Personal protective equipment

for use in a filovirus disease outbreak

Rapid advice guideline

World Health Organization

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Foreword

Health workers are among the first to respond when an infectious pathogen threatens a community. Indeed, they are often among the first to be affected -- a cluster of cases of severe illness in health care workers can be the first sign that something unusual is going on. Before the cause of an outbreak has been identified and before infection-control measures have been put in place, health workers can find themselves at heightened risk of infection. This was the case in 2014, when the Ebola epidemic began in West Africa. Many doctors, nurses and other health workers became infected in the workplace and died.

Responding to an urgent request from Member States, the World Health Organization (WHO) undertook the development of a rapid advice guideline on Personal Protective Equipment, an important component of Infection Prevention and Control.

The publication in October 2014 of the guideline summary marked the first time that WHO implemented a new, state-of-the-art approach to the development of evidence-informed, rapid advice guidelines. It was also the first time that a rapid advice guideline included technical specifications.

Based on this and other experiences over the past two years, WHO is putting in place processes, procedures and methods for developing guidelines in response to public health emergencies, addressing the need for timely guidance containing valid, feasible recommendations, often in the context of sparse data and challenging field conditions.

In many countries, the health system depends heavily on just a few health workers. This human resource is precious. Infection, and worse, death, of just a few can drastically reduce a health system's capacity to deliver basic care. Thus, any effort that protects a country's health workers also protects its health system and its long term investment in health.

Maximizing health gains while minimizing the risk for health workers and their families equates to health protection of the larger community as well.

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Abbreviations and acronyms

AIDS	acquired immunodeficiency syndrome
CDC	Centers for Disease Control and Prevention (of the United States of America)
CI	confidence interval
DOI	declaration of interest
ERG	external review group
ETU	Ebola treatment unit
EU	European Union
EVD	Ebola virus disease
GDG	Guideline Development Group
GRADE	Grading of Recommendations Assessment, Development and Evaluation
GRC	Guideline Review Committee
HIV	human immunodeficiency virus
IPC	infection prevention and control
mRNA	messenger ribonucleic acid
MSF	Médecins sans Frontières (Doctors without Borders)
NIOSH	National Institute for Occupational Safety and Health
OHRI	Ottawa Hospital Research Institute
PICO	population, intervention, comparator, outcome
PPE	personal protective equipment
PVC	polyvinyl chloride
RNA	ribonucleic acid
SARS	severe acute respiratory syndrome
WHO	World Health Organization

Executive summary

Background

Filoviruses (Ebola and Marburg) are highly contagious pathogens, which cause severe and often fatal illness in humans. Health workers are at increased risk of infection with these viruses because of their close and prolonged contact with severely ill patients with a high viral load. The risk of transmission of Ebola virus can be reduced if appropriate measures are taken, including the use of personal protective equipment (PPE). The urgent need for clear standards for PPE use became acutely apparent during the unprecedented outbreak of Ebola virus disease (EVD) in certain western African countries in 2013–16.

Methods of guideline development

The present guidelines, which were developed between July and October 2014 in accordance with WHO rapid advice guideline procedures, are intended for health workers providing direct care to patients with known or suspected filovirus disease. A Guideline Development Group (GDG) was formed, comprising 13 experts in a broad range of technical areas who were invited on the basis of their knowledge, experience and technical expertise. All GDG members completed a WHO declaration of interest (DOI) form, which was reviewed by a WHO steering group before their invitation was confirmed. The GDG held an expert technical consultation on 6 and 7 October 2014.

The consultation considered the biology of the virus and modes of transmission. The virus is present in body fluids, such as blood, vomit, faeces, sweat, saliva, urine, breast milk, amniotic fluid, cerebrospinal fluid and semen. The main route for acquisition of filovirus is through blood or other body fluids of infected individuals coming into contact with the mucous membranes of the mouth, nose or eyes, or with non-intact skin. Airborne transmission has not been documented. The GDG therefore concluded that

the mucosae of mouth, nose and eyes need to be protected from contaminated droplets and fluids. Since hands are known to carry pathogens to other parts of the body, including the face, and to other individuals, hand hygiene and gloves are essential. Gowns or coveralls, protective footwear, and head covers help to prevent transmission through non-intact skin and inadvertent contamination of mucosae from soiled skin.

