

Commentary

Occupational Safety and Health Protections Against Ebola Virus Disease

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Even as the Ebola epidemic is finally showing signs of remitting, controversy continues regarding the modes of disease transmission, the understanding of which necessarily dictates methods of prevention. The initial public health response to the epidemic was based on assumptions formed during previous outbreaks, and in the belief that transmission was restricted to direct “contact” with other infected patients. However, the current Ebola outbreak differed from previous experiences in its intensity of transmission, speed of spread, and fatality rate and was also particularly unforgiving on health workers occupationally infected. Even with these differences, however, other modes of transmission were not considered by public health authorities, thus denying both the hard-hit health worker populations and the wider public more protective guidance. International Labor Conventions require employers to provide a comprehensive safety program that anticipates work-related risks and specifies strategies for protection against them. Such a precautionary approach is recommended in future epidemic planning, especially where evidence regarding transmission is incomplete. Am. J. Ind. Med.

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INTRODUCTION

The largest epidemic of Ebola Virus Disease (EVD) ever recorded has been raging in West Africa for almost a year but is finally showing signs that it is beginning to ebb. First identified in Central Africa in 1976 the Ebola Virus (EV) has since caused periodic, usually small outbreaks of EVD, with initial human infection thought typically to result from contact with infected animals or their excretions [WHO, 2015].

The first cases of the present outbreak were reported in March, 2014. As of February 4, 2015, the World Health Organization (WHO) reported that there have been 22,495 total cases of EVD with almost 9,000 deaths. Guinea, Liberia, and Sierra Leone are the three countries most seriously affected and termed “intense-transmission countries” [WHO, 2015]. All have very weak health systems,

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having only recently emerged from long periods of conflict and instability. On August 8, the WHO Director-General declared this outbreak a Public Health Emergency of International Concern. The subsequent response has proven to be uneven and difficult both on the international and local levels [Pathmanathan et al., 2014].

The current EV disease outbreak appears more severe than past outbreaks in several important respects. First, the intensity of transmission, speed of spread and extent of the outbreak are much greater than in the past [Meltzer et al., 2014]. Second, the fatality rate (estimated to be around 60–70%) has been higher than in most past outbreaks [WHO, 2014].

Occupationally acquired infections are a significant component of the current epidemic. From 5% to more than 10% of EVD cases are reported to have occurred in health care workers who have been occupationally infected with EV [Kilmarx et al., 2014]. In Sierra Leone, the incidence of EVD among health care workers is estimated to be 103 times higher than in the general population [Kilmarx et al., 2014]. Reported cases have also occurred in members of other occupationally exposed groups, such as transport workers and members of burial teams.

Protection of worker health, while critical in its own right, is also essential to the overall control of the epidemic.

- (1) **Community Protection.** Workers who have been exposed to EV in infected work settings may carry the disease home thus contributing to community-based transmission of the disease [Collegium Ramazzini Statement, 2011].
- (2) **Worker Protection.** It is clear that the health systems in the most seriously affected countries have been overwhelmed and that workers in these countries need better safeguards than have been available [Wolz, 2014]. The occurrence of occupationally acquired EV infections among nurses working in advanced health care systems in the US and in Europe has also revealed a lack of adequate preparedness in these countries. The loss of health care workers to EV infection further decimates the workforce of already under-resourced communities.

To be sure, while broader public health actions such as contact tracing, infection control and medical care procedures, and waste management are fundamental to outbreak control, unless workers throughout the world are prepared, trained, and adequately protected, effective containment of EVD will not occur.

Containment of EV is possible. The successes of Senegal, Nigeria, and Mali in limiting outbreaks after identifying EV disease within their borders are encouraging signs. The increasingly effective treatment of infected health care workers and the containment of secondary spread of

infection in the U.S. and Europe also bode well. And guidelines to protect workers who may be exposed to EVD are evolving in a favorable direction. Even so, workers need higher levels of protection than some current guidance recommends [IOM, 2014].

Application of the Precautionary Principle

Scientific uncertainty surrounds the mode of interpersonal transmission of EV. Classic teaching has been that EV spreads only by direct contact with infected persons or their body fluids or by contact with objects such as needles and syringes that have been contaminated by EV. However, the possibility of transmission via inhalation of infectious airborne particulates cannot definitively be excluded, especially in intimate settings where health care workers are exposed to patients who are coughing or releasing copious amounts of vomits and diarrhea [Osterholm et al., 2015]. Patients with EV infection can forcefully expel many gallons of contaminated body fluids in the span of a few hours.

