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The 1995 Kikwit Ebola outbreak: lessons hospitals and physicians can apply to future viral epidemics

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Abstract

Objective: This article looks at lessons learned from the 1995 Kikwit Ebola outbreak and suggests how modern hospitals should apply these lessons to the next lethal viral epidemic that occurs.

Method: The 1995 Kikwit Ebola outbreak in the Democratic Republic of the Congo (formally Zaire) is one of the most well studied epidemics to have occurred to date. Many of the lessons learned from identifying, containing and treating that epidemic are applicable to future viral outbreaks, natural disasters and bioterrorist attacks. This is due to Ebola's highly contagious nature and high mortality rate.

Results: When an outbreak occurs, it often produces fear in the community and causes the basic practice of medicine to be altered. Changes seen at Kikwit included limited physical examinations, hesitance to give intravenous medications and closure of supporting hospital facilities. The Kikwit Ebola outbreak also provided beneficial psychological insight into how patients, staff and the general community respond to a biological crisis and how this will affect physicians working in an epidemic.

Conclusions: General lessons from the outbreak include the importance of having simple, well-defined triage procedures; staff who are flexible and able to adapt to situations with unknowns; and the need to protect staff physically and emotionally to ensure a sustained effort to provide care.

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1. Introduction

Although not garnering the headlines it once did, Ebola outbreaks continue to occur with devastating results. The most recent outbreak was identified on November 27, 2007, and involved 51 cases in western Uganda [1] (Table 1). To date, more than 1000 human deaths have been linked to the Ebola virus [1]. Recent Ebola outbreaks have been a study in infection control and medical practice during disasters where health infrastructures were overwhelmed, information was limited and supplies were scarce. Even though most Ebola outbreaks have occurred in third-world countries, there are many practical lessons that can be applied if a hemorrhagic fever outbreak should occur in the United States. As the

recent New Orleans/Katrina experience and the severe acute respiratory syndrome (SARS) outbreak in Toronto highlight, even first-world hospital systems can be overwhelmed by disasters and be forced to perform with inadequate information, supplies, medical staff and social support. The Kikwit Ebola outbreak of 1995 was one of the most well studied infectious epidemics and one of the first times that the Ebola virus was treated in a hospital setting. The lessons learned from this outbreak are still applicable to this day.

2. Background history of the 1995 Kikwit outbreak

It is currently believed that the source case for this Ebola outbreak was a farmer/charcoal miner, who contracted the disease and died in January of 1995 [2–4] (Table 2). The national health system of the Democratic Republic of the Congo was not alerted to a possible

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Table 1

Countries with reported cases of Ebola infections and dates of occurrence

England (lab technicians studying viruses) — 1976
Gabon—1994, 1996, 1997, 2002–2003, 2005
Italy—1992
Ivory Coast—1994
Philippines—1992
South Africa—1996
Sudan—1976, 1979, 2004
Uganda—2000–2001, 2007
United States—1989, 1996 (Ebola Reston named after Reston, Virginia)
Zaire/Congo—1976, 1995, 2002–2003

Information in boldface indicates primate infections only.

infectious epidemic until April [5–7]. The presenting indicator of an expanding infectious disease was a high number of cases of “bloody diarrhea” resulting in death [7]. Early in the epidemic, bacillary dysentery caused by *Shigella* or *Salmonella* was thought to be the pathogen responsible for the outbreak [2,7,8].

In late April/early May, additional health warnings were initiated after several health care providers at Kikwit General Hospital died. The deaths were traced back to a laboratory technician, who had undergone an operation at the facility for what was initially thought to be a surgical abdomen [2,5,6,9]. After some of the hospital staff involved in the operation and their family members developed Ebola, general panic occurred in the city. Many of the patients and staff fled the hospital [2,6,10].