A rapid review was carried out to answer the following question: "*What are the benefits and harms of double gloves, full face protection, head cover, impermeable coveralls, particulate respirators, and rubber boots as PPE when compared with alternative less robust PPE for health workers caring for patients with filovirus disease?*" Thirty studies of non-comparative design and case reports were included in the qualitative synthesis. Eleven studies reported on filoviruses, two on unspecified haemorrhagic fevers, 11 on Crimean-Congo haemorrhagic fever and six on Lassa fever. The usability of the data was limited because of poor reporting on sample sizes, the proportion of health workers in a cohort, adherence to PPE protocols, and the specifications of PPE. Because of the heterogeneity of the included studies, pooling of effect estimates from individual studies was considered inappropriate. Using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework, the body of evidence for all outcomes was assessed to be of very low quality. The review concluded that there was insufficient evidence to allow conclusions to be drawn regarding the effectiveness and harms of robust PPE compared with alternative PPE for health workers caring for patients with filovirus disease.

The GDG also considered other information. A WHO Collaborating Centre for Occupational Health carried out a literature review of the values and preferences of health workers regarding the use of PPE in the context of Ebola and other infectious diseases, including hepatitis B virus, human immunodeficiency virus (HIV) infection and severe acute respiratory syndrome (SARS). A total of 56 references were identified. The literature review identified five main domains that affect the use and acceptability of PPE: (1) beliefs and values, such as risk perception and safety climate; (2) interference with work activities and impaired mobility; (3) comfort, such as weight of PPE and heat stress; (4) work factors, such as number of patient encounters; and (5) use and availability, including difficulty in dressing and undressing, and training.

An online survey of values and preferences was also carried out among health workers who used PPE in 2014 during the Ebola outbreak. The objectives of the survey were: (1) to gain an understanding of health workers'

experiences wearing different types of PPE, and (2) to determine the perspective of health workers on PPE, including their preferences, and the feasibility and acceptability of different types of PPE. Forty-four health workers deployed by WHO or *Médecins sans Frontières* (MSF) responded. The main concerns in relation to health worker safety and well-being were heat-associated stress, fogging of eyewear affecting vision, and the masks and respirators getting wet. The need for training, good quality products, comfortable sizes and a good fit were highlighted in many responses.

The GDG took into account several guiding principles in its decision-making:

1. General infection prevention and control (IPC) recommendations should be adhered to.
2. The aim should be to achieve the best possible protection against filovirus infection while allowing health workers to provide optimal care to patients with maximum ease, dexterity and comfort and minimum heat-associated stress.
3. Disposable items are preferred, to minimize handling of potentially contaminated PPE.
4. Ease of removal, availability, ease of training and cultural acceptability are important factors.
5. Considering the lack of evidence to show that any one of the options recommended is superior or inferior to any other recommended option in terms of health worker safety, the guidelines focus on providing options with acceptable minimum standards.

In developing the recommendations, the GDG used evidence-to-decision tables, in line with the GRADE methodology. These tables contained the following elements: quality of evidence for desirable and undesirable effects, values and preferences, resource implications, feasibility, applicability, implementation considerations, and research priorities.

Recommendations

The mucous membranes of the eyes, mouth and nose of all health workers should be completely covered. The eyes should be protected by either a face shield or goggles, while the mouth and nose should be covered by a fluid-resistant medical or surgical mask with a structured design that does not collapse against the mouth (e.g. duckbill or cup shape). Because EVD is not airborne, there is no need to use a particulate respirator, except during procedures that generate aerosols of body fluids. Health workers should wear double gloves, preferably nitrile, and should use protective bodywear in addition to regular on-duty clothing. The protective bodywear may be either a disposable gown and apron, or a disposable coverall and apron. The gown and coverall should be made of fabric that has been tested for resistance to penetration by blood or body fluids or by bloodborne pathogens. A disposable, waterproof apron is preferred but, if not available, heavy-duty, reusable waterproof aprons may be used provided that they are appropriately cleaned and disinfected between patients. Health workers should wear waterproof boots (e.g. rubber or gum boots) and a head cover that covers both the head and the neck. Ideally, the head cover should be separate from the gown or coverall.

Summary of recommendations

The following recommendations are intended to prevent virus exposure among health workers providing clinical care to patients with known or suspected filovirus disease.

