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REVIEW

Ebola virus disease: Effects of respiratory protection on healthcare workers



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KEYWORDS

Ebola virus diseases;
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Abstract Ebola virus disease outbreak in West Africa sends an alarming message to all countries in the world, to increase the level of coordination and application of preventive measures globally to avoid a disastrous epidemic in the World, as the current situation in West Africa is critical especially after the World Health Organization increased the alarming level to an emergency in public health all over the world. Viral hemorrhagic fevers are important because they can readily spread within a hospital or mortuary setting, there is no effective cure or vaccine, they have a high mortality rate and they are difficult to recognize and diagnose rapidly. WHO has recommended respiratory protection for HCWs performing certain tasks such as aerosol-generating procedures, laboratory procedures, and autopsies. Particulate respirators are designed to help reduce the wearer's exposure to certain airborne particles. The most effective way to block aerosolized particles is to use either a half-face or a full-face respirator. HCWs still need shoe covers, a full face respirator and latex or nitrile gloves to decrease the risk of Ebola virus contamination.

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Abbreviations: VHF, Viral hemorrhagic fever; EVD, Ebola virus disease; WHO, World Health Organization; PPE, Personal protective equipment; HCWs, Health care workers

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Overview

Ebola virus disease outbreak in West Africa sends an alarming message to all countries in the world, to increase the level of coordination and application of preventive measures globally to avoid a disastrous epidemic in the World, as the current situation in West Africa is critical especially after the World Health Organization increased the alarming level to an emergency in public health all over the world [1]. Ebola virus disease is a severe, often fatal disease in humans and nonhuman primates such as monkeys, gorillas, and chimpanzees [2].

Ebola virus is one of the causes of viral hemorrhagic fever (VHF) [3]. Viral hemorrhagic fever describes a severe, multi-organ disease in which the vascular system is damaged and the body's ability to regulate itself is impaired. VHFs are often accompanied by hemorrhages which can be life threatening. Viral hemorrhagic fevers are important because they can readily spread within a hospital or mortuary setting, there is no effective cure or vaccine, they have a high mortality rate and they are difficult to recognize and diagnose rapidly [4].

The first cases of Ebola virus disease (EVD) were reported in 1976 in the Democratic Republic of Congo and since then sporadic cases and small scale outbreaks have occurred in central African countries [5]. There are five strains of EV but the Zaire strain is the most severe, with a case-fatality rate up to 90% [6]. The unprecedented scale of the current outbreak of EVD in Sierra Leone, Guinea, Liberia and Nigeria, led to the World Health Organization [7,8,5] declaring an international public health emergency. The outbreak has since spread to Senegal, and a reportedly unrelated outbreak has since occurred in the Democratic Republic of Congo (World Health Organization) [9]. As of 22nd August 2014, the West African outbreak has resulted in 2615 cases and 1427 deaths and is unprecedented because it has continued for more than double the length of time of the largest previous outbreak in Uganda in 2000 (3 months vs. 8 months), has resulted in more than six times as many cases (425 cases vs. 2615 cases), and has for first time occurred in more than one country simultaneously and in capital cities [10,5]. Among the total cases, 1251 have been laboratory confirmed, and genetic sequencing has showed that the similarity of the virus to the Zaire EV is 97% [11]. Unlike past outbreaks, the current outbreak of EVD has not been contained and has resulted in social unrest, breakdown in law and order, shortages of personal protective equipment (PPE) and depletion of the healthcare workforce, with over 240 health care workers (HCWs) becoming infected and 120 HCW deaths (WHO) [5,12]. The inability to contain this outbreak has been blamed variously on lapses in infection control, shortages of PPE and other supplies, myths and misconceptions about EVD, and the fact that it is occurring in large cities rather than small villages. HCWs, many of whom are nurses, are on the frontline of the response, and their occupational health and safety is critical to control of the outbreak and maintenance of the health workforce during a crisis. The Centers for Disease Control and Prevention (CDC) [13,14]

and World Health Organization (WHO) [7–9] have recommended the use of respirators.

