorists may want to use bioagents against these nations and other nations in the future. The victims of these bioterrorist attacks may report to emergency departments in hospital facilities in countries where these attacks occur.

Ghanaian nurses and medical officers (MOs) in emergency departments should be able to detect and differentiate between bioterrorist attacks from other emergencies and respond appropriately. Apart from patients reporting from the community during periods of bioterrorist attacks, Ghanaian hospitals are vulnerable settings for bioterrorist attacks because they are set up for easy access by patients. The recent stationing of an American Army base in Ghana (The Government of the Republic of Ghana, 2018) is also a call for adequate preparations against any forms of terrorist attacks by terrorist who may want to attack an ally of the United States as such intended attacks have occurred in other African countries (Njenga, Nyamai, & Kigamwa, 2003). The preparations against bioterrorist attacks should take into account improvements in knowledge and preparedness of emergency department health professionals against bioterrorist attacks as emergency departments may be the first point of call by patients during an attack. This study utilized qualitative approaches to explore emergency department nurses' and emergency department MOs' knowledge, attitudes, and preparedness toward a potential bioterrorist attack.

Literature Review

This literature review covers the following areas: the meaning, threat, and brief history of bioterrorism; knowledge, attitudes, and preparedness of health professionals toward bioterrorist attacks; the role of health professionals in the prebioterrorism phase; the role of health professionals in the bioterrorism phase; and the role of health professionals in the postbioterrorism phase.

The Meaning, Threat, and Brief History of Bioterrorism

Bioterrorism is the intentional use of microorganisms or toxins derived from living organisms to cause death or illness in human beings, plants, or animals on which human beings depend (Friend, 2006). Although many agents can be used as biologic weapons, smallpox, plague, and anthrax are the best-known organisms for bioterrorism (Monahan, Sands, Neighbors, Marek, & Green, 2007). Bioterrorism attacks could involve the dissemination of aerosolized anthrax spores, botulism and other toxins, water or food supply contamination, aerial sprays, or direct contact with infected individuals (Monahan et al., 2007). Specific agents may be plants or animal diseases that are readily available, highly virulent, lethal, easy to aerosolize. and disseminate without harming the terrorist themselves (Monahan et al., 2007). Biological warfare threats are described as one of the three types of weapons of mass destruction (WMD): nuclear, chemical, and biological (Cary, 2009; Croddy, Wirtz, & Larson, 2005; Eitzen, 1997; MacDonald, 2005; Pitschmann, 2014). In assessments of technology requirements and cost, biological weapons have become relatively easy and inexpensive to manufacture and are considered high risk (Wagar, 2016).

A report issued by the U. S. Commission on the prevention of WMD proliferation and terrorism stated that bioterrorism is the most likely WMD threat to the world (Graham & Talent, 2010). Many analysts have supported this claim by stressing that the bioweapons field does not face the stiff technical challenges that are present in the nuclear field (Ouagrham-Gormley, 2013). While nuclear weapons require the production of fissile material that has limited civilian use and does not exist in nature, biological weapons rely on materials that are not only available in nature but can also be obtained from commercial suppliers because it has legitimate commercial or pharmaceutical uses (Ouagrham-Gormley, 2013). The use of microorganisms as bioweapons has occurred for centuries. Biological warfare was used well before the germ theory for disease was first proposed in 1530 (Lederberg, 2000). Bioterrorism had already begun 14 centuries BC when the Hittites sent infected rams to their enemies (Barras & Greub, 2014).

Infectious diseases were also recognized for their potential impact on people and armies as early as 600 BC (Eitzen & Takafuji, 1997). Polluting wells and other sources of water of the opposing army with bacteria and protozoa was a common strategy that was used by many countries in warfare (Riedel, 2004). Although the use of biological weapons has occurred for centuries, improved production techniques and genetic engineering have expanded the potential for widespread casualty rates (Monahan et al., 2007; Smeltzer, Bare, Hinkle,

& Cheever, 2008). Since the 1990s, Al-Qaeda has shown an increased interest in biological weapons by going to great lengths to set up a laboratory with pathogens in Afghanistan (Bilala & Galamas, 2015). In recent years, terrorists have also developed the interest in using bioweapons to cause panic and fear through the causation of disease. Terrorists attempted to cause a disaster with anthrax through the postal system during the 2001 terrorist attacks in the United States (Clarke, 2002; Kearns et al., 2014; McFee et al., 2004; Murphy, 2004). Recent events such as the disappearance of vials containing the severe acute respiratory syndrome virus from a French laboratory or the alleged selling of the toxin *abrin* through a black market website confirm that there is no place for unpreparedness or passive attitudes when it comes to bioterrorism preparedness (Lupkin, 2014; Wigglesworth, 2014). Terrorist attacks are increasingly becoming more lethal and less discriminate (Bilala & Galamas, 2015). Although governments and policymakers in Africa may be of the view that issues of bioterrorism should only be the concern of developed countries, evidence available shows that there has been and continue to be occurrences of terrorism in African countries such as Kenya, Tanzania, and Nigeria. The frequency with which Ebola is occurring in Africa raises concerns about accessibility to the virus and human usages of the virus for harmful purposes (Teckman, 2013). The increase in natural outbreaks of Ebola in the African region, coupled with a possibility of a terrorist group recruiting experts to acquire the virus and to prepare it for use as a bioweapon, should make policymakers and governments consider preparedness toward the risk of a deliberate outbreak (Teckman, 2013). Improving emergency departments preparedness and response against potential bioterrorism is important especially in Africa where there are weak surveillance systems and weak political capacities to respond to the proliferation of bioweapons (Teckman, 2013).

Knowledge, Attitudes, and Preparedness of Health Professionals Toward Bioterrorist Attacks

The use of bioweapons by terrorists in attacking nations and their people has become a real possibility (Das & Kataria, 2010). Many countries across the world are also developing biological weapons for potential usage in future warfare (Tucker, 2013). Health professionals must have the knowledge and be prepared to care for patients of bioterrorism attacks in the event of such attacks. Although biological warfare was used well before 1530 (Lederberg, 2000), the preparedness of health-care systems against bioterrorism has been found to be inadequate in many countries. In a study to assess bioterrorism competencies among health practitioners in Australia, many clinicians consistently self-assessed themselves as lower in competence, and clinicians with medical degrees self-assessed themselves as the lowest in bioterrorism competence (Canyon, 2009). In a recent study that assessed knowledge, attitudes, and preparedness of some health workers in Iran, it was concluded that there was poor knowledge, inappropriate attitudes, and inappropriate levels of preparedness among health professionals (Moghadam, Pour, Toorchi, & Heris, 2016). Related studies have found positive effects of bioterrorism education on knowledge, attitude, preparedness, and confidence of health professionals regarding care of clients exposed to bioagents (Aghaei & Nesami, 2013; Gershon et al., 2004). Although studies regarding knowledge, attitudes, and preparedness of health professionals in Africa have been lacking, some evidence suggests that there is the possibility of bioterrorist attacks with the use of the Ebola virus (Cenciarelli et al., 2015).