3. Lethality of Ebola

The mortality rate of Ebola depends on the subtype causing the infection and ranges from 50% to 90% [10–13]

Table 2

Expanded timeline of 1995 Kikwit outbreak

January: Incident case is believed to occur
March–April: Written report to local health officials regarding hemorrhagic gastrointestinal disease thought to be due to <i>Shigella</i> or <i>Salmonella</i>
Late April/Early May: Additional health warnings after hospital staff who operated on a patient with a “surgical abdomen” become infected
May 4th: Isolation unit was established at Kikwit General Hospital
May 6th: Government requests international help
May 8th: Secondary hospitals closed down to prevent spread of infection.
May 8th: WHO agrees to send medical teams
May 10th: Organism is identified as Ebola by CDC
May 10–19th: International medical teams arrive (WHO, Doctors Without Borders, CDC)
May 11th: Isolation unit standards improve with dramatic reduction in health care providers becoming ill
May 12th: International press arrives and epidemic becomes a bigger story than expected
May 20th: Secondary hospitals partially reopened for emergencies
July 14th: Isolation unit closes
July 31st: Convalescent unit closes
August 8th: Doctors Without Borders (last international medical team) leaves
Total length of outbreak = 7 months

(Table 3). The virus is transmitted only during the active disease state by direct contact with infected body secretions [10,12,14,15]. There is also a fear that Ebola can be transmitted by aerosolization, leading to its possible use as a biological weapon [4,11,14,16,17]. Currently, Ebola is listed as a Category A pathogen by the National Institutes of Health due to its high mortality rate and weaponization potential [11,18–21]. It is known that terrorist groups such as Aum Shinrikyo have tried to recover Ebola viruses with the intention of using them as a biological weapon [14].

The Kikwit outbreak provided much of our current clinical scientific knowledge about Ebola. The health care professionals who went to contain the disease in 1995 were facing many unknowns, which placed them at a greater physical and psychological risk. Unfortunately, the general lack of information regarding an infectious vector has also occurred in later virus outbreaks, such as SARS and the avian flu [21–23].

4. The Congo and world reactions to the outbreak

On May 4, 1995, a 30-bed unit at the 350-bed Kikwit General Hospital was converted to a makeshift isolation unit, which was staffed by one doctor and three volunteer nurses [8]. The world community was asked for help 2 days later by the government of the Democratic Republic of the Congo [6,8]. On May 8, the Congolese authorities decided to close the other surrounding health facilities near Kikwit in an attempt to prevent the spread of the infection and the subsequent destruction of the remaining health care infrastructure [8]. A definitive diagnosis of Ebola was not made until May 9 or 10 (depending on the literature cited) [2,7,8]. Between May 10 and May 19, nine international medical teams, including the World Health Organization (WHO), Doctors Without Borders and the Centers for Disease Control and Prevention (CDC), arrived, bringing supplies and knowledge [5,8]. The arriving teams helped to augment the understaffed hospital, provided barrier supplies and disinfectant, improved the quality of the isolation unit’s effectiveness, assisted in developing safer burial procedures and improved the triage system for sick patients. The secondary health facilities were not reopened until May 20 and even then they only dealt with medical and surgical emergencies [8].

By May 11, 164 reported cases of Ebola were identified, of which 134 individuals had died [5,10]. Sixty-three of the total cases identified were health care workers (38% of those infected), of whom 47 had already died or would die [5,10].

Table 3

Subtypes of Ebola viruses

Côte d’Ivoire (Ivory Coast) (primarily infects primates)
Reston (primarily infects primates)
Sudan (40–70% fatality rate based on 1979 outbreak)
Zaire (70–90% fatality rate based on 1976 epidemic)

After May 11, with the implementation of better disease isolation and barrier protective measures, only three new cases were reported in health care providers and Red Cross volunteers. Of the 316 suspected cases of Ebola identified during the 7-month outbreak, 252 people died [6,9,18,21]. Overall, 20–25% of the victims were health care workers [6,10,18]. Of the hospital staff infected, physicians had the highest rate of infection at 31% (4/13), followed by technicians/room attendants at 11% (7/62) and nurses at 10% (22/212) [9].

5. Medical practice disrupted

Medical treatment during the outbreak was severely hampered due to issues of contagion. Treatment decisions were often based only on physical appearance or what could be gained from a limited examination. This led to a general sense of frustration and helplessness in the treating staff, who felt they were not able to offer the care they were used to or had been trained to deliver.