Previous assumptions about the behavior of the virus, its mode of transmission and infectivity, and current recommendations on prevention strategies, which are based on those assumptions, need to be reconsidered [WHO-CDC, 2014]. Exposures from such sources as projectile vomiting, copious diarrhea, coughing, or other virus-laden body fluids, as well as exposures to aerosol-generating medical procedures, should be assumed to be hazardous not only via direct exposure to mucous membranes and skin, but also via the respiratory route.

Options to protect workers against EV exposures are limited, and must rely extensively on the application of appropriate work practices and personal protective equipment. Unfortunately, within the hierarchy of control methods available in occupational safety and health, reliance on work practices and PPE is less desirable and efficacious than other control options [Institute of Medicine, 2014]. Therefore, an abundance of precaution should be adopted when relying on work practices and PPE, and this precautionary approach should be incorporated into an Ebola safety and health plan [Brousseau and Jones, 2014].

Basic Principles of Occupational Safety and Health Apply

Any employer or organization whose workers may be at risk of exposure to EV, is required to have in place a comprehensive occupational safety and health program that anticipates work-related risks and describes strategies for protection against such risks [ILO, 1981]. Workers at risk in the current EV epidemic are not confined to the health care

sector, but include any person who has physical contact with, transports, cares for, disposes of, and cleans up contamination from persons known or thought to be infected with EVD. These include workers in transportation, security, mortuary activities, and waste management.

Safety and health protections should be the most feasible in accordance with the conditions of the work being performed. Workers have the absolute right to know about the risks they face from their work.

A well-established “hierarchy of control” methods has been established in the field of occupational safety and health to limit exposures and risks. This hierarchy needs to be embodied in the occupational health and safety plan. Four central principles in this hierarchy are:

- (1) Elimination or isolation of an hazard at its source, which is the most effective protective strategy.
- (2) Engineering controls that interpose physical barriers between a worker and a hazard are also inherently more protective than strategies that rely on performance of the correct work practices, use of Personal Protective Equipment (PPE) and individual behavior.
- (3) Organization of Work and Work Practices to minimize hazards is of critical importance.
- (4) Personal Protective Equipment (PPE) is a necessary component of an occupational safety and health program when inherently more effective control measures such as elimination or isolation of a hazard is not feasible or to supplement these measures when those controls may not be adequate.

Also essential to the safety and health plan is the designation of one or more persons to be responsible for worker safety, for the training of workers in safe work practices and for overseeing use of personal protective equipment (PPE).

In the case of Ebola, prevention of exposure cannot be achieved by eliminating the hazard and in many low resource settings, such as the presently affected countries in West Africa, engineering controls, such as negative pressure isolation and ante-rooms are not present. Therefore, workers with exposure opportunity must be protected using effective organization of work and work practices, together with scrupulous PPE use.

The Organization of Work/Work Practices

The organization of Ebola Treatment Units (ETU), whether they are in the field or in medical centers should be designed so that the delivery of patient care is performed using procedures that prevent exposure and minimize risk to workers. This is achieved through a carefully articulated plan

that defines exposure zones (zones of likelihood of exposure to EV from infected patients or contaminated surfaces or equipment) and rigorously specifies work practices and other measures that will avoid or minimize exposure. Other occupational settings where workers may have contact with persons potentially-infected with EV, such as airports, border crossings, or facilities that handle hazardous waste should also have written safety and health plans that describe approaches to duties, safety procedures, and required use of PPE.

Principles of Personal Protective Equipment Use

In addition to the organization of work and training in safe work practices described above, any worker with potential exposure should be provided with all necessary personal protective equipment (PPE). Individuals and groups of workers should be trained in the use of this equipment, including how to safely apply and remove PPE. A great deal of experience in use of PPE has been gained from high-hazard industries, whose workers rely heavily upon PPE protections in health and safety programs [See Safety Daily Advisor, 2013]. One of the key principles here is considering PPE as a system that includes several types of protective clothing and equipment that must be integrated to provide consistent levels of protection.

Working in full PPE garments poses physiological risks to workers in the form of dehydration and heat stress. Rigorous attention must be paid to limiting work shifts and to use of proper decontamination procedures during breaks between shifts. Sufficient time must be allowed for donning, decontaminating, and doffing PPE. A “buddy system” which involves participation in the doffing process of a trained and qualified person (also dressed in full PPE) is essential to minimize risk of contamination. Workers must be trained in the recognition of symptoms of heat stress in themselves and others to facilitate timely interventions [Wolz, 2014].