It is necessary to prepare health professionals in Africa toward improved care of patients during bioterrorism attacks. The preparedness of health professionals will largely depend on their knowledge and attitudes toward bioterrorism preparedness. Some improvements in the preparedness of health-care systems against bioterrorism only started in some developed countries when anthrax was posted to some top officials during September 11, 2001, attacks in the United States (Clarke, 2002; Kearns et al., 2014; McFee et al., 2004; Murphy, 2004). Overall, biological weapons are easily obtained and easily disseminated, and they result in significant mortality and morbidity (Smeltzer et al., 2008). The potential use of biological agents calls for continuous increased surveillance by health departments and an increased index of suspicion by clinicians (Smeltzer et al., 2008). Programs such as Bioterrorism Hospital Preparedness Program in the United States which is aimed at offering national guidance and financial support to state- and local-level agencies against bioterrorism should be replicated across African countries (Office of the Assistant Secretary for Preparedness and Response, Hospital Preparedness Program, 2012). The Bioterrorism Hospital Preparedness Program was originally focused on building capacity in pediatric departments, trauma units, and burn care centers, in response to a terrorist attack (Kearns et al., 2014; Office of the Assistant Secretary for Preparedness and Response, Hospital Preparedness Program, 2012). Bioterrorism planning efforts usually include planned development, revision of emergency medical services, extensive education, protocols, destination guidelines, and hospital coordination (Kearns et al., 2014). All of these efforts contribute to an effective response and positive patient outcomes during periods of bioterrorism (Kearns et al., 2014). Although some researchers in developed countries have shown interest in conducting studies into

emergency department preparations toward bioterrorism preparedness, the case of Africa is quite different. Published articles on the subject of bioterrorism preparedness of health professionals in Africa were found to be lacking.

The Role of Health Professionals in the Prebioterrorism Phase

Prebioterrorism phase is the period preceding the occurrence of a bioterrorist attack. Although the current literature on bioterrorism does not report bioterrorist acts within hospital facilities in Ghana, hospitals can be vulnerable settings for bioterrorist attack as they are set up for easy access by patients. Clinical staff must be on the alert because bioterrorists may also use this receptive nature of hospitals to cause attacks in the future. Effective disease surveillance, communication systems, adequate epidemiologic, and laboratory capacity are fundamental components of the emergency department during the prebioterrorism phase (Das & Kataria, 2010; Wagar, 2016). Syndrome surveillance within hospital facilities in which electronic symptom data were continuously analyzed for signals could indicate an outbreak requiring a response (Das & Kataria, 2010). Syndromic surveillance systems seek to use existing health data in real time to provide immediate analysis and feedback to those charged with investigation and follow-up of potential outbreaks (Das & Kataria, 2010).

Large-scale vaccinations against organisms of bioterrorism can be used by emergency departments to prevent the devastating effects of bioterrorism during attacks (Henning, 2004; Mandl et al., 2004; Sosin, 2003). Local planning by health facilities is a critical component of the role of health professionals in the prebioterrorist phase. Health professionals need to be aware of planning issues and be able to identify their roles in emergency situations and also show functional competence (Canyon, 2009). Planning should include evaluation of laboratory facilities and upgrading of same, evaluating hospital preparedness in emergency response and case management in case of an imminent attack (Das & Kataria, 2010). It may also include conducting training of health professionals, forming a rapid response team (RRT) and quick response medical team who would be the first responders. There is the need to also work out legal provisions and ensure the requirement of safe drinking water and adequate stocks of medicines and vaccines in the planning stages (Das & Kataria, 2010). Other critical components in planning toward a possible bioterrorist attack are coordination with security organizations, organization of mock drills for health professionals, and preparing contact details so that communications are unhampered during an attack (Das & Kataria, 2010). The public should be informed about possible attacks so that voluntary reporting is encouraged (Das & Kataria, 2010). It is important to carry out a review of situations based on current information on threat perceptions (Das & Kataria, 2010). Close collaboration between the clinical and public health community is critical to minimizing the effect of a potential bioterrorist attack (Das & Kataria, 2010).

The Role of Health Professionals in the Bioterrorism Phase

In this phase, RRT and quick response medical team s are activated to ensure rapid epidemiological investigation, quick laboratory support, mass casualty management, initiation of preventive, curative, and specific control measures for containing further spread of the disease (Das & Kataria, 2010). In this phase, an incident commander is usually selected to direct all bioterrorist response operations (Das & Kataria, 2010). Response operations for mass casualties are conducted in accordance with the disaster or emergency plan that was prepared in the prebioterrorism phase (Das & Kataria, 2010). Health professionals must assess situations, contact key emergency personnel in the facility, and implement action plans (Das & Kataria, 2010). Testing for suspected organism must be quickly done (Das & Kataria, 2010; Wagar, 2016). Tented hospitals may be set up to contain the outbreak (Das & Kataria, 2010; Terndrup & Nafziger, 2016). Methods to control disease and quarantine measures are instituted (Brannen et al., 2016; Das & Kataria, 2010; Terndrup & Nafziger, 2016). Once the disease is identified, treatment protocols are communicated and sent to all concerned by the fastest possible means (Das & Kataria, 2010; Mckinney, Wesley, Sprang, & Troutman, 2005). Standard operating procedures for laboratory testing are made available for implementation, and laboratory reagents are quickly distributed to the concerned laboratories (Das & Kataria, 2010). The public should be reassured to prevent any form of panic (Das & Kataria, 2010). All contaminated clothing and equipment are usually disposed of by incineration (Das & Kataria, 2010).

The Role of Health Professionals in the Postbioterrorism Phase

Any setbacks that occurred as a result of the bioterrorist attack are restored and lessons learned in this phase are incorporated in future preparedness plans toward a bioterrorism attack (Brannen & Stanley, 2004; Das & Kataria, 2010). Any damage done to the public health facilities and the essential items utilized during the response phase are replenished (Das & Kataria, 2010). The RRTs compile and analyze data to identify the deficiencies experienced in the implementation of the

response measures (Das & Kataria, 2010). The necessary changes are then incorporated in the contingency plan for possible future attacks (Mandl et al., 2004).

Methods

Design

A qualitative explorative descriptive design was used in carrying out this study. A qualitative study, rooted in a philosophical tradition, is an approach to explore people's everyday life experiences (Polit & Beck, 2010). The qualitative study design was chosen to explore the knowledge, attitude, and preparedness of Ghanaian emergency department nurses and MOs in bioterrorism.

Research Questions

This study was guided by the following research questions:

1. What do emergency department nurses and emergency department MOs know about bioterrorism?
2. What are the attitudes of emergency department nurses and emergency department MOs toward bioterrorism preparedness?
3. How prepared are emergency department nurses and emergency department MOs toward potential bioterrorism attacks?