Recommendation	Strength of recommendation	Quality of evidence of effectiveness of preventing filovirus transmission to health workers
1. The mucous membranes of eyes, mouth and nose should be completely covered by PPE.	Strong	High quality evidence for protecting mucous membranes compared with no protection.
2. Use either a face shield or goggles.	Strong	Very low quality evidence comparing face shields and goggles.
3. Use a fluid-resistant medical or surgical mask with a structured design that does not collapse against the mouth (e.g. duckbill or cup shape).	Strong	Low quality evidence comparing medical or surgical mask with particulate respirator.
4. Use a fluid-resistant particulate respirator during procedures that generate aerosols of body fluids.	Strong	Moderate quality evidence, when evidence on protection against other pathogens during aerosol-generating procedures is also considered.
5. Use double gloves.	Strong	Moderate quality evidence comparing double gloves to single gloves.
6. Nitrile gloves are preferred over latex gloves.	Strong	Moderate quality evidence on health worker tolerance of nitrile gloves compared with latex gloves.
7. Use protective bodywear in addition to regular on-duty clothing (e.g. surgical scrubs).	Strong	High quality evidence for using protective bodywear compared with not using protection, based on accumulated evidence from other infections with similar modes of transmission.
8. The choice of PPE for covering clothing should be either a disposable gown and apron, or a disposable coverall and apron; the gown and the coverall should be made of fabric that has been tested for resistance to penetration by blood and other body fluids or by bloodborne pathogens.	Conditional	Very low quality evidence comparing gowns and coveralls.
9. The choice of apron should be, in order of preference: • a disposable, waterproof apron • if disposable aprons are not available, heavy-duty, reusable waterproof aprons may be used provided that they are appropriately cleaned and disinfected between patients.	Strong	Very low quality evidence comparing disposable and reusable aprons.
10. Use waterproof boots (e.g. rubber or gum boots).	Strong	Very low quality evidence comparing boots with closed shoes with or without shoe covers.
11. Use a head cover that covers head and neck.	Conditional	Low quality evidence comparing head covers with no head cover.
12. It is suggested that the head cover is separate from the gown or coverall, so that it can be removed separately.	Conditional	Low quality evidence comparing different types of head covers.

Implementation

The following points are considered a priority for the successful implementation of the recommendations.

- Comply with technical specifications and acceptable minimum standards specified in this document.
- Provide thorough training to health workers on the use of PPE before they engage in any clinical care; this should be followed by mentoring for all health workers during their work.
- Ensure effective resource management for PPE items, including stock management at national and facility level, availability of different sizes and recommended shapes of PPE, having items easily accessible, controlling the quality of items purchased, and setting up a system to prevent, or ensure early reporting of, shortages.
- Have in place written protocols for the management of used and potentially contaminated PPE items, including safe discarding and decontamination and reuse, if recommended by the manufacturer.
- Have cooling and rehydrating facilities available for health workers taking off PPE.

1. Background

Filoviruses (Ebola and Marburg viruses) are the cause of some of the most severe viral haemorrhagic fevers in humans. For Ebola, an average case–fatality rate of 65% has been reported (95% confidence interval (CI) 55–76%). Ebola and Marburg viruses are known to be endemic only in sub-Saharan Africa (1). In most outbreaks, the virus is introduced into humans from a zoonotic source on a single or a few occasions; this is followed by amplification through human-to-human transmission. The largest outbreak of Ebola virus disease (EVD) prior to 2014 was in Uganda in 2000–01 with 425 cases (2), while for Marburg, the largest outbreak was in Angola in 2004–05, when 252 cases occurred (3).

The outbreak of EVD in western Africa in 2013–16 was unprecedented in terms of the number of cases, the geographical extent, and its occurrence in capital cities and large urban areas as well as rural areas. Guinea, Liberia and Sierra Leone were the three most affected countries. Up to 8 April 2015, 25 515 confirmed, probable and suspected cases, and more than 10 000 deaths, had been reported to WHO. These included 861 confirmed infections in health workers, 499 of whom died (4).