Requirements for Respiratory Protection

Exposures to such potential sources of EV infection as projectile vomiting, coughing, or splashes from virus-contaminated body fluids or aerosol-generating medical procedures should be assumed to be hazardous, and therefore require use of respiratory protection [Brosseau and Jones, 2014]. Levels of protection can later be titrated downwards, but only if credible science emerges to show that the virus is not contained in aerosols and that it is not capable of transmission via the airborne route. Until such time, the following requirements must be applied:

- (1) All workers in an EV exposure zone should be provided with respiratory protection, either a fit-tested filtering face piece respirator or hooded powered air-purified respirator (PAPR). Use of a PAPR reduces the need for procedures such as fit testing and also reduces risk of heat stress. Where a PAPR is not available or feasible for use, a fit-tested filtering face piece respirator (such as an N-95) should be used. All respirator use should be done in the context of a respiratory protection program that is described in detail in the employer/organization's safety and health plan including necessary training. Full face protection from splashes (goggles, face shield, protective clothing) must also be provided. (See PPE Addendum)
- (2) Hands-on simulation training and rehearsal is needed in donning, doffing, and adjusting PPE. Workers should watch and evaluate other workers until they achieve a sufficient level of competence in these procedures before they enter an exposure zone.

Hazard Pay, Isolation of Workers at Risk, Protection of Benefits, and Compensation

Offers of financial rewards for taking unnecessary risks (also known as “hazard pay”) have been proposed for health care workers in some of the affected areas in West Africa. These approaches are not an acceptable alternative to providing the best possible worker protections.

Although there have been no cases reported of disease transmission from an asymptomatic infected persons, social, and political pressures may result in policies involving voluntary or mandatory isolation (quarantine). During such time, the livelihood of workers and their families should be protected by providing them with full wages, benefits and seniority protections. The families of workers who die or become disabled from work-induced EVD should be fully compensated for the losses they have incurred.

CONCLUSION—A BETTER GLOBAL RESPONSE IS NEEDED

For more than a decade repeated calls have been made urging health care systems around the world and their workers to become better prepared for outbreaks of new and emerging infections. In 2004, the International Commission on Occupational Health (ICOH) and the International Social Security Association (ISSA) called for a “systematic occupational risk prevention program” for health care workers to include training regarding work risks and the provision of protective measures, as an integral part of an administrative process addressing health care quality

[ICOH and SSA, 2004]. In 2007, WHO declared that the loss of health care workers to preventable diseases because of inadequate safeguards threatens the viability of the health care system [WHO, 2007].

These warnings, and the failure of nations and the international community to act on them have been clearly confirmed in the current outbreak.

Now we must act belatedly upon these warnings to ensure that workers in EV exposure zones receive the full protections to which they are entitled, and to ensure that health systems in countries around the world are better prepared to confront future outbreaks of emerging infectious diseases.

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APPENDIX 1 Recommended PPE Requirements

Selection of Specific PPE Forming a Protective Ensemble

PPE is recommended to include a garment, gloves, footwear, and eye/face/respiratory protection devices. Recommendations are provided in terms of ideal, minimum, and unacceptable products for each type of PPE. Different alternative products are recommended.

PPE items are recommended in terms of their type, overall design, and design attributes. Where available, specific standards are also described as the minimum basis of performance. Both North American and European/International standards are referenced.

The recommended PPE must form an “ensemble” of clothing and equipment that addresses the need for liquid penetration resistant interfaces (joints between different items of clothing and equipment, such as between gloves and garment sleeves) and the manner in which the ensemble is donned and doffed (particularly when contaminated).

These recommended guidelines are significantly more protective than those issued to date by global and domestic public health agencies, including the WHO and CDC. However we have found that there is a need to reference PPE recommendations based on established product performance standards to ensure appropriate and reliable levels of health care worker protection.

PPE Decontamination

Prospective decontamination procedures and agents must be considered in the selection of PPE items, as certain processes may degrade the ensemble item during the doffing process and result in exposure.

Care must be taken in decontamination of PPE. Many recommended disinfectants are designed for use on surfaces rather than PPE. Improper decontamination processes or solutions can damage single-use PPE during the doffing process and cause exposure. Further, the impact of decontamination on multiple-use PPE items (e.g., respirator facepieces or the seams of multi-use garments) is not fully

known. Multi-use PPE should be carefully inspected after decontamination and any deterioration monitored.

One common (and improper) approach to decontamination is the notion that increasing the strength of a bleach solution will improve effectiveness. This should never be attempted when decontaminating PPE.

PPE Use—Donning

The selected PPE must be donned in the correct sequence in order to provide an effective ensemble for protection against contact with individuals with Ebola Virus disease or contamination. The specific donning order will depend on the actual items of PPE comprising the ensemble, as the donning process will be affected by how interfaces are formed. All PPE should be donned in accordance with an established standard operating procedure, under supervision, and with assistance as needed.