Sample

This study was conducted in six selected hospitals in the Ashanti Region of Ghana. There are 25 district hospitals located in the Ashanti Region (Ghana Health Service, 2015). Six emergency departments in the Ashanti Region were included as sites for this study. The sites for the study were selected based on predetermined criteria. A purposive sampling technique was utilized in selecting 60 emergency department nurses and 15 emergency department MOs for focus group discussions (FGDs) and semistructured interviews, respectively. Almost all hospitals in the region have emergency departments. These emergency departments are mainly staffed by Registered General Nurses (RGNs) who are usually supported by health assistants (Atakro, Gross, Sarpong, Armah, & Akuoko, 2018). The study population was RGNs and MOs who worked in emergency departments of selected hospitals in the Ashanti region for a year or more. Only RGNs and MOs who had valid professional identification numbers (PINs) were involved in the study. All participants were aged between 24 and 65 years. Table 1 shows the total number of nurses and MOs who were working in the various emergency departments of selected hospital sites during the period of the study.

Table 1. Total Number of Nurses and Medical Officers in ED.

Hospital	Total number of ED nurses by hospital site	Total number of ED medical officers by hospital site
Site 1	25	5
Site 2	30	4
Site 3	25	6
Site 4	24	6
Site 5	23	5
Site 6	25	5
Total	152	31

Note. ED = emergency department.

Inclusion or Exclusion Criteria

All hospitals included in the study had emergency departments with a minimum bed capacity of 20 beds. Only RGNs and MOs who were working in selected emergency departments and had active PINs were included in the study. All other categories of nurses or MOs who were working in emergency departments but were not RGNs or MOs with active PINs were excluded from the study.

Institutional Review Board Approval and Informed Consent

The study was approved by the committee on human research, publication, and ethics of Kwame Nkrumah University of Science and Technology with reference number CHRPE/AP/368/18. Administrative approval was sought and granted by hospitals where the study was conducted. The study was explained to participants who were involved in the study. Anonymity and confidentiality were explained to participants who were assured that withdrawal will not in any way attract sanctions. Consent forms were signed by participants after necessary explanations of consent procedures. Participants were identified with codes to maintain anonymity and confidentiality. The study did not cause any physical or psychological harm to any participant. Consent to publish was also granted by participants.

Data Collection

Data were collected in six selected emergency departments in the Ashanti region. Purposive sampling technique was used to select hospitals and recruit emergency department nurses and emergency department MOs for FGDs and semistructured interviews. Data collection started after ethical clearance was granted by the committee on human research, publication, and ethics of Kwame

Nkrumah University of Science and Technology with reference number CHRPE/AP/368/18. Consent procedures were explained to participants before the start of data collection. All participant signed informed consent forms for data collection and publication. A total of 60 emergency department nurses and 15 MOs were involved in FGDs and semistructured interviews. The sample size for FGD and semistructured interviews was determined by qualitative data saturation. Data collection spanned a period of 2 months from January 2018 to February 2018. Inclusion criteria were nurses and MOs who had worked within emergency departments for a year or more. FGDs were mostly conducted in nurses' restrooms and conference rooms after they had closed from their shifts. Semistructured interviews were mostly conducted in restrooms and offices of MOs. Nurses were involved in 12 FGDs with each group consisting of five emergency department nurses. Participants' names were represented by alphabets and numbers in order to ensure anonymity and confidentiality: FGEDN1 (focus group emergency department nurse 1) and IMO2 (MO 2 involved in a semistructured interview). Attitude and preparedness questions were asked after bioterrorism was explained to nurses as almost all of them indicated that they did not know about bioterrorism. Similar explanations were done for the minority of MOs who demonstrated inadequate knowledge in bioterrorism.

Data Analysis

Holloway and Wheeler's (2010) data analysis pattern was used during data analysis. This pattern takes the following form: validating, transcribing, cleaning, and coding data. The researchers employed the following activities: transcription, validation, cleaning, and coding. Themes were developed through content analysis of data collected. The team of researchers who collected the study data came together to transcribe data from audio recordings. Transcripts were read several times by the team to identify codes. The team used similar code to create families and similar families were grouped together as themes. Themes were discussed by all researchers to make sure they reflected the phenomenon that was captured during the data collection. Some participants were also consulted to make sure the themes that were developed represented their views. Participants were identified with alphabets and numbers in order to maintain anonymity: FGEDN1 and IMO2.

Rigor

The interview guide for this study was pretested on five emergency department nurses and three emergency department MOs in similar health facilities. The pretest helped researchers to modify questions for clarity. The pretest also helped to ensure that the data collected answered the research questions. The research team had prolonged interactions with the participants to ensure an in-depth understanding of emerging findings. Data transcriptions and coding were done by the research team which included two nursing education experts to ensure that the correct experiences and views of the participants were reported. Discussion of themes was done by the research team to ensure correct representations of participants' views. Study participants were consulted for their comments on themes to make sure it represented their views.

Results

Sample Characteristics

See Table 2.

Thematic Results

Three main thematic categories were extracted from data. These thematic categories are as follows: differences in bioterrorism knowledge between emergency department nurses and emergency department MOs, unprepared emergency department nurses and emergency department MOs for care during bioterrorism attacks, and positive attitudes of emergency department nurses and emergency department MOs toward bioterrorism preparedness.

Differences in bioterrorism knowledge between emergency department nurses and emergency department MOs. Differences in bioterrorism knowledge between nurses and MOs were found in this study. While nurses demonstrated lack of knowledge about bioterrorism, almost all MOs had a good idea about bioterrorism. MOs were more current on global and regional issues of bioterrorism when compared with emergency department nurses. This thematic category had two subthemes: lack of bioterrorism knowledge by emergency department nurses and a good idea of bioterrorism by emergency department MOs.

Lack of bioterrorism knowledge by emergency department nurses. Almost all emergency department nurses demonstrated inadequate knowledge of bioterrorism. Many of them indicated that they have never heard or have never been taught anything regarding bioterrorism and could not explain what it was. The lack of bioterrorism knowledge is shown in the following statements by emergency department nurses:

> What is that? What is it about? I have not been taught anything like that. May be you will need to explain what

Table 2. Demographic Characteristic of Participants.

Variables	ED nurses *N* (%)	ED medical officers *N* (%)
Gender		
Male	19 (31)	10 (67)
Female	41 (69)	5 (33)
Age		
20–24	2 (3)	—
25–29	20 (33)	4 (27)
30–34	18 (30)	3 (20)
35–39	7 (12)	3 (20)
40–44	5 (8)	2 (13)
45–49	5 (8)	1 (6.7)
50–54	2 (3)	1 (6.7)
55–59	1 (2)	1 (6.7)
Religion		
Christianity	45 (75)	10 (67)
Islam	15 (25)	5 (33)
Marital status		
Single	38 (63)	5 (33)
Married	20 (33)	10 (67)
Divorced	2 (3)	—
Educational level		
Diploma	41 (68)	—
Degree	17 (28)	11 (73)
Masters	2 (3)	4 (27)
Number of working years in ED		
1–4	30 (50)	7 (47)
5–9	12 (20)	3 (20)
10–14	5 (8)	1 (7)
15–19	4 (7)	2 (13)
20–24	3 (5)	1 (7)
25–29	4 (7)	1 (7)
30–34	2 (3%)	—

Note. ED = emergency department.