Every patient in the isolation unit did have a chart, even during the earlier stages of the outbreak, but initial records were poorly kept [6,24]. These poor records made it difficult to know exactly what care was provided to patients and what their symptom progression was [6]. Post-outbreak studies have found that approximately 41% of the patients had recorded evidence of hemorrhaging; however, hemorrhage was not a reliable marker of who would die or recover [24]. Symptoms seen in terminal patients included obtundation, anuria, shock, hiccups, tachypnea and a period of fever, which would resolve to normothermia 2 days before death [24]. It was noted that disease transmission only occurred during symptomatic periods and not during latency or convalescence [10,12,14–16]. The latency period (time from exposure to time of becoming symptomatic) ranged from 2 days to 3 weeks [24]. Unfortunately, exposure history was often unreliable because patients did not know when they were exposed or would lie to avoid being sent to the isolation unit, which was viewed as a death sentence.

General examinations and workups were severely limited. Routine vital signs, such as blood pressure, were unavailable due to difficulty with disinfecting the blood pressure cuffs [6]. Labs and X-rays were unavailable due to general shortages (material and staff) and problems with disinfecting the equipment. For a period of time, physicians were not changing gloves between patients due to shortages. The staff were simply washing their gloves in a 2% solution of calcium hypochlorite between examining patients to try to maintain some degree of infection control [6,8].

In the emergency room, an algorithm was developed based on the presence of physical symptoms and history, such as exposure history, injection of the conjunctivae and presence of bloody diarrhea, to determine who would be admitted to the isolation unit [6]. The algorithm was based on readily identifiable symptoms and did not rely on labs.

Fortunately, the emergency department could be separated into two areas, one of which functioned as an observation area. Patients were observed for up to 24 h to see if they met algorithm criteria for admission to the isolation unit. If it appeared that a patient would eventually meet criteria, the decision was made to move them to the isolation area sooner rather than later. Oftentimes, the decision to transfer a patient to the inpatient isolation ward would be based on the risk of the patient potentially infecting others, particularly if they were symptomatic with diarrhea and/or vomiting [6]. The presence of the algorithm helped reduce the psychological stress on staff since it made the decision of whether to admit or not less of a personal call [23].

During the early days of the outbreak, intravenous medications and hydration were not available due to both the lack of supplies and the risk/fear of staff being exposed to blood [25]. Later, during the outbreak, transfusion of blood and serum from convalescent patients was tried with good result (seven of eight transfused patients survived) [25]. There appeared to be a survival benefit, but the cause is contested because it is not clear if the benefit was simply due to volume restitution, replacement of clotting factors or a specific immunological factor provided by the convalescent serum [11,25].

An effective way to control agitated patients was required to prevent the agitated patient from either intentionally or unintentionally infecting staff, disrupting other patients' treatment and further depleting resources. Haloperidol and diazepam were frequently used for this purpose due to their relative availability and multiple means of administration (e.g., oral, intramuscularly, intravenously) [6].

Most of the patients' daily needs, such as feeding and bathing, were met by family members, who were also put at risk [8]. In the quarantine units, one family member was allowed to assist each patient. Although it was supposed to be the same family member at all times, the restriction was difficult for the staff to monitor and enforce [6,8]. Families were given one set of gloves every 2 days in an attempt to provide barrier protection for them; however, these precautions were inadequate. The family members often slept in the bed with the infected patient, which was a common occurrence in this hospital prior to the outbreak [6].

When the patients' symptoms started to improve noticeably (i.e., reduction in fever) and they were able to feed themselves, they were moved to the convalescent unit. The typical patient spent 15 days in the isolation ward and approximately 20 days on the convalescent ward. Patients would often return to the hospital after they were discharged from the convalescent ward because they were physically attacked or shunned by their neighbors [26].