Health workers are at increased risk of EVD because of their close and prolonged contact with severely ill EVD patients with a high viral load (5). To prevent transmission of the virus to health workers in health care settings, strict adherence to effective infection prevention and control (IPC) measures is critical at all levels of health care. Personal protective equipment (PPE) is an important component of IPC. At the beginning of the EVD outbreak in western Africa, a lack of clear standards for PPE use, together with the availability of a huge diversity of items (in terms of design, type and amount of information about specifications) in affected areas, created confusion among health workers, programme managers, policy-makers and partners at local, national and global levels. Health workers were also not familiar with PPE.

As part of its response to the outbreak, WHO has developed this rapid advice guideline on use of PPE, taking into consideration multiple aspects, such as effectiveness, safety and comfort of end-users (i.e. health workers), feasibility and sustainability.

2. Purpose and target audience

These recommendations provide guidance on the appropriate selection of PPE for preventing transmission of filovirus to health workers while allowing satisfactory working conditions. Currently, there are differing practices related to PPE in different settings. This document attempts to harmonize the various PPE options on the basis of the best available evidence. The recommendations are intended for health workers, such as doctors, nurses and others providing clinical care or taking samples from patients with suspected, probable or confirmed filovirus infection. The recommendations do not apply to cleaners, hygienists, laboratory workers, mortuary staff, burial teams and other workers. Cleaners, hygienists and burial teams require heavy-duty PPE, for example rubber gloves instead of surgical gloves. It is recognized that PPE for those groups of workers is extremely important.

These guidelines are applicable in all health care settings where care is provided for patients with suspected, probable or confirmed filovirus infection. This includes Ebola treatment units, transitional care facilities (where suspected Ebola patients are referred for diagnostic testing and supportive care until they can be transferred to a free-standing Ebola treatment unit for isolation and care) and general health care settings with patients who fulfil Ebola case definitions. The guidelines may also be applicable in high-risk exposure areas in general hospitals (a specific risk assessment should be made by an IPC expert) such as operating theatres and delivery or labour wards of maternity facilities, although some modifications to PPE may be required (e.g. sterile gloves, elbow-length gloves).

The guidance provided will be valuable for policy-makers, health care managers, IPC specialists, logisticians and health workers providing patient care.

This document should be read in conjunction with the WHO interim IPC guidance on patient care, environmental cleaning and management of linen, waste management and non-patient care activities (6). The recommendations in this rapid advice guideline should be implemented together with all the IPC requirements outlined in section 4 and detailed in the interim IPC guidance (6).

3. Methods of guideline development

These guidelines were developed according to the WHO handbook for guideline development (7). Because of the urgent need for these guidelines, an expedited process was followed. A steering group consisting of WHO staff members from different departments (Annex 1) developed a "scoping" document, detailing the aims, methods, outcomes and timelines for the process. This was reviewed and approved by the WHO Guidelines Review Committee (GRC). A rapid review of the effectiveness (benefits and harms) of different types and components of PPE (face protection, masks, gloves, head cover, clothing and boots) was commissioned (see section 5.2). Other evidence used to inform recommendations included an online survey and a literature review of values and preferences of health workers related to PPE. Information on virus characteristics, modes of transmission and general principles of IPC also informed the recommendations. Recommendations were drafted through an evidence-to-recommendations exercise, using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework (8) and an expert consultation. On the basis of these draft recommendations, and taking into account available evidence and information on, for example, known modes of virus transmission and values and preferences of health workers, technical specifications were determined in consultation with specialists on medical devices. Technical specifications of specific PPE were indicated in terms of existing international quality standards, including those of the European Union, the American National Standards Institute and the International Safety Equipment Association.

3.1 Technical consultation

The GDG held an expert technical consultation on 6–7 October 2014 (Annex 1). The GDG comprised 13 experts from a broad range of technical areas who participated as independent experts and did not represent any agency, institution or country. The consultation reviewed the available evidence of effectiveness, considering both the benefits and harm of different types of PPE, and drew up recommendations on the selection and technical description of individual components of PPE.

The consultation also included expert consultants, who provided specific information on selected technical issues, and observers representing major

stakeholders involved in the response to the then existing Ebola epidemic (Annex 1). Staff from WHO Headquarters and regional offices participated as secretariat. Consultants, observers and secretariat were not involved in the decision-making process or in making recommendations. All participants signed a confidentiality agreement and were reminded of the need for confidentiality until the full WHO process had been concluded.