> it is to us because I have completely no idea about it. [FGEDN1]
>
> Bio . . . what? Where is that one also coming from? I have not heard that before. Our teachers did not teach us anything around that topic as far as I can remember. It is a term I am trying to see whether I can remember. [FGEDN31]
>
> Honestly I don't know what that is. I don't deal with anything like that here so I can't tell you what it is. I am not sure any of us can explain that to you. [FGEDN40]

A good idea of bioterrorism by emergency department MOs. In a sharp contrast with the inadequate knowledge demonstrated by nurses, MOs had good idea of bioterrorism. Many MOs said that they had heard about bioterrorism when they watched, listened, or read the international news.

> Yes, during George Bush era, I heard of it as basically the use of poisonous organisms to cause harm to individuals or countries. Also in Syria, during the war, people were attacked with it and Saddam Hussein too used it. I have been reading through the internet, news that is times magazine, news week and I get to hear these things. (IMO2)
>
> I know about it. They are biological agents which are used for terrorism to harm people. These are usually used by people who want to terrorise other people for political reasons. You hear these things when you read the news or listen to CNN and stuff. (IMO4)

Unprepared emergency department nurses and MOs for care during bioterrorism attacks. In this study, both emergency department nurses and emergency department MOs were found to be unprepared for the care of patients during the times of bioterrorism. Nurses did not have knowledge of bioterrorism but stated that they were not prepared after the concept of bioterrorism was explained to them. Although MOs had knowledge about bioterrorism, they indicated that they have never been prepared for a bioterrorism response. The theme of unpreparedness by nurses and MOs had four subthemes. These four subthemes are as follows: lack of bioterrorism sensitization through research and training, a continuous struggle to overcome common health problems as contributing factor to bioterrorism unpreparedness, lack of a hospital surveillance system for bioterrorism, and preference for reactive leadership in preventing disasters.

Lack of bioterrorism sensitization through research and training. All participants indicated that there had never been workshops or any form of training in bioterrorism at their various health facilities. Participants stated that one of the main reasons for their unpreparedness was inability of health authorities to sensitize them through training and research. Participants were of the view that more research needs to be conducted in the area of bioterrorism in order to develop surveillance systems that can protect citizens in times of bioterrorism. They believed dissemination of bioterrorism research in Ghana will help create awareness about the dangers of unpreparedness. These concerns were expressed in the following statements:

> We are not prepared at all. We do not do any research in bioterrorism in Ghana. Our researchers here should conduct research into the topic of bioterrorism so that people can see the need to prepare our system.

We should be trained as well. We can't handle such issues if we are not trained. There must be some experts that will help us. (FGEDN32)

As for preparedness, we are not. There is no training in our schools on that and even when we completed we were not taken through anything like that. I did my rotation here and after that I started working here. Since then our managers did not tell us anything about preparing for a potential bioterrorism. Many be it is because our researchers too don't look in that direction. We may be able to detect when researchers show us how we can do that. (FGEDN42)

As for being prepared for something like bioterrorism, we are not. There was no school training and there were no workshops as well. The whole system is not prepared, not only people working in the hospital. There is no public sensitization or conferences on this topic. How can we be prepared when people who should be talking about this things are not doing so? The researchers must research and create the awareness for us to get into it. (IMO3)

I don't remember out managers ever talking about something like bioterrorism. I don't think they even think about the possibility of bioterrorism in Ghana. I think they have never considered training us. There is no research on bioterrorism here and so no training too. We have no training and our surveillance and techniques against bioterrorism not properly done. (IMO6)

A continuous struggle to overcome common health problems as contributing factor to bioterrorism unpreparedness. Many participants said as it was difficult for Ghanaian leaders to help fight common problems such as malaria, illegal mining, and cholera effectively. Therefore, they will not consider any preparations for a possible bioterrorist attack which looks to be a remote occurrence. However, participants were confident that the organization of workshops will happen when Ghana is attacked with a bioweapon. These concerns were seen in the following statements by nurses and MOs:

Not prepared because in terms of fighting against common illnesses, the country's preparation is just about 50% and not even 100%. Should anything like bioterrorism happen, it will be difficult to deal with. If it happens, before we realise that it is bioterrorist attack, it would have already spread. Our system is such that we always wait for the thing to happen before we take action. (FGEDN28)

No, we are not prepared against bioterrorism. Even those conditions we have identified such as malaria, and meningitis are not well dealt with. So I think we are not prepared and well equipped. These are old problems and they still exist with us. I think our leadership is finding things difficult with planning. (FGEDN41)

We are not prepared at all. Our focus is on how to get the necessary thing for the usual problems we face such as malaria and cholera. Even for malaria and cholera, we don't have all that we need, how can we prepare professionals and the system for something like bioterrorism. We need the preparation but it will not happen anytime soon. (IMO8)

I have not been trained in any way in my practice of medicine. It is not a trending topic in Ghana. In Ghana, we cannot even fight cholera or galamsey not to talk of bioterrorism. I am sure if one happens, then the health service will organise workshops on it and try to prepare the system. I see it as a very distant program. (IMO1)

Lack of hospital surveillance system for bioterrorism. Lack of hospital surveillance systems was cited as a reason for the unpreparedness of emergency department nurses and MOs in bioterrorism. Participants indicated that it was impossible for them to detect any act of bioterrorism due to the lack of hospital surveillance systems in their hospitals. Participants believed that technology will need to improve regarding detection of bioterrorism in Ghana. These concerns were described in the following statements:

No we are not prepared because we do not research into certain issues such as this and the level of technology in the country is poor so it will be difficult to detect such attacks. I am not sure we have experts here to really deal with it when it happens. The system must be developed for it otherwise before we realise many people will die. (FGEDN6)

We can't detect it when it happens because there is no system for that. As for Ghana it is God who is protecting us. We always wait for the thing to happen. There should be technology to detect such things. Our researchers should help us develop a system to detect something like that. (FGEDN40)

No we are not prepared as doctors. I think the whole nation is not prepared so how can doctors be prepared. I have not had any formal training on bioterrorism. I just hear about it in the foreign news. We do not have the requisite or necessary infrastructure to even detect a bioterrorist attack. We have to put in place the necessary infrastructure by training health and security personnel on how to detect an attack and also having a system will help. (IMO10)

No, not at all prepared. There are no materials and not enough protective clothing to even wear in situations like that. Technology to detect such things are not also

> unavailable. How are we expected to prevent such attacks where the system is not available? I believe in other countries, they will have such systems. Let's learn from them. (IMO15)