6. Concerns and coping mechanisms of patients

A study by De Roo et al. [2] of the survivors of the outbreak reported on the psychological effects of being

infected. Only 32% of those surveyed suspected that they had Ebola when symptoms appeared. Prior to the diagnosis being confirmed, 50% were concerned that they would fall seriously ill, 47% were experiencing denial, 21% were concerned about being stigmatized by neighbors and 15% experienced shame for becoming sick [2]. Eighty percent of the subjects shared their anxiety with family members before the diagnosis was confirmed, while 12% tried to escape from contact with family and neighbors. When presenting to the hospital, 9% downplayed their symptoms and exposure risk to medical personnel [2]. During the time period when it was certain that they were infected with Ebola, all reported experiencing fear. Fifty-six percent were fearful of pain and suffering, 53% were fearful of dying a horrible death, 41% were fearful of separation from relatives and 23% feared being abandoned by relatives. In terms of support and optimism, 50% reported believing that they had a chance to recover and 85% reported receiving support from medical staff, 70% from family and 24% from other patients. All patients identified a belief in God or a spiritual connection as being important. The most discouraging experience for patients who survived was witnessing the death of friends and/or colleagues who were with them on the isolation unit [2].

7. Effects on staff

Many of the staff who volunteered to work in the isolation unit reported undergoing severe psychological stress related to their separation from normal support, concern over contracting Ebola, fear they would infect their family and having to witness the death of close colleagues, which was both an emotional loss and a reminder of the risk they themselves were taking [10] (Table 4). Similar stressors were reported among health care staff in Asia and Canada during the SARS epidemic [21,23,27–39]. In the Congo, it was common for staff to develop psychosomatic symptoms similar to those seen in Ebola patients. Symptoms of headache, fatigue, muscle pains and perceived fever were most common [13]. For the most part, the staff did very well during the initial phase of the crisis because they were busy and did not have time to ruminate about or fully assess their situation [13]. Once the epidemic became more “routine,” staff began to develop

more emotional and psychological problems. Many of the staff felt underappreciated during and after the crisis and did not feel that their sacrifices were recognized. The nursing staff felt that they were at the greatest risk due to close patient contact [10]. The staff who stayed during the crisis had a strong sense of duty and were heavily vested in their professional role as a coping mechanism.

The staff were unprepared for the isolation they experienced from their families, community and other medical colleagues who were not working in the isolation unit. Physicians and staff were allowed to return home at the end of their shifts. This freedom created problems for the health care workers and their families. Families feared that they were infected. Neighbors, who were fearful of being infected by the health care workers, stoned them and their families. Health care families were not able to purchase food because people refused to take money from them. At times, their homes were burned [6].

The isolation that health care workers experienced when they were shunned by family and other health care workers was particularly devastating. It caused staff to question the risks they were taking [6]. This raises the question of whether or not the staff should have been quarantined, not only for infection control but also for their own safety and their families’ safety and to provide a more cohesive critical group identity that ensured ongoing patient care. This is a difficult question to answer. During the SARS epidemic, staff who were forcibly quarantined experienced the highest rates of psychological distress and incapacity [23]. If nothing else, staff should be offered the choice of staying at the hospital in order to allow them the option of reducing their families’ risk of exposure.

At the height of the Ebola epidemic, 10 people died each day. Many of the deaths occurred in colleagues who the staff were attending. This resulted in additional emotional isolation and the breakdown of protective denial in the staff. One of the positive steps taken was to provide private rooms, when possible, to staff who had become infected [6]. This sent a message that the institution cared for the staff by providing special privileges for their services during the crisis.

Although no long-lasting staff strikes took place during this outbreak, there were periods when they were threatened [6,8]. The potential is common for staff, who have previously agreed to work with endemic patients, to change their mind during life-threatening viral epidemics. In other viral epidemics, such as later Ebola outbreaks and SARS, there were incidents where nursing staff and other support staff, such as individuals in charge of body disposal, threatened to quit working if their conditions were not met [22,23]. Usually, these conditions related to the need for more nursing autonomy, higher levels of infection control and better safeguards for patients and their families [23]. It is easy to see how additional problems in controlling a viral epidemic will arise if staff concerns go unaddressed.