While taping may be recommended for some interfaces, it is important to use tape that does not degrade protection. For example, when tape is removed during doffing (particularly a tape with strong adhesive such as duct tape) it can cause a tear in the garment. Filtering facepiece respirators should never be taped to the hood of a protective coverall or other PPE—this can disrupt the fit of the respirator on the wearer’s face, which affects its protective performance

PPE Use—Doffing (Assuming Contamination)

Extreme care must be exercised when doffing PPE following use where contamination has occurred or is suspected. A specific sequence for doffing the PPE must be followed, in an order that prevents any transfer of contamination from the PPE to the individual wearer or others. The following considerations should be included in operating procedures for doffing of ensembles with known or suspected contamination:

- 1) The wearer must assume that any surface could be contaminated.
- 2) All doffing must be performed under supervision and with assistance as needed.
- 3) The last items to be removed should be the face/eye protection or respirator, and inner gloves.
- 4) Any time the wearer of the contaminated ensemble or an individual assisting in the doffing process touches a potentially contaminated surface or PPE item, the wearer or assisting individual must rinse their gloved hands with an appropriate decontamination solution that does not cause degradation of the gloves.
- 5) For some types of ensembles, it is possible to cut off the garment to permit easier doffing without contact with contaminated surfaces. If cutting of the garment is performed, then the procedures used for the cutting process should account for the design of the garment (e.g., the placement of seams and closures).

Matrix of Recommended Personnel Protective Equipment for Potential Exposure to Ebola Virus - Part 1

Function	Preference	Garments	Gloves
Patient care (indoor or controlled environment settings)	Ideal	NFPA 1999 Single Use Garment (certified)—full body hooded garment—breathable <i>No current products certified</i>	NFPA 1999 Single Use Examination Glove (certified)—double gloving; <i>Several products certified—see attached list; exterior glove should be longer than inner glove; tape may be needed to effect interface; nitrile glove styles preferred due to potential latex allergies</i>
	Minimum	Hooded garments with materials that pass ASTM F1671 or meeting ISO 16604 at 14 kPa with taped or sealed seams, closures with sealable cover flaps; Alternative configuration involves standard coverall with hooded PAPR or air-fed hood constructed of same material meeting above requirements; or Hooded garment or multiple garments covering full body marked to EN 14126, Type 3-B or higher, Performance level 5 for viral penetration resistance; performance level 2 for tensile, tear, and seam strength; Preference for garments demonstrating breathability that still meet minimum barrier requirements; breathability is defined as garment materials having total heat loss values greater than 450 W/m ² (per ASTM F1868, Proc. C); evaporative resistance less than 15kPam ² /W (per ASTM F1868, Proc. B or ISO 11092), moisture vapor transport rates greater than 650 g/m ² —24 hr (ASTM E96 B), greater than 6,000 g/m ² —24 hr (ASTM E96 BW), or greater than 8,000 g/m ² —24 hr (ISO 15,946) <i>Multiple products in this market place are available meeting these requirements; many forms of chemical protective clothing will meet the barrier and liquid integrity requirements of the above specifications, including garments certified to NFPA 1992</i>	Gloves meeting ASTM D3578 (latex rubber), ASTM D6319 (nitrile), ASTM D6977 (chloroprene); or EN 455 (examination gloves); Double gloving required for all examination glove types; Heavier, thicker gloves may be used including unsupported neoprene, nitrile, or other rubber gloves that do not compromise patient-care functions; these gloves should meet the minimum requirements of ANSI/ISEA 105 for Detection of Holes, Level 1 cut resistance, Level 1 puncture resistance, Level 1 abrasion resistance, and Level 3 dexterity; or Thicker gloves that meet criteria in EN 420 (finger dexterity level 3), EN 388 (at least Level 1 performance for abrasion resistance, blade cut resistance, and puncture resistance), and EN 374-2; <i>Several industry gloves are available that meet these standards and are acceptable if of sufficient length and provided in appropriate sizes; tape may be needed to effect interface; tape should be selected that does not tear garment and is placed on sleeve to allow removal during doffing (using tab)</i>
Body removal/burial or liquid waste disposal (involving heavy physical work or	Not acceptable	Garments constructed of air-permeable materials without demonstrated viral penetration resistance (liquid hold out capabilities are not sufficient); garments that do not cover full body; garments that do not have sealed or taped seams, or cover flaps over exposed zippers <i>Examples of these types of products include various non-laminated or un-coated polypropylene products</i> ; Standard surgical gowns that do not provide full body liquid protection (most AAMI PB70 or EN 13795 surgical gowns are not full body garments and provide protection only in critical zones)	Thin gauge polyethylene or vinyl gloves; Any thin gauge glove that uses non rubber or non-plastic exterior; Coated fabric gloves; Flocked gloves
	Ideal	NFPA 1999 Multiple Use Garment (certified)—full body garment—breathable; <i>Current products exist but are not full body (with hoods)</i>	NFPA 1999 Single Use Cleaning Glove (certified) worn over NFPA 1999 Single Use Examination Glove (certified)— <i>No current products certified to</i>