Preference for reactive leadership in preventing disasters. Majority of participants stated that health sector leaders will only take steps against bioterrorism when Ghana is attacked by a bioweapon. Almost all participants agreed that health authorities are more reactive than proactive when it comes to preventing disasters. The preference for reactive leadership as cause of bioterrorism unpreparedness is expressed in the following statement by participants:

> In Ghana, we only try to handle the issue when it occurs. We want to see the disaster happen and kill many people before we are moved. It happens even with our flooding system. Every year when there is flooding then we try to do something about it. That is how our leaders operate. It is not right but that is our system. I can assure you that when we experience a bioterrorist attack, our leaders will then start organising workshops and setting the system up. (FGEDN29)
>
> The problem is the way we see things in Ghana. We react to the problem. The problem of bioterrorism is expected to happen before our leaders will take action. It is unfortunate but that is the truth. Even if we create the awareness, I believe many of our leaders will still give excuses and say we don't have money, but you will see them wasting money on unnecessary thing. (IMO9)
>
> As for our system, it is more reactive. We wait for the disaster to occur, then we start synpathising with the victims and them we forget in a few month until another disasters happens. It happens here all the time in terms of fires and flooding. I assure you that when bioterrorism takes place, our leaders will then start to do something about these things. (IMO7)

Positive attitudes of emergency department nurses and MOs toward bioterrorism preparedness. Majority of emergency department nurses and emergency department MOs demonstrated positive attitudes toward bioterrorism preparedness in Ghana. Participants indicated that there is bound to be massive casualty rates if the health-care system and professionals are not prepared for such potential eventualities. Many participants recommended training in surveillance and early detection of bioterrorist attacks to minimize the effect of bioterrorism. Many participants also said that it is necessary to prepare for any potential bioterrorist attacks because a number of terrorist groups are present within the West African subregion. Participants believed that the presence of terrorist groups such as Boko-haram and Al-Qaeda in Africa is a call for adequate preparedness against bioterrorism by African countries. They also indicated that as many nations are also arming themselves with WMD, Ghana must be prepared and ready to respond to such attacks by having good surveillance systems and caring for victims of such attacks. Participants described the need to prepare for possible bioterrorist attacks in the following statements:

> Yes it is necessary to set up a place for such attacks because should it happen, it will have a devastating impact on the populace. I think it is necessary because where the world is going, we need to be ready for anything. There are more terrorist groups in the world and Africa now. They may want to attack nations with a bioweapon. I think we should do more research about it and know how to avoid it. (FGEDN19)
>
> It is necessary to prepare because the world is heading in a direction where nations are fighting for supremacy because of resources to develop their respective countries so they can cause such attacks to gain control over countries who are endowed with gold, timber, and diamond and so on. I heard a similar thing happened in Adolf Hitler's time where he poisoned the Jews. A similar thing can happen in the future. We need to have systems that will detect such things. (FGEDN58)
>
> We should prepare because if it happens, there will be a lot of casualties. We should be able to identify and suspect attacks. We should also be trained on how to manage such cases. (IMO5)

Participants believed that terrorist groups will start using unconventional means of attacking nations once they realize that conventional systems of attacks have been blocked by nations. Physical structures and human resource preparations were the two areas emphasized by many participants. They indicated that appropriate physical structures without the training of the human resource will not result in needed changes regarding bioterrorism preparedness. Participants mentioned research as one way of gaining more knowledge and preparing against bioterrorism. Positive attitudes toward bioterrorism preparedness were demonstrated through the following statements by emergency department nurses and emergency department MOs;

> It is important to get prepared. Awareness creation among the general public and health personnel and security personnel is very important. There should be improvement in technology. There should be further research on such topics so that they can come out with the need to create places for such attacks. We should intensify education and support cooperation among health team and general public. (FGEDN54)

> We have to prepare against bioterrorism but it should not just be about the structure or buildings. The greatest resource we can have is human resource. We should create the awareness so that personnel are trained on bioterrorism. It will go a long way to help us to identify such problems when they come and it will also benefit other people and help us prepare well and have a fair knowledge should it happen. (IMO3)
>
> Yes it is necessary to set up the system because of how the sub-region is becoming. There is heightened security issues in the sub-region. Al-Qaeda is causing terrorist actions in Algeria and Mali, destroying a lot of centres. Also Islamic state is having branches in West Africa which we have heard some of our school graduates are even joining. Boko-haram has pledged allegiance to Islamic state so once they realise that the normal ways of breaching security and attacking are now blocked or difficult, they will use unconventional ways to circumvent the system. So it makes it very important to set up the place against bioterrorism. (IMO1)

Discussion

This study sought to explore the knowledge, attitudes, and preparedness of emergency department nurses and emergency department MOs in Ghana toward bioterrorism. Although there is some literature regarding knowledge, attitude, and preparedness of health workers in other parts of the world, findings in this study revealed a perspective of a lower middle-income African country. Even though common themes emerged from the perspective of MOs and nurses, it was interesting to note that there were differences in knowledge in terms of what nurses knew and what MOs knew about bioterrorism. MOs had better knowledge of bioterrorism than their nursing counterparts. Despite the differences in knowledge, there were similar findings regarding unpreparedness for a potential bioterrorist attack and positive attitudes toward bioterrorism preparedness. Although researchers in this study did not find studies that compared knowledge of nurses and MOs in bioterrorism in Africa or Ghana, there were studies in other parts of the world that assessed knowledge of nurses, medical students, dentists, and MOs in bioterrorism (Aghaei & Nesami, 2013; Canyon, 2009; De Felice, Giuliani, Alfonsi, Mosca, & Fabiani, 2008; Kabir, Naik, Kumar, & Bhas, 2016; Katz et al., 2006a, 2006b; Menon, Parkash, Srivastava, Nagarajappa, & Tangade, 2010; Moshagh-Eshgh, Aghaei, & Majd, 2007; Rose & Larrimore, 2002). These studies had dissimilar conclusions. The studies that assessed nurses knowledge in bioterrorism found low levels of knowledge of nurses in bioterrorism (Aghaei & Nesami, 2013; De Felice et al., 2008; Katz et al., 2006a, 2006b; Moshagh-Eshgh et al., 2007; Rose & Larrimore, 2002). A study in Malaysia by Kabir et al. (2016) found that more than 60% of medical students had knowledge of bioterrorism and majority could mention the main organisms that could be used as bioweapons. However, only 40% of dentists in India had knowledge of bioterrorism (Menon et al., 2010). Although authors did not find previously published research that assessed knowledge, attitudes, and preparedness of health professionals in Ghana, it was realized in this study that MOs were more knowledgeable in bioterrorism as a result of being current with global issues. They seem to watch, listen, and read more news than their nursing counterparts. Many MOs indicated that they knew about bioterrorism from the international media. Nurses could also be encouraged to be concerned about global issues. These attributes can be inculcated from nursing school and facilitated by nursing tutors or lecturers. The curriculum of nurses should also be planned in a way that will make nurses have an interest in current global and regional health issues. Evidence available shows that training of health professionals in bioterrorism can improve their knowledge (Aghaei & Nesami, 2013; Gershon et al., 2004). Adequate knowledge of bioterrorism by health professionals could gradually lead to a well-prepared health workforce that will be ready to adequately care for patients during times of bioterrorism. In Australia, many clinicians self-assessed themselves as lower in bioterrorism competence and clinicians with medical degrees self-assessed themselves as the lowest in bioterrorism competence (Canyon, 2009). Participants in this study cited inability to manage older health issues facing Ghana, unavailable of surveillance systems, lack of research and training in bioterrorism, and a reactive leadership as contributing factors to unpreparedness toward bioterrorism in Ghana. Starting a conversation and some level of preparation toward bioterrorism may not demand huge financial commitments from health managers. Partnering with academicians to train nurses and doctors in bioterrorism will be an inexpensive but useful activity toward preparing Ghanaian health facilities and its personnel toward a potential bioterrorist attack. Setting up committees to create awareness and start some level of preparation toward a potential bioterrorist attack is another inexpensive but useful activity because such a system can also be used to fight other naturally occurring disasters. Continuous professional development programs should be instituted to create the awareness of Ghanaian health professionals toward bioterrorism preparedness in health facilities. Participants seem to support these measures when they stated that a mere physical infrastructure will not bring about the needed change in bioterrorism preparedness. A computer syndromic surveillance system could be integrated into existing health management systems in Ghana. Syndromic surveillance systems seek to