Table 4
Factors negatively affecting the psychological well-being of staff

Concerns over contracting the illness
Concerns for safety of their family
Isolation from family
Witnessing the death of colleagues
Isolation from colleagues
Sense of loss of control
Sense of being underappreciated
Extended length of epidemic

8. Discussion

It is not possible to predict what infectious agent will cause the next epidemic. As seen in the Kikwit outbreak, it took 4 months before it was clear that an outbreak was occurring and to identify the infectious agent. This would be a more dramatic problem if the epidemic resulted from a biological weapon attack utilizing multiple agents simultaneously, making it difficult for treating physicians to recognize one disease's symptoms and isolate the pathogens responsible [20,40]. Even with known diseases such as Ebola, where there was some basic science information available, there were still several important unknowns that needed to be answered. (What strain of agent is involved? Has the virus mutated? Is the data accurate and applicable to this situation?) In the recent SARS outbreaks, there were disagreements between hospital administrators and nurses over what level of isolation precautions were necessary to protect staff [22,23,41]. If an infectious outbreak such as Ebola, SARS or avian flu occurs, and if supplies are available, it is best to assume that most infectious transmission routes and provide protection until proven otherwise. This sends a message to the staff that their interests, safety and concerns (e.g., fear of infecting their own family) are being addressed and that the institution recognizes the risks they are taking and is trying to protect them, as well as their patients. This outbreak did demonstrate that with the proper supplies and precautions, the risk to staff can be significantly reduced even when there are unknowns.

Hospitals will need to have emergency staffing plans to deal with staffing deficits, whether the shortage is due to inability of staff to come in, as was the case with Katrina; staff becoming ill; or staff refusing to work [23,42]. As the Kikwit Ebola outbreak demonstrated, during massive viral epidemics, surge capacity is decreased, not increased [21,23]. Instead of being able to render aid (e.g., personnel or bed space), surrounding hospitals were actually shut down by the government in order to prevent the spread of the infection. The ability of outside staff being used to help augment existing staff shortages rarely occurs during a true emergency since other facilities do not want to share staff and distant staff wish to avoid exposure and the risk of death. Also, a viral outbreak (i.e., avian flu) could potentially go on for months to years, making the long-term use of outside personnel impractical [21,23]. Hospitals need to have plans in place that define how they will function for a prolonged period of time with at least a 40–50% reduction in staff [23]. Whatever plans are enacted, there needs to be provision for handling routine medical emergencies such as heart attacks, surgical emergencies and pregnancies [21]. These plans also need to make provisions that assume that other facilities will have closed and that their institution is the only functional hospital for their region. As was seen in Kikwit and with Hurricane Katrina, it took approximately 1–2 weeks for outside help to arrive and be functionally implemented [21].

Staff often experiences severe emotional stress during viral outbreaks. It is important to maintain teamwork and effective leadership while at the same time giving individuals the opportunity to provide input into the decisions that affect their lives. It is often the nursing staff who feels the greatest level of stress due to their constant contact with sick patients, who may not be improving despite the nursing staff's best efforts [23]. Physicians usually cope somewhat better with this situation because they are in a position to make treatment decisions and are less directly involved in implementing patient care [23]. It is important for administrators and doctors to be receptive to suggestions from nursing staff and support personnel. Input is empowerment and provides a sense that these critical staff retain some control over their situation. If suggestions are not acted on, clear explanations as to why they were not should be provided and alternatives should be explored. Administration needs to be supportive of staff and not be seen as pedantic and overly controlling. In cases where staff and support personnel did not feel appreciated or listened to, there was a high degree of dissatisfaction and an increased occurrence of absenteeism and staff strikes, which further reduced personnel in an already-strained system [22,23].

If an outbreak occurs, it will be helpful to quickly utilize occupational health services. During the outbreak, staff and volunteers were able to continue to function and were less likely to strike when they believed their own physical safety needs were being addressed. Steps such as initiating a nursing buddy system; having a breakroom on-site with food, water and a place to rest; and providing "special" medical examinations upon request from staff taking care of the ill were helpful in this viral outbreak and others to maintain staff functioning [23]. All of these steps helped to reduce the physical and mental stress staff were under, while at the same time helping them to feel appreciated and part of a team.