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Matrix of Recommended Personnel Protective Equipment for Potential Exposure to Ebola Virus - Part 1

Function	Preference	Garments	Gloves
significant potential for body fluid exposure)	Minimum	Garments with materials that pass ASTM F1671 or meeting ISO 16604 at 14 kPa with taped or sealed seams, closures with sealable cover flaps; materials show high levels of tensile strength (250 N), tear resistance (75 N), and seam strength (125 N); or Garment marked to EN 14126, Type 3-B or higher, Performance level 5 for viral penetration resistance; performance level 4 for tensile, tear, puncture, and seam strength; Preference for garments demonstrating breathability that still meet minimum barrier requirements; breathability is defined as garment materials having total heat loss values greater than 450 W/m ² (per ASTM F1868, Proc. C), evaporative resistance less than 15kPam ² /W (per ASTM F1868, Proc. B or ISO 11092), moisture vapor transport rates greater than 650 g/m ² —24 hr (ASTME96 B), greater than 6,000 g/m ² —24 hr (ASTM E96 BW), or greater than 8000 g/m ² —24 hr (ISO 15946); <i>Multiple products in this market place are available meeting these requirements; many forms of chemical protective clothing will meet the barrier and liquid integrity requirements of the above specifications, including garments certified to NFPA 1992</i>	<i>cleaning glove requirements</i> Inner gloves meeting ASTM D3578 (latex rubber), ASTM D6319 (nitrile), ASTM D6977 (chloroprene) or EN 455 (examination gloves); Outer gloves that are at least 0.3 mm (11 mil) thick including unsupported neoprene, nitrile, or other rubber gloves that do not compromise patient-care functions; these gloves should meet the minimum requirements of ANSI/ISEA 105 for Detection of Holes, Level 1 cut resistance, Level 1 puncture resistance, Level 1 abrasion resistance, and Level 3 dexterity; or Outer gloves that are at least 0.3 mm (11 mil) thick that meet criteria in EN 420 (finger dexterity level 3), EN 388 (at least Level 1 performance for abrasion resistance, blade cut resistance, and puncture resistance), and EN 374-2; <i>Several industry gloves are available that meet these standards and are acceptable if of sufficient length and provided in appropriate sizes; tape may be needed to effect interface; tape should be selected that does not tear garment and is placed on sleeve to allow removal during doffing (using tab)</i>
	Not acceptable	Garments constructed of air-permeable materials without demonstrated viral penetration resistance (liquid hold out capabilities are not sufficient); garments that do not cover full body; garments that do not have sealed or tape seams, or cover flaps over exposed zippers; Any garment designed of relatively light weight materials that may easily tear or snag under rugged field conditions	Single glove; Any thin gauge glove; Any coated work glove; Any non-barrier glove
Physical security/emergency response (varied settings and site conditions)	Ideal	NFPA 1999 Multiple Use Garment (certified)—full body garment—breathable; <i>Current products exist but are not full body (with hoods); product exposure may warrant disposal; NFPA 1994 Class 4 or NFPA 1999 multiple use BRN ensemble (includes gloves, footwear, and designated respirator protection); No current products certified</i>	NFPA 1999 Single Use Cleaning Glove (certified) worn over NFPA 1999 Single Use Examination Glove (certified)— <i>No current products certified to cleaning glove requirements</i>
	Minimum	Garments with materials that pass ASTM F1671 or meeting ISO 16604 at 14 kPa with taped or sealed seams, closures with sealable cover flaps; materials show high levels of tensile strength (250 N), tear resistance (75 N), and seam strength (125 N); or Garment marked to EN 14126, Type 3-B or higher, Performance level 5 for viral penetration resistance;	Inner gloves meeting ASTM D3578 (latex rubber), ASTM D6319 (nitrile), ASTM D6977 (chloroprene) or EN 455 (examination gloves); Outer gloves that are at least 0.3 mm (11 mil) thick including unsupported neoprene, nitrile, or other rubber gloves that do not compromise patient-care functions; these gloves should meet the minimum requirements of

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Matrix of Recommended Personnel Protective Equipment for Potential Exposure to Ebola Virus - Part 1