use existing health data in real time to provide immediate analysis and feedback to those charged with investigating and following up on potential outbreaks (Henning, 2004). Preparation for bioterrorism should be proactive in nature rather than a reactive one. Many participants said that measures may only be put in place by Ghanaian authorities when bioterrorism occurs as authorities seem to be more reactive rather proactive in such cases. Situations, where ad hoc measures are put in place after disasters happen, should begin to change to prevent high casualty levels. Inadequate preparation toward bioterrorism seems to be a global problem (Canyon, 2009; Katz et al., 2006a, 2006b; Moghadam et al., 2016). The events of September 11, 2001, and the anthrax crisis that followed tested the capabilities of the public health system of the United States and showed its fragility (Morse, 2002). Emergency departments are first points of call when harm is caused by disasters. Emergency department staff should be prepared through drills to get them ready for any possible bioterrorist attack. Evidence suggests that regular disaster exercises have beneficial effects on subsequent actual disaster responses (Klein, Brandenburg, Atas, & Maher, 2005). Standardized protocols should be developed by the Ghana Health Service and tested through drills. Short of having an actual emergency or disaster plan to test plans, drills, or exercises is the only way to predict whether the implementation of plans will be effective in an actual disaster or emergency (Klein et al., 2005). There is also a need for funding support for bioterrorism preparedness in many jurisdictions (Fraser & Brown, 2000; Sidel, Gould, & Cohen, 2002). Governmental and other funds for bioterrorism preparedness would be useful if an event were to occur and, even if it did not, would be useful to strengthen medical and public health infrastructure, so they can respond effectively to other naturally occurring emergencies—a so-called dual-use strategy (Fraser & Brown, 2000; Wetter, Daniell, & Treser, 2001). Laboratory systems, availability of medicines, and public health education should be improved in readiness for a potential bioterrorist attack. Health-care providers could be vaccinated against the major microorganisms that can be used in bioterrorism to make them ready to care for clients without fear of being infected. There were inconsistent findings on attitudes toward bioterrorism preparedness by researchers. A study in Iran concluded that health professionals had inappropriate attitudes toward bioterrorism preparedness (Moghadam et al., 2016). Another study in the same region found that 96.9% of nurses were indifferent toward bioterrorism preparedness (Moshagh-Eshgh et al., 2007). A study in India found positive attitudes of dentists toward bioterrorism preparedness (Menon et al., 2010). Training emergency department health professionals in Ghana will not be a difficult task as emergency department MOs and emergency department nurses demonstrated positive attitudes toward the need to prepare toward any potential bioterrorist attacks. More research in bioterrorism needs to be conducted in Ghana in order to recommend localized systems that can help detect bioterrorism and care for patients of bioterrorist attacks. This systems will help Ghana in fighting possible bioterrorism and other natural disasters such as Ebola should they occur.

Strengths and Limitations

Although this study seems to be the first in the sub-Saharan African region to explore knowledge, attitudes, and preparedness of emergency department nurses and emergency department MOs, there are some associated limitations. The study was qualitative in nature and was conducted in Ashanti region, which is one of the 10 regions in Ghana. Although generalization is not entirely impossible in qualitative research, a further quantitative study covering many more regions in Ghana would help provide a more general perspective. However, evidence has shown that while generalization is not entirely impossible in a qualitative study, it is not the main aim of qualitative study (Myers, 2000). This study utilized FGDs and semistructured interviews to collect data from 75 participants. This was done to arrive at results that formed a total phenomenon of knowledge, attitudes, and preparedness toward bioterrorism in the Ashanti region. Qualitative rigor procedures such as team analysis and prolong interaction with participants enabled researchers to arrive at themes that represented the exact views of participants. Questions in this study were developed to assess only health workers. Although various categories of health workers were studied, responses from community members would have provided another perspective of the study. Further study could be done to recommend a syndromic surveillance system for Ghana. The authors of this study are currently collaborating with computer engineering experts to research and develop a syndromic surveillance system for early detection of a bioterrorism attack in Ghana.

Implications of Study

Curricula revisions in nursing and medical education in Ghana are necessary for the effective education of nursing students and medical students in bioterrorism preparedness. Leaders in the health sector in Ghana could advocate for a prepared health sector and health professionals through further research in the area of knowledge and bioterrorism preparedness. Of equal importance is the need to review studies conducted in syndromic surveillance systems in other parts of the world and recommend a feasible system for Ghana.

Conclusion

Evidence available through this study shows differences in bioterrorism knowledge between emergency department nurses and emergency department MOs. MOs in the emergency department had more knowledge of bioterrorism than emergency department nurses. However, findings regarding preparedness and attitudes were similar. Although emergency department nurses and emergency department MOs had positive attitudes toward bioterrorism preparedness, they stated that they were unprepared for any task of preventing or caring for patients during a potential bioterrorist attack. Bioterrorism is regarded as a real and potential threat that confronts every country. Proactive planning toward bioterrorism should no longer be a luxury but a national priority (Metodiev, 2010). Human resource and physical infrastructure preparedness are necessary to avert high casualty rates in a case of a bioterrorist attack. Curriculum revisions and continuous professional development programs in bioterrorism can improve knowledge and contribute to preparedness toward bioterrorism. A well-prepared emergency department against bioterrorism could serve a dual purpose of dealing with other disasters when they occur. More studies in bioterrorism should be conducted in support of the advocacy that is needed to increase attention and funding toward a well-equipped health emergency department in Africa which can also be beneficial for protecting the public in other possible naturally occurring disasters.