Health care professionals need to understand the patients' mind-sets during a viral outbreak, as well as their own potential stress reactions. Physicians need to realize that their patients will be frightened and may potentially lie about symptoms and exposure risk. Patients may see health care providers as the enemy due to the providers' power to quarantine them. Being placed in quarantine may be seen as a "death sentence," which could result in the populace avoiding health officials or in violence being directed toward health officials. It is important for medical personnel to see these reactions for what they are: misguided but self-protective behaviors, manifestations of the illness (e.g., delirium) and the patient's fear of being sick. If medical staff do not appreciate the source of these behaviors, they may question their role, become hostile and experience a loss of professional identity and a breakdown of their own protective denial. (Why should some individuals place themselves at risk when they are being viewed as the enemy?) Due to this potential antagonistic relationship and the possible delirium that can be caused by the infection,

Table 5

Lessons learned from the Kikwit Ebola outbreak of 1995

Loss of surge capacity due to neighboring hospitals closing to reduce spread of infection can occur.
Hospitals should prepare to be self-sufficient for at least 7 days before outside help and supplies can arrive.
Hospitals need long-term crisis management plans due to viral epidemics lasting for months.
Medical staff will need to be flexible in how they deliver medical care (e.g., modified physical examinations) and, where possible, to try to develop standardized procedures based on reality of the situation (e.g., triage protocol based primarily on observation and limited exam).
Supply shortages could occur due to the nature of supplies needed in a viral infection (e.g., barrier protection), the increased number of supplies needed and the extended duration for which supplies are needed.
Expect a loss of staff for multiple reasons (e.g., abandoning post, illness, inability to obtain replacement staff).
Expect staff who stay to do well during initial crisis, but potentially experience emotional symptoms such as psychosomatic symptoms when crisis becomes routine.
Need to provide incentives and recognition to staff/volunteers to maintain morale both during and after the crisis.
Provide for needs of staff and families, such as food and security.
When possible, provide special accommodations and recognition to staff who become ill as a way to show staff who are still working that their contributions and sacrifices are appreciated.

doctors and support staff need to be ready to deal with agitated patients both mentally and physically. Mental preparation is realizing the level of fear a patient is experiencing. The physical preparation is being comfortable with and willing to use pharmacological agents (e.g., haloperidol), physical restraint or both.

9. Conclusion

Kikwit's Ebola outbreak highlights concerns and problems that may occur during the next endemic or pandemic infection. General lessons from the outbreak include the importance of having simple, well-defined triage procedures; staff who are flexible and able to adapt to situations with unknowns; and the need to protect staff physically and emotionally to ensure a sustained effort to provide care. Unfortunately, many of the lessons learned and applied to the training of local personnel during the Kikwit outbreaks were rapidly forgotten and had to be relearned and reinstituted during later Ebola outbreaks in the Congo and elsewhere [43,44]. These lessons also applied well in the "first" world SARS epidemic and following Hurricane Katrina (Table 5).