Ebola virus disease (EVD)

Ebola virus disease is a severe acute viral illness often characterized by the sudden onset of fever, intense weakness, muscle pain, headache and sore throat. This is followed by vomiting, diarrhea, rash, impaired kidney and liver function, and in some cases, both internal and external bleeding [14,15]. Outbreaks of Ebola have occurred sporadically in parts of Africa, South America, the Middle East and Eastern Europe, with fatality rates ranging up to 90% [1].

Modes of transmission of Ebola

Ebola is spread through direct contact with blood or body fluids (including, but not limited to urine, saliva, sweat, feces, vomit, breast milk and semen) of an infected person or animal, or through contact with objects that have been contaminated with the blood or other body fluids of an infected person, dead or alive [14,16]. Transmission is believed to occur via contact with mucous membranes and non-intact skin (i.e., rashes, cuts, etc.). Risk of infection by inhalation of contaminated aerosols by healthcare workers has not been documented but is thought to be low at this time based on case history evidence [15,17]. Ebola virus is readily killed by soap, bleach, direct sunlight, or drying. Machine washing clothes that have been contaminated with fluids will destroy Ebola virus. Ebola virus survives only a short time on surfaces that are in the sun or have dried [18].

Factors to be considered in making recommendations for respiratory protection of HCWs

When determining recommendations for the protection of HCWs, a risk analysis approach is required that takes into account all relevant factors which could impact on the occupational health and safety of HCWs (Fig. 1). The severity of the outcome (case-fatality rate and disease severity) must be considered [19]. Any level of uncertainty around modes of transmission must also be evaluated, particularly if the disease has a high case-fatality rate. In addition, the availability of pre- and post-exposure prophylaxis or treatment must be considered. The immune status and co-morbidities in HCWs should also be considered, as some HCWs may be innately more vulnerable to infection [20].

As the aging of the nursing workforce occurs in developed countries, there is likely to be a high proportion of HCWs with chronic conditions. In this case, facemasks have been recommended for HCWs by CDC and WHO because of the assumption that EV is not transmitted via the airborne route [13,8]. However, there is uncertainty about transmission, the consequences of EVD infection are severe and there is no proven treatment, vaccine or post-exposure prophylaxis. Recommend-

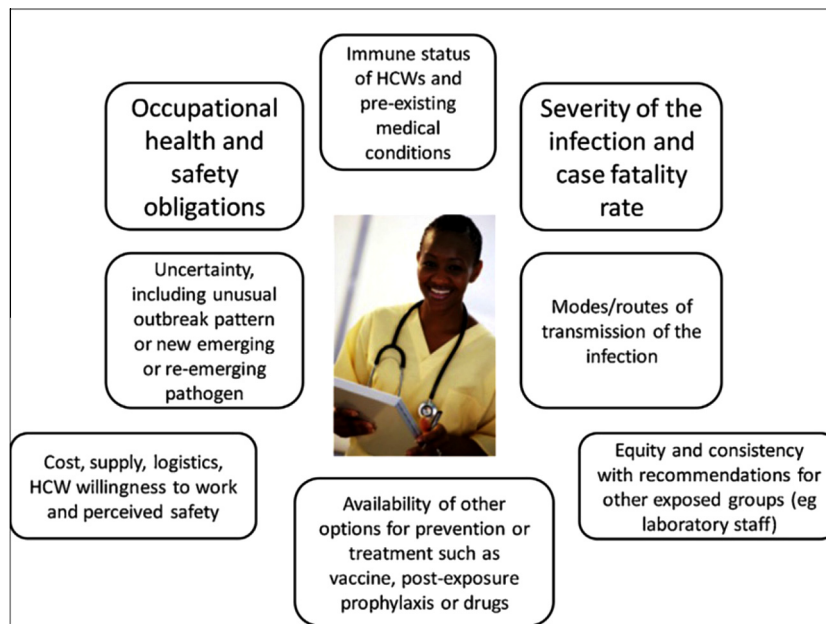


Figure 1 Factors to consider in making recommendations for respiratory protection of health care workers.

ing a surgical mask for EVD has much more serious implications than for influenza, which has a far lower case-fatality rate and for which there are easily accessible vaccines and antiviral therapy [21].

Further, numerous HCWs have succumbed to EVD during this epidemic, including senior physicians experienced in treating EVD and presumably less likely to have suffered lapses in infection control [7]. The high case-fatality rate warrants the use of better protection such as a respirator and full body suit with face shield, where it can be provided [18].