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Authors' Contributions

C. A. A. conceptualized the study, collected and analyzed the data, and prepared the manuscript; S. B. A., J. S. A., A. A. B., and K. G. A. collected and analyzed the data; A. M., I. G., D. F. A., K. K. J., and L. S. collected and analyzed the data.

Authors' Note

The raw data of this manuscript is kept under lock and key by the corresponding author due to the sensitive nature of data. These data will only be released under a request from the corresponding author supported by a compelling justification.

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References

Aghaei, N., & Nesami, M. B. (2013). Bioterrorism education effect on knowledge and attitudes of nurses. *Journal of Emergency Trauma Shock*, *6*(2), 78–82.

Atakro, C. A., Gross, J., Sarpong, T., Armah, E., & Akuoko, C. P. (2018). Qualitative inquiry into Registered General Nurses' experiences in the emergency centre. *African Journal of Emergency Medicine*, *8*(1), 16–20. doi:10.1016/j.afjem.2017.08.007.

Barras, V., & Greub, G. (2014). History of biological warfare and bioterrorism. *Clinical Microbiology and Infection*, *20*(6), 497–502. doi:10.1111/1469-0691.12706.

Bilala, A. Y., & Galamas, F. (2015). A bioterrorism prevention initiative. *The Nonproliferation Review*, *22*(1), 83–92. doi:10.1080/10736700.2015.1070016.

Brannen, D. E., Branum, M., Pawani, S., Miller, S., Bowman, J., & Clare, T. (2016). Medical allocations to persons with special needs during a bioterrorism event. *Online Journal of Public Health Informatics*, *8*(3), 1–18. doi:10.5210/ojphi.v8i3.6977.

Brannen, D. E., & Stanley, S. A. (2004). Critical issues in bioterrorism preparedness: Before and after September 2001. *Journal of Public Health Management and Practice*, *10*(4), 290–298.

Canyon, D. (2009). An assessment of bioterrorism competencies among health practitioners in Australia. *Emerging Health Threats Journal*, *2*, 7. doi:10.3134/ehtj.09.007.

Cary, S. (2009). The tipping point: Biological terrorism. *Journal of Strategic Security*, *2*(3), 13–24. Retrieved from http://scholarcommons.usf.edu/jss%5Cnhttp://scholarcommons.usf.edu/jss/vol2/iss3/2.

Cenciarelli, O., Gabbarini, V., Pietropaoli, S., Malizia, A., Tamburrini, A., Ludovicic, G. M., . . . ,Gaudio, P. (2015). Viral bioterrorism: Learning the lesson of Ebola virus in West Africa 2013–2015. *Virus Research*, *210*, 318–326.

Clarke, S. C. (2002). Bioterrorism: An overview. *British Journal of Biomedical Science*, *59*(4), 232–234. doi:10.1080/09674845.2002.11783666.

Croddy, E. A., Wirtz, J. J., & Larson, J. (2005). Weapons of mass destruction: An encyclopedia of worldwide policy, technology, and history. Santa Barbara, CA: ABC-CLIO.

Das, S., & Kataria, V. K. (2010). Bioterrorism: A public health perspective. *Medicine and Health Sciences*, *66*(3), 255–260.

De Felice, M., Giuliani, A. R., Alfonsi, G., Mosca, G., & Fabiani, L. (2008). Survey of nursing knowledge on bioterrorism. *International Emergency Nursing*, *16*(2), 101–108.

Eitzen, E. M. (1997). Use of biological weapons. In R. Zajtchuk & R. F. Bellamy (Eds.), *Textbook of military medicine: Warfare, weaponry, and the casualty, part I*

(pp. 451–466). Washington, DC: Office of the Surgeon General, Department of the Army USA.

Eitzen, E. M., & Takafuji, E. T. (1997). Historical overview of biological warfare. In F. R. Sidell, E. T. Takafuji & D. R. Franz (Eds.), *Medical aspects of chemical and biological warfare* (pp. 415–423). Washington, DC: Office of the Surgeon General, Borden Institute, Walter Reed Army Medical Center.

Fraser, M. R., & Brown, D. L. (2000). Bioterrorism preparedness and local public health agencies: Building response capacity. *Public Health Reports*, *115*, 326–330.

Friend, M. (2006). Biowarfare, bioterrorism, and animal diseases as bioweapons. In *Disease emergence and resurgence: The wildlife-human connection* (pp. 231–272). Reston, VA: US Geological Survey. Retrieved from https://www.medvet.umontreal.ca/etudes/EnseignementLigne/Disease_Emergence_and_Resurgence.pdf.

Gera, P., Gupta, A., Verma, P., Singh, J., & Gupta, J. (2017). Recent advances in vaccine development against Ebola threat as bioweapon. *VirusDisease*, *28*(3), 242–246. doi:10.1007/s13337-017-0398-0.

Gershon, R. R. M., Qureshi, K. A., Sepkowitz, K. A., Gurtman, A. C., Galea, S., & Sherman, M. F. (2004). Clinicians' knowledge, attitudes, and concerns regarding bioterrorism after a brief educational program. *Journal of Occupational and Environmental Medicine*, *46*(1), 77–83. doi:10.1097/01.jom.0000105903.25094.e6.

Ghana Health Service. (2015). *The health sector in Ghana facts and figures*. Accra, Ghana: Author.

Graham, B., & Talent J. (2010). *Prevention of WMD proliferation and terrorism report card: An assessment of the U.S. government's progress in protecting the United States from weapons of mass destruction proliferation and terrorism*. Washington, DC: Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism. Retrieved from http://www.pharmathene.com/WMD_Report_Card.pdf.

Henning, K. J. (2004). An overview of syndromic surveillance; What is syndromic surveillance? *MMWR*, *53*, 5–11.

Holloway, I., & Wheeler, S. (2010). *Qualitative research in nursing and healthcare*. Retrieved from http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1119096367.html.

Kabir, B., Naik, D. G., Kumar, V. P., & Bhas, G. (2016). Awareness and knowledge about bioterrorism among medical students at a university in Malaysia. *Malaysian Applied Biology Journal*, *45*, 63–67.

Katz, A. R., Nekorchuk, D. M., Holck, P. S., Hendrickson, L. A., Imrie, A. A., & Effler, P. V. (2006a). Bioterrorism preparedness survey of Hawaii mental health professionals. *International Journal of Mental Health*, *35*(1), 12–25.

Katz, A. R., Nekorchuk, D. M., Holck, P. S., Hendrickson, L. A., Imrie, A. A., & Effler, P. V. (2006b). Hawaii physician and nurse bioterrorism preparedness survey. *Prehospital and Disaster Medicine*, *21*(6), 404–413.

Kearns, R. D., Myers, B., Cairns, C. B., Rich, P. B., Hultman, C. S., Charles, A. G., . . . ,Cairns, B. A. (2014). Hospital bioterrorism planning and burn surge. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science*, *12*(1), 20–28. doi:10.1089/bsp.2013.0065.