Function	Preference	Garments	Gloves
		<p>performance level 4 for tensile, tear, puncture, and seam strength;</p> <p>Preference for garments demonstrating breathability that still meet minimum barrier requirements; breathability is defined as garment materials having total heat loss values greater than 450 W/m² (per ASTM F1868, Proc. C) evaporative resistance less than 15 kPam²/W (per ASTM F1868, Proc. B or ISO 11,092), moisture vapor transport rates greater than 650 g/m²—24 hr (ASTM E96 B), greater than 6,000 g/m²—24 hr (ASTM E96 BW), or greater than 8,000 g/m²—24 hr (ISO 15946), <i>Multiple products in this market place are available meeting these requirements; many forms of durable chemical protective clothing will meet the barrier and liquid integrity requirements of the above specifications, including garments certified to NFPA 1992 or NFPA 1994 (any class)</i></p>	<p>ANSI/ISEA 105 for Detection of Holes, Level 1 cut resistance, Level 1 puncture resistance, Level 1 abrasion resistance, and Level 3 dexterity; or Outer gloves that are at least 0.3 mm (11 mil) thick that meet criteria in EN 420 (finger dexterity level 3), EN 388 (at least Level 1 performance for abrasion resistance, blade cut resistance, and puncture resistance), and EN 374-2; <i>Several industry gloves are available that meet these standards and are acceptable if of sufficient length and provided in appropriate sizes; tape may be needed to effect interface; tape should be selected that does not tear garment and is placed on sleeve to allow removal during doffing (using tab)</i></p>
Not acceptable		<p>Garments constructed of air-permeable materials without demonstrated viral penetration resistance; liquid hold out capabilities not sufficient; Any garment designed of relatively light weight materials that may easily tear or snag under rugged field conditions</p>	<p>Single glove; Any thin gauge glove; Any coated work glove; Any non-barrier glove</p>

Matrix of Recommended Personnel Protective Equipment for Potential Exposure to Ebola Virus - Part 2

Function	Preference	Footwear	Face/Eye Protection
Patient care (indoor or controlled environment settings)	Ideal	NFPA 1999 Single Use Footwear Covers(certified) worn over regular footwear. Alternatively barrier footwear may be worn but may require disposal following use; <i>No products currently certified to NFPA 1999</i>	NFPA 1999 Full Facemask (certified) NIOSH certified loose fitting PAPR or tight fitting (full facepiece) PAPR with P100 filters or full facepiece APR with P100 filters (certified); hood materials should meet same requirements as garments; or EN 136 full face masks EN 143 P3 particulate filters rated for solid/liquid particulates, or EN12941/EN12942 PAPR with EN 143 P3 particulate filters rated for solid/liquid particulates; hood materials should meet same requirements as garments; <i>There are no NFPA 1999 products currently certified; however, there are multiple versions of APR and PAPR available in market place certified by NIOSH as well as products marked to European standards</i>
	Minimum	Any full barrier footwear cover demonstrating ASTM F1671 or meeting ISO 16604 at 14 kPa with taped or sealed seams and durable wear surface Full barrier footwear (such as rubber boots) that extend to mid-calf may be worn; <i>Many of these products are made of the same materials as the garments previously described; selected items must have sufficient overlap with garment leg to provide leak free interface; garment leg worn over footwear cover</i>	P100 filtering facepiece (NIOSH certified) and that are also compliant with the barrier requirements of ASTM F2100 as medical face masks) in combination with non-vented goggles and full faceshield (both certified to ANSI Z87.1); or EN 140 or EN 405 half masks outfitted with EN 143 P3 particulate filters rated for solid/liquid particulates worn with ISO 4849 goggles and faceshields; Filtering facepiece respirators should have four point suspension (two straps) and an elastomeric or foam face seal; N95 filtering facepieces (NIOSH certified) that are also compliant with the barrier requirements of ASTM F2100 as medical face masks in combination with non-vented goggles and full faceshield (both certified to ANSI Z87.1); or EN 140 or EN 405 half masks outfitted with EN 143 P3 particulate filters rated for solid/liquid particulates worn with ISO 4849 goggles and faceshields; Filtering facepiece respirators should have four point suspension (two straps) and an elastomeric or foam face seal. NFPA 1999 Single Used Medical Face Mask combined with Single Use Eye /Face Protection Device; <i>There are no NFPA 1999 products currently certified; however, there are multiple version of P100 and N95 filtering facepieces available in market place certified by NIOSH as well as product marked to European standards</i>
	Not acceptable	Covers made with unsealed seams or lack of durable wear surface; Any non-barrier footwear or footwear that does not create effective interface with garment leg by having sufficient overlap	N95 filtering facepieces or respirators using EN 143 P1 filters that do not demonstrate fluid resistance characteristics; Surgical masks, including facemasks meeting ASTM F2100, that do not provide respiratory protection; Combinations of devices that do not provide fitted protection of wearer or do not fully cover eyes and face or result in exposed skin of the wearer when combined with garments
Body removal/burial or liquid waste	Ideal	NFPA 1999 Multiple Use Footwear (certified); <i>Limited number of current</i>	NFPA 1999 Full Facemask (certified) NIOSH certified loose fitting PAPR or