References

- [1] Olukya G. Ebola outbreak in Uganda kills 16. http://www.newsvine.com/_news/2007/11/29/1130193-new-subtype-of-ebola-suspected-in-uganda [Accessed November 29, 2007].
- [2] De Roo A, Ado B, Rose B, et al. Survey among survivors of the 1995 Ebola epidemic in Kikwit, Democratic Republic of Congo: their feelings and experiences. *Trop Med Int Health* 1998;3:883–5.
- [3] Leirs H, Mills JN, Krebs JW, et al. Search for the Ebola virus reservoir in Kikwit, Democratic Republic of the Congo: reflections on a vertebrate collection. *J Infect Dis* 1999;179(Suppl 1):S155–63.
- [4] Roels TH, Bloom AS, Buffington J, et al. Ebola hemorrhagic fever, Kikwit, Democratic Republic of the Congo, 1995: risk factors for patients without a reported exposure. *J Infect Dis* 1999;179(Suppl 1):S92–7.
- [5] Heymann DL, Barakamfitiye D, Szczeniowski M, et al. Ebola hemorrhagic fever: lessons from Kikwit, Democratic Republic of the Congo. *J Infect Dis* 1999;179(Suppl 1):S283–6.
- [6] Guimard Y, Bwaka MA, Colebunders R, et al. Organization of patient care during the Ebola hemorrhagic fever epidemic in Kikwit, Democratic Republic of the Congo, 1995. *J Infect Dis* 1999;179(Suppl 1):S268–73.
- [7] Muyembe-Tamfum JJ, Kipasa M, Kiyungu C, Colebunders R. Ebola outbreak in Kikwit, Democratic Republic of the Congo: discovery and control measures. *J Infect Dis* 1999;179(Suppl 1):S259–62.
- [8] Kerstiens B, Matthys F. Interventions to control virus transmission during an outbreak of Ebola hemorrhagic fever: experience from Kikwit, Democratic Republic of the Congo, 1995. *J Infect Dis* 1999;179(Suppl 1):S263–7.
- [9] Tomori O, Bertolli J, Rollin PE, et al. Serologic survey among hospital and health center workers during the Ebola hemorrhagic fever outbreak in Kikwit, Democratic Republic of the Congo, 1995. *J Infect Dis* 1999;179(Suppl 1):S98–S101.
- [10] Hewlett BL, Hewlett BS. Providing care and facing death: nursing during Ebola outbreaks in central Africa. *J Transcult Nurs* 2005;16:289–97.
- [11] Reed DS, Mohamadadeh M. Status and challenges of filovirus vaccines. *Vaccine* 2007;25:1923–34.
- [12] Ebola haemorrhagic fever—fact sheet revised in May 2004. *Wkly Epidemiol Rec* 2004;79:435–9.
- [13] Locsin RC, Matua AG. The lived experience of waiting-to-know: Ebola at Mbarara, Uganda—hoping for life, anticipating death. *J Adv Nurs* 2002;37:173–81.
- [14] Bossi P, Tegnell A, Baka A, et al. Task Force on Biological and Chemical Agent Threats, Public Health Directorate, European Commission, Luxembourg. Bichat guidelines for the clinical management of haemorrhagic fever viruses and bioterrorism-related haemorrhagic fever viruses. *Euro Surveill* 2004;9:E11–2.
- [15] Formenty P, Leroy EM, Epelboin A, et al. Detection of Ebola virus in oral fluid specimens during outbreaks of Ebola virus hemorrhagic fever in the Republic of Congo. *Clin Infect Dis* 2006;42:1521–6 [Electronic publication 2006 Apr 26].
- [16] Dowell SF, Mukunu R, Ksiazek TG, et al. Transmission of Ebola hemorrhagic fever: a study of risk factors in family members, Kikwit, Democratic Republic of the Congo, 1995. *Commission de Lutte contre les Epidemies a Kikwit*. *J Infect Dis* 1999;179(Suppl 1):S87–S91.
- [17] Geisbert TW, Jahrling PB. Exotic emerging viral diseases: progress and challenges. *Nat Med* 2004;10(12 Suppl):S110–21.
- [18] Crowcroft NS, Morgan D, Brown D. Viral haemorrhagic fevers in Europe—effective control requires a coordinated response. *Euro Surveill* 2002;7:31–2.
- [19] Bray M. Defense against filoviruses used as biological weapons. *Antiviral Res* 2003;57:53–60.
- [20] Hall RCW, Hall RCW, Chapman MJ. Effects of terrorist attacks on the elderly, part 1: medical complications of biological, chemical, nuclear and bombing attacks. *Clin Geriatr* 2006;14:26–35.
- [21] Hall RCW, Hall RCW. The 1995 Kikwit Ebola outbreak—model of virus properties on system capacity and function: a lesson for future viral epidemics. *Am J Disaster Med* 2007;2(4):270–6.
- [22] Campbell A. The honourable. Spring of fear. Volume 1. The SARS Commission Executive Summary, Dec 2006. Available at: www.sarscommission.ca/report/v1/html [Accessed March 25, 2007].
- [23] Hall RCW, Hall RCW. When the system is overwhelmed: protecting the provider during biodisaster. Satellite Conference,