Klein, K. R., Brandenburg, D. C., Atas, J. G., & Maher, A. (2005). The use of trained observers as an evaluation tool for a multi-hospital bioterrorism exercise. *Prehospital and Disaster Medicine*, *20*(3), 159–163. doi:10.1017/S1049023X00002387.

Lederberg, J. (2000). Infectious history. *Science*, *288*, 287–293.

Lupkin, S. (2014, April 16). French lab loses SARS vials. *ABC News*. Retrieved from http://abcnews.go.com/Health/french-lab-loses-sars-vials/story?id=23349738.

MacDonald, R. (2005). Nuclear weapons 60 years on: Still a global public health threat. *PLoS Medicine*, *2*(11), 1056–1059. doi:10.1371/journal.pmed.0020301.

Mandl, K. D., Overhage, J. M., Wagner, M. M., Lober, W. B., Sebastiani, P., Mostashari, F., . . . ,Grannis, S. (2004). Implementing syndromic surveillance: A practical guide informed by early experience. *Journal of the American Medical Informatics Association*, *11*, 141–150.

McFee, R. B., Leikin, J. B., & Kiernan, K. (2004). Preparing for an era of weapons of mass destruction (WMD)—Are we there yet? Why we should all be concerned. Part II. *Vetenary Human Toxicology*, *46*(6), 347–351.

Mckinney, P., Wesley, G. C., & Sprang, M. V., & Troutman, A. (2005). Educating health professionals to respond to bioterrorism. *Public Health Reports, 120*, 42–47. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=c8h&AN=106541462&lang=pt-br&site=ehost-live.

Menon, I., Parkash, G. H., Srivastava, B. K., Nagarajappa, R., & Tangade, P. (2010). Bioterrorism-knowledge, attitude and practice among faculty members of dental schools of Uttar Pradesh, India. *Journal of the Indian Association Of Public Health Dentistry*, *15*, 141–148.

Metodiev, K. (2010). Risk infections and bioterrorism. *Prehospital and Disaster Medicine*, *25*, 62.

Moghadam, S. A. B., Pour, S. H., Toorchi, M., & Heris, Y. S. (2016). Knowledge and attitude of Iranian red crescent society volunteers in dealing with bioterrorist attacks. *Emergency*, *4*(1), 16–20.

Monahan, F. D., Sands, J. K., Neighbors, M., Marek, J. F., & Green, C. J. (2007). *Phipps medical_surgical nursing: Health and illness persepectives* (8th ed.). Philadelphia, PA: Elsevier.

Morse, A. (2002). Bioterrorism preparedness for local health departments. *Journal of Community Health Nursing*, *19*(4), 203–211. doi:10.1207/S15327655JCHN1904_01.

Moshagh-Eshgh, Z., Aghaei, N., & Majd, H. A. (2007). Knowledge and attitude of nurses regarding bioterrorism. *Advances in Nursing and Midwifery*, *17*(57), 1–2.

Murphy, J. K. (2004). After 9/11: Priority focus areas for bioterrorism preparedness in hospitals. *Journal Health Care Management*, *49*(4), 227–235.

Myers, M. (2000). Qualitative research and the generalizability question: Standing firm with proteus. *The Qualitative Report, 4*(3). Retrieved from http://nsuworks.nova.edu/tqr/vol4/iss3/9.

Njenga, F. G., Nyamai, C., & Kigamwa, P. (2003). Terrorist bombing at the USA embassy in Nairobi: The media response. *East African Medical Journal*, *80*(3), 159–164. doi:10.4314/eamj.v80i3.8686.

Office of the Assistant Secretary for Preparedness and Response, Hospital Preparedness Program. Healthcare Prepared_ness Capabilities. (2012). *National guidance for healthcare system preparedness*. Retrieved from http://www.phe.gov/Preparedness/planning/hpp/reports/Documents/capabilities.pdf.

Ouagrham-Gormley, S. B. (2013). Dissuading biological weapons proliferation. *Contemporary Security Policy*, *34*(3), 473–500. doi:10.1080/13523260.2013.842294.

Pitschmann, V. (2014). Overall view of chemical and biochemical weapons. *Toxins*, *6*(6), 1761–1784. doi:10.3390/toxins6061761.

Polit, D. F., & Beck, C. T. (2010). *Essentials of nursing research: Appraising evidence for nursing practice* (7th ed.). New Philadelphia, OH: Lippincott Williams & Wilkins.

Riedel, S. (2004). Biological warfare and bioterrorism: A historical review. *University Medical Center Proceedings*, *17*(4), 400–406.

Rose, M. A., & Larrimore, K. L. (2002). Knowledge and awareness concerning chemical and biological terrorism: Continuing education implications. *Journal of Continuing Education*, *33*, 253–258.

Sidel, V. W., Gould, R. M., & Cohen, H. W. (2002). Bioterrorism preparedness: Cooptation of public health ? *Medicine and Global Survival*, *7*(2), 82–89.

Smeltzer, S. C., Bare, B. G., Hinkle, J. L., & Cheever, K. H. (2008). *Brunner and Suddart's textbook of medical-surgical nursing*. Philadelphia, PA: Lippincott William & Wilkins.

Sosin, D. M. (2003). Syndromic surveillance: The case for skillful investment. Biosecurity and bioterrorism. *Biodefense, Strategy, Practice and Science*, *1*(4), 247–253.

Teckman, A. M. (2013). The bioterrorist threat of Ebola in East Africa and implications for global health and security. Global Policy, 1–11. Retrieved from https://pdfs.semanticscholar.org/64df/eddfe6c774ed2c558aa2fbbb6db79793d261.pdf.

Terndrup, T. E., & Nafziger, S. D. (2016). *Bioterrorism*. Retrieved from https://www.researchgate.net/publication/286930217_Bioterrorism.

The Government of the Republic of Ghana. (2018). *Agreement between the governemnt of the United States of America and the government of the Republic of Ghana on defence cporporation, the status of United States forces and access to and use of agreed fcilities and areas in the Republic of Ghana*. Accra, Ghana: Minstry of Defence.

Tucker, J. B. (2013). *Biopreparedness and public health* (pp. 7–17). Amsterdam, the Netherlands: Springer. doi:10.1007/978_94_007_5273_3.

Wagar, E. (2016). Bioterrorism and the role of the clinical microbiology laboratory. *American Society for Microbiology*, *29*(1), 175–188.

Wetter, D. C., Daniell, W. E., & Treser, C. D. (2001). Hospital preparedness for victims of chemical or biological terrorism. *American Journal of Public Health*, *91*, 710–716.

Wigglesworth, A. (2014, January 21).'Darkweb' vendor allegedly sold poison to covert agent in N.J. *philly.com*. Retrieved from http://www.philly.com/philly/news/Man_allegedly_sold_poison_through_.html.