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Matrix of Recommended Personnel Protective Equipment for Potential Exposure to Ebola Virus - Part 2

Function	Preference	Footwear	Face /Eye Protection
disposal (involving heavy physical work or significant potential for body fluid exposure)	<p>items certified; product exposure may warrant disposal; NFPA 1999 Single Use Footwear Covers (certified) worn over footwear that meets toe impact/compression and puncture resistance requirements of ASTM F2413. No current certified footwear covers; selected items must have sufficient overlap with garment leg to provide leak free interface; garment leg worn over footwear cover</p>	<p>Contiguous rubber or plastic footwear that provides effective interface with garment leg by having sufficient overlap; Barrier-based footwear that has barrier materials and seams demonstrating ASTM F1671 or meeting ISO 16604 at 14 kPa; Many forms of durable hazardous materials protective footwear will meet these requirements</p>	<p>tight fitting (full facepiece) Full facepiece PAPR with P100 filters or full face piece APR with P100 filters (certified); hood materials should meet same requirements as garments; or EN 136 full face masks EN 143 P3 particulate filters rated for solid/liquid particulates, or EN12941/EN12942 PAPR with EN 143 P3 particulate filters rated for solid /liquid particulates; hood materials should meet same requirements as garments; There are no NFPA 1999 products currently certified; however, there are multiple versions of APR and PAPR available in market, place certified by NIOSH as well as products marked to European standards</p> <p>P100 filtering facepiece (NIOSH certified and that are also compliant with the barrier requirements of ASTM F2100 as medical face masks) in combination with non-vented goggles and full faceshield (both certified to ANSI Z87.1); or EN 140 or EN 405 half masks outfitted with EN 143 P3 particulate filters rated for solid/liquid particulates worn with ISO 4849 goggles and faceshields; Filtering facepiece respirators should have four point suspension (two straps) and an elastomeric or foam face seal. N95 filtering facepieces (NIOSH certified) that are also compliant with the barrier requirements of ASTM F2100 as medical face masks in combination with non-vented goggles and full faceshield (both certified to ANSI Z87.1); or EN 140 or EN 405 half masks outfitted with EN 143 P3 particulate filters rated for solid/liquid particulates worn with ISO 4849 goggles and faceshields; Filtering facepiece respirators should have four point suspension (two straps) and an elastomeric or foam face seal. NFPA 1999 Single Use Medical Face Mask combined with Single Use Eye /Face Protection Device; There are no NFPA 1999 products currently certified; however, there are multiple version of P100 and N95 filtering facepieces available in market place certified by NIOSH as well as product marked to European standards</p> <p>N95 filtering facepieces or respirators using EN 143 P1 filters that do not demonstrate fluid resistance characteristics; Surgical masks, including facemasks meeting ASTM F2,100 that do not provide respiratory protection; Combinations of devices that do not provide fitted protection of wearer or do not fully cover eyes and face or result in exposed skin of the</p>
	<p>Minimum</p>		
	<p>Not acceptable</p>	<p>Covers made with unsealed seams or lack of durable wear surface; Any non-barrier footwear or footwear that does not create effective interface with garment leg by having sufficient overlap</p>	

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Matrix of Recommended Personnel Protective Equipment for Potential Exposure to Ebola Virus - Part 2