WHO recommendation for personal protection equipment (PPE) against Ebola virus disease

WHO emphasizes the importance of consistent use and implementation of Standard Precautions by all health care workers when providing care to all patients, regardless of their diagnoses. These precautions include a wide range of measures, including the use of PPE [5–8].

The prevention of Ebola virus infection depends on avoiding contact with blood and body fluids of infected individuals and with objects contaminated with these fluids. Barrier precautions are used to prevent skin or mucous membrane exposure of the eyes, nose, and mouth with blood, other body fluids, secretions (including respiratory droplets), or excretions. For those working to control the Ebola virus disease (EVD) outbreak and treat patients, WHO recommends that all health care workers have the mucous membranes of their eyes, mouth and nose completely covered by PPE. The recommended personal protective equipment for most activities is included in Table 1 [8].

Some tasks require additional body protection. Certain tasks—including administering aerosol-generating medical procedures, certain laboratory tasks, and autopsies—require respiratory protection [7].

Hand hygiene is strongly emphasized. It is of the highest importance that hand hygiene be performed thoroughly and often, including before and after donning and before and after doffing PPE. The WHO states that a risk assessment must be done by competent experts appointed by the employer [6–9]. PPE should be selected based primarily on the potential exposures and need for protection against infective fluids and agents. However, work conditions, environmental conditions, tasks and accessibility to decontamination facilities should also be considered [21].

Health workers should be trained on the risks, mitigating effects of the PPE, and their use. Training should be mandatory and thorough followed by mentoring before workers engage in any activities. PPE can help provide a barrier to infectious material. However, it is very important that all local infection control protocols and manufacturer's user instructions be followed when removing (doffing) the equipment to avoid contamination [18].

Respiratory protection for HCWs

Surgical/medical masks or respirators are another type of PPE recommended for those in contact with potential EVD cases. These products may need to be fluid resistant depending upon the eye and face protection being worn. A respirator is a device designed to help provide the wearer with respiratory protection against inhalation of a hazardous atmosphere. To help reduce nose, mouth and respiratory system exposures to airborne particles (< 100 µm), particulate-filtering respirators are often recommended [1,12]. Particulate respirators are available as:

1. A filtering half face piece respirator, where the filter is the entire respirator.
2. An elastomeric (reusable) half mask with a particulate filter.

Table 1 Summary of WHO PPE Recommendations by Task.

Task	Recommended PPE
Work in patient areas	<ul style="list-style-type: none"> • Gloves • Gown: disposable impermeable • Medical mask • Eye protection (eye visor, goggles or face shield) • Shoes: closed, puncture and fluid resistant (e.g. rubber boots)
Strenuous tasks or exposure to blood and body fluids	<ul style="list-style-type: none"> • Gloves, double set • Gown: disposable impermeable • Apron: waterproof (if gown is not impermeable) • Medical mask • Eye protection (eye visor, goggles or face shield) • Boots: rubber or disposable overshoes and leg coverings with shoes
Aerosol generating medical procedures	<ul style="list-style-type: none"> • Gloves • Gown: disposable impermeable • Respirator: FFP2, NIOSH N95 or equivalent • Eye protection (eye visor, goggles or face shield) • Shoes: closed, puncture and fluid resistant (e.g. rubber boots)
Handling infectious waste	<ul style="list-style-type: none"> • Gloves, heavy duty/ rubber • Gown: impermeable • Eye Protection (eye visor, goggles or face shield); Goggles preferred for liquid handling • Shoes: closed, puncture and fluid resistant (e.g. rubber boots)
Laboratory personnel handling potential Ebola specimens	<ul style="list-style-type: none"> • Gloves • Gown: disposable impermeable • Respirator* • Eye Protection (eye visor, goggles or face shield) • Shoes: closed with overshoes or boots* FFP2, NIOSH N95 or equivalent for handling. PAPR for aliquoting, centrifugation or other aerosol generating procedures
Handling of human remains	<ul style="list-style-type: none"> • Gloves, double • Gown: disposable impermeable • Mask • Eye protection (eye visor, goggles or face shield) • Rubber boots or closed puncture or fluid resistant shoes and overshoes
Autopsies of known or suspected Ebola virus disease cases	<ul style="list-style-type: none"> • Gloves, double • Gown: disposable impermeable • Respirator: FFP2, NIOSH N95 or equivalent or a PAPR • Eye protection (eye visor, goggles or face shield) • Shoes: closed or boots

3. An elastomeric (reusable) full face piece with a particulate filter.
4. A powered air purifying respirator (PAPR) that includes a particulate filter.
5. A supplied air respirator.