- University of Alabama Birmingham South Central Center for Public Health Preparedness/Alabama Department of Public Health/Tulane University School of Public Health, Montgomery, AL, February 27, 2007. Available at: www.adph.org/alphtn [Accessed March 25, 2007].
- [24] Bwaka MA, Bonnet MJ, Calain P, et al. Ebola hemorrhagic fever in Kikwit, Democratic Republic of the Congo: clinical observations in 103 patients. *J Infect Dis* 1999;179(Suppl 1):S1–S7.
 - [25] Mupapa K, Massamba M, Kibadi K, et al. Treatment of Ebola hemorrhagic fever with blood transfusions from convalescent patients. International Scientific and Technical Committee. *J Infect Dis* 1999; 179(Suppl 1):S18–S23.
 - [26] Thacker PD. An Ebola epidemic simmers in Africa: in remote region, outbreak shows staying power. *JAMA* 2003;290:317–9.
 - [27] Bergeron S, Cameron S, Armstrong-Stassen M, Pare K. Diverse implications of a national health crisis: a qualitative exploration of community nurses' SARS experiences. *Can J Nurs Res* 2006;38:42–54.
 - [28] Koh D, Lim MK, Chia SE, et al. Risk perception and impact of Severe Acute Respiratory Syndrome (SARS) on work and personal lives of healthcare workers in Singapore: what can we learn? *Med Care* 2005; 43:676–82.
 - [29] Lee S, Juang Y, Su Y, et al. Facing SARS: psychological impacts on SARS team nurses and psychiatric services in a Taiwan general hospital. *Gen Hosp Psychiatry* 2005;27:352–8.
 - [30] Maunder R. The experience of the 2003 SARS outbreak as a traumatic stress among frontline healthcare workers in Toronto: lessons learned. *Phil Trans R Soc Lond* 2004;359:1117–25.
 - [31] Maunder R, Hunter J, Vincent L, et al. The immediate psychological and occupational impact of the 2003 SARS outbreak in a teaching hospital. *Can Med Assoc J* 2003;168:1245–51.
 - [32] Maunder R, Lancee W, Rourke S, et al. Factors associated with the psychological impact of Severe Acute Respiratory Syndrome on nurses and other hospital workers in Toronto. *Psychosom Med* 2004;66: 938–42.
 - [33] Nickell L, Crighton E, Tracy C, et al. Psychosocial effects of SARS on hospital staff: survey of a large tertiary care institution. *Can Med Assoc J* 2004;170:793–8.
 - [34] Phua D, Tang J, Tham K. Coping responses of emergency physicians and nurses to the 2003 Severe Acute Respiratory Syndrome outbreak. *Acad Emerg Med* 2005;12:322–8.
 - [35] Poon E, Liu K, Cheong D, et al. Impact of Severe Acute Respiratory Syndrome on anxiety levels of front-line health care workers. *Hong Kong Med J* 2004;10:325–30.
 - [36] Sim K, Chong P, Chan Y, Soon WS. Severe Acute Respiratory Syndrome—related psychiatric and posttraumatic morbidities and coping responses in medical staff within a primary health care setting in Singapore. *J Clin Psychiatry* 2004;65:1120–7.
 - [37] Sim K, Chua HC. The psychological impact of SARS: a matter of heart and mind. *Can Med Assoc J* 2004;170:811–2.
 - [38] Tam C, Pang E, Lam L, Chiu HF. Severe Acute Respiratory Syndrome (SARS) in Hong Kong in 2003: stress and psychological impact among frontline healthcare workers. *Psychol Med* 2004;34:1197–204.
 - [39] Wong TW, Yau J, Chan C, et al. The psychological impact of Severe Acute Respiratory Syndrome outbreak on healthcare workers in emergency departments and how they cope. *Eur J Emerg Med* 2005; 12:13–8.
 - [40] Alibek K. *Biohazard*. New York: Random House; 1999.
 - [41] Chia S, Koh D, Fones C, et al. Appropriate use of personal protective equipment among healthcare workers in public sector hospitals and primary healthcare polyclinics during the SARS outbreak in Singapore. *Occup Environ Med* 2005;62:473–7.
 - [42] Rice K, Colletti L, Hartmann S, et al. Learning from Katrina. *Nursing* 2006;36:44–7.
 - [43] No authors listed. Outbreak(s) of Ebola haemorrhagic fever, Congo and Gabon, October 2001–July 2002. *Wkly Epidemiol Rec* 2003;78: 223–8.
 - [44] Peters CJ, LeDuc JW. An introduction to Ebola: the virus and the disease. *J Infect Dis* 1999;179(Suppl 1):ix–xvi.