Function	Preference	Footwear	Face/Eye Protection
Physical security/emergency response (varied settings and site conditions)	Ideal	NFPA 1999 Multiple Use Footwear (certified); <i>Limited number of current items certified; product exposure may warrant disposal</i> ; NFPA 1999 Single Use Footwear Covers (certified) worn over footwear that meets toe impact/compression and puncture resistance requirements of ASTM F2413 <i>No current certified footwear covers; selected items must have sufficient overlap with garment leg to provide leak free interface; garment leg worn over footwear cover</i>	wearer when combined with garments NFPA 1999 Full Facemask (certified) NIOSH certified loose fitting PAPR or tight fitting (full facepiece) PAPR with P100 filters or fullfacepiece APR with P100 filters (certified); hood materials should meet same requirements as garments; or EN 136 full face masks EN 143 P3 particulate filters rated for solid/liquid particulates, or EN12941/EN12942 PAPR with EN 143 P3 particulate filters rated for solid/liquid particulates; hood materials should meet same requirements as garments. <i>There are no NFPA 1999 products currently certified; however, there are multiple versions of APR and PAPR available in market place certified by NIOSH as well as products marked to European standards</i>
	Minimum	Contiguous rubber or plastic footwear that provides effective interface with garment leg by having sufficient overlap Footwear meeting NFPA 1992 or NFPA 1994, or EN13832-3 Barrier-based footwear that has barrier materials and seams demonstrating ASTM F1671 or meeting ISO16604 at 14 kPa; <i>Many forms of durable hazardous materials protective footwear will meet these requirements</i>	P100 filtering facepiece (NIOSH certified) in combination with non-vented goggles and fullfaceshield (both certified to ANSI Z87.1); or EN140 or EN 405 half masks outfitted with EN 143 P3 particulate filters rated for solid/liquid particulates worn with ISO 4849 goggles and faceshields; Filtering facepiece respirators should have four point suspension (two straps) and an elastomeric or foam face seal. N95 filtering facepieces (NIOSH certified) that are also compliant with the barrier requirements of ASTM F2100 as medical face masks in combination with non-vented goggles and full faceshield (both certified to ANSI Z87.1); or EN140 or EN 405 half masks outfitted with EN 143 P3 particulate filters rated for solid/liquid particulates worn with ISO 4,849 goggles and faceshields; Filtering facepiece respirators should have four point suspension (two straps) and an elastomeric or foam face seal. NFPA 1999 Single Used Medical Face Mask combined with Single Use Eye/Face Protection Device; <i>There are no NFPA 1999 products currently certified; however, there are multiple versions of P100 and N95 filtering facepieces available in market place certified by NIOSH as well as product marked to European standards</i>
	Not acceptable	Covers made with unsealed seams or lack of durable wear surface; Any non-barrier footwear or footwear that does not create effective interface with garment leg by having sufficient overlap	N95 filtering facepieces or respirators using EN 143 P1 filters that do not demonstrate fluid resistance characteristics; Surgical masks, including facemasks meeting ASTM F2100 that do not provide respiratory protection; Combinations of devices that do not provide fitted protection of wearer or do not fully cover eyes and face or result in exposed skin of the wearer when combined with garments

Referenced Standards:

AAMI PB70, Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities, 2012.

ANSI/ISEA 105, Hand Protection Selection Criteria, 2011.

ANSI Z87.1, American National Standard for Occupational and Educational Eye and Face Protection Devices, 2010.

ASTM D3578, Standard Specification for Rubber Examination Gloves, 2010.

ASTM D6319, Standard Specification for Nitrile Examination Gloves for Medical Application, 2010.

ASTM D6977, Standard Specification for Polychloroprene Examination Gloves for Medical Application, 2010.

ASTM E96, Standard Test Methods for Water Vapor Transmission of Materials, 2014.

ASTM F1671, Standard Test Method for Resistance of Materials Used in Protective Clothing to Penetration by Blood-Borne Pathogens Using Phi-X174 Bacteriophage Penetration as a Test System, 2013.

ASTM F1868, Standard Test Method for Thermal and Evaporative Resistance of Clothing Materials Using a Sweating Hot Plate, 2014.

ASTM F2100, Standard Specification for Performance of Materials Used in Medical Face Masks, 2011.

EN 136, Respiratory protective devices. Full face masks. Requirements, testing, marking, 1998.

EN 140, Respiratory protective devices. Half masks and quarter masks. Requirements, testing, marking, 1999.

EN 143, Respiratory protective devices. Particle filters. Requirements, testing, marking, 2000.

EN 374-2, Protective gloves against dangerous chemicals and microorganisms. Determination of resistance to penetration, 2014.

EN 388, Protective gloves against mechanical risks, 2003.

EN 405, Respiratory protective devices. Valved filtering half masks to protect against gases or gases and particles. Requirements, testing, marking, 2009.

EN 420, Protective gloves. General requirements and test methods, 2009.

EN 455, Medical gloves for single use. Requirements and testing for physical properties, 2013.

EN 14126, Protective clothing. Performance requirements and tests methods for protective clothing against infective agents, 2003.

EN 12941, Respiratory protective devices. Powered filtering devices incorporating a helmet or a hood. Requirements, testing, marking, 2008.

EN 12942, Respiratory protective devices. Power assisted filtering devices incorporating full face masks, half masks or quarter masks. Requirements, testing, marking, 2008.

EN 13795, Surgical drapes, gowns and clean air suits, used as medical devices for patients, clinical staff and equipment. General requirements for manufacturers, processors and products, test methods, performance requirements and performance levels, 2013.

ISO 4849, Personal eye-protectors—Specifications, 1981.

ISO 16604, Clothing for protection against contact with blood and body fluids—Determination of resistance of protective clothing materials to penetration by blood-borne pathogens—Test method using Phi-X 174 bacteriophage, 2004.