Particulate respirators are designed to help reduce the wearer's exposure to certain airborne particles. Currently, health authorities have not documented EVD as being transmitted from infected individuals via airborne Ebola virus. However, droplets containing the Ebola virus that have become aerosolized (e.g. from coughing, sneezing, vomiting, medical procedures, and surfaces etc.) may have the potential to come into contact with a person's mucous membranes in their nose or mouth or non-intact skin. Therefore, respiratory protection may be helpful in providing a barrier to help prevent infectious materials from contacting a wearer's mucous membranes. They may also help limit inadvertent touching of the nose, mouth and/or eyes (if a full-face piece or powered-air respirator is used). Respiratory protection is recommended for workers

performing certain tasks such as aerosol-generating procedures, laboratory procedures, and autopsies [16,19].

Why N95 masks are not enough: use full face respirators for real protection

This explains why N95 masks are not enough for protecting from Ebola. Most people do not know this, but N95 masks are actually designed to prevent the person who is wearing the mask from infecting others. These masks are NOT designed to protect the wearer from a contagion floating around in the air [17]. The only truly effective way to block aerosolized particles is to use either a half-face respirator or a full-face respirator (Fig. 2). Both 3 M, North Safety and MSA Safety Works all make highly effective respirators in half face and full face configurations. If HCWs wear only a half-face respirator, they will need to also protect their eyes, because Ebola virus easily enters through their eye ducts [19,18].



Figure 2 Demonstrates standard respiratory protection for HCWs with either a half-face respirator or a full-face respirator.

WHO recommendations for respirator decontamination

Bleach kills Ebola, so it is a good idea to stock up on some bleach right now. Any protective gear that HCWs wear in public may acquire Ebola contamination on its surfaces, so they will need to decontaminate their gear using a water-bleach solution each time after wearing their gear anywhere near Ebola patients or in areas where Ebola contamination may have occurred. Disposable gear, of course, does not need to be washed but it does need to be carefully contained in a biohazard containment/disposable vessel such as being sealed inside trash bags which are then placed inside sturdy barrels or other containers [18,19,5].

For decontamination scrub-down, this is usually a two-person operation, where the person wearing the suit stands in an isolated room or a makeshift outdoor shower and is meticulously scrubbed down with bleach and water by a second person doing the scrubbing and rinsing. This second person, of course, must also be wearing isolation gear or order to minimize their own risk of acquiring an infection from the washing process [18]. HCWs must keep in mind that a body suit does not offer full protection against Ebola all by itself. They still need shoe covers, a full face respirator and latex or nitrile gloves. Even then, risk of contamination is not reduced to zero. There is always a risk that a few Ebola particles slip through the edges of the gear and end up on your body [12,14].

Ideally, HCWs should be scrubbed and rinsed while wearing their gear, then they should remove the gear and strip down to being completely nude. They should then move to a different location where they experience a full body shower combined with a strong bleach-water soak and scrub for the feet [8,7,13]. All clothes should be thoroughly washed and then dried in direct sunlight. Because UV light destroys Ebola, the more decontamination procedures they can conduct in direct sunlight, the better. For washing reusable gear, the best guess right now would be 5% bleach and 95% water. Stronger laboratory cleaning solutions like Triton-X are likely to be effective at even lower concentrations such as 1–2% [9,14].

In conclusion, while EVD is predominantly spread by contact with blood and body fluids, there is some uncertainty about the potential for aerosol transmission. Particulate respirators are designed to help reduce the wearer's exposure to certain airborne particles. The most effective way to block

aerosolized particles is to use either a half-face or a full-face respirator. HCWs still need shoe covers, a full face respirator and latex or nitrile gloves to decrease the risk of Ebola virus contamination.

Conflict of interest

None declared.

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