3.2 Conflict of interest assessment

All members of the GDG completed the WHO declaration of interest (DOI) form before their invitation was confirmed and data were shared with them under non-disclosure agreements. All completed DOI forms were reviewed by the WHO steering group prior to the technical consultation. Three experts were considered to have interests of a professional nature, but these did not present a significant conflict with the objectives of the meeting (Annex 2). DOI statements were summarized by the WHO secretariat at the start of the meeting.

3.3 Decision-making during the consultation

Decisions at the consultation were made by consensus. If a consensus could not be reached, disagreements were resolved by voting; decisions required a two-thirds majority. Whenever voting was used, the numbers of people voting for and against were recorded with the recommendation. Specific concerns and opinions of GDG members were reported.

3.4 External peer review

An external review group (ERG) (Annex 1) independently reviewed the guideline document and recommendations produced by the consultation. The ERG consisted of seven experts and stakeholders, some of whom had experience in managing the Ebola outbreak in western Africa. The reviewers were asked to comment on the recommendations, the applicability of the recommendations in various settings, feasibility and acceptability issues, text that needed additional clarification, and other issues deemed appropriate. Comments made by the members of the ERG are reflected in the final version of the guideline.

4. PPE in the framework of infection prevention and control and health worker safety and well-being

4.1 Infection prevention and control

To prevent virus transmission in health care settings, procedures and protocols referred to as "controls" need to be applied. These are (in decreasing order of IPC effectiveness): administrative controls, environmental and engineering controls, and personal protective equipment. While PPE is the most visible control used to prevent transmission, it must be used in conjunction with administrative and engineering controls (such as facilities for barrier nursing and work organization, water and sanitation, hand hygiene infrastructure, waste management and ventilation). PPE must be correctly selected and used in a safe manner; safety concerns are especially important when PPE is put on, removed or decontaminated. The current document deals only with the choice of PPE; information on safe use of PPE is given elsewhere (9).

The practices of health workers are equally important in preventing infections. Standard precautions are the basic IPC measures, which should be used, as a minimum, in the care of all patients (Table 1). They are designed both to protect health workers and to prevent infections from spreading to other patients. It is not always possible to identify patients with filovirus infection, because early symptoms are nonspecific. For this reason, it is important that health workers use standard precautions consistently with all patients, regardless of their diagnosis. Rigorous adherence to these precautions is crucial for the control of outbreaks.

Details of standard precautions and best practices for prevention and control of filovirus infection in health care settings can be found in the WHO IPC guidance mentioned above (6).

Table 1. Standard precautions

Standard precautions	Key components	WHO reference documents
Hand hygiene	Use alcohol-based hand rub Wash with soap and water	*Hand hygiene in health care in the context of filovirus disease outbreak response* (10).
Personal protective equipment based on point-of-care risk assessment	Select appropriate PPE Remove PPE safely	The present document.
Prevention of needle-stick or sharps injuries	Never reuse syringes, needles and other similar equipment Dispose of syringes, needles and sharp objects at the point of care in appropriate, puncture resistant containers	Best practices for injections and related procedures toolkit (11).
Safe waste management	Develop a management plan for health care waste Disinfect materials with 0.5% chlorine solution Incinerate or autoclave health care waste, then dispose of in pits	Ebola virus disease: key questions and answers concerning health care waste (12).
Cleaning, disinfection and sterilization, where applicable, of equipment and linen used in patient care	Clean laundry and surfaces at least once a day Clean and disinfect areas contaminated with body fluids with 0.5% chlorine solution	Ebola virus disease: key questions and answers concerning water, hygiene and sanitation (13).
Cleaning and disinfection of the environment		

4.2 Safety and well-being of health workers

Safeguarding the health and well-being of health workers in the workplace, including providing facilities for hand hygiene and appropriate PPE, is a priority, and is the responsibility of policy-makers, employers, and managers. The steps to be carried out are summarized below.

- A risk assessment of the workplace should be carried out by competent IPC experts appointed by the employer.
- All health workers at risk should be provided with adequate, effective and sustainable protective measures commensurate with the risk.
- Health workers should be informed of the risks they may face, and the mitigating effects of PPE when used consistently and correctly. Compliance with all control measures is the responsibility of the health worker.
- Policy-makers and managers need to consider issues such as climate conditions and cultural norms, to ensure that protection measures are adopted and to maximize compliance.

- The recommended PPE should be available and accessible to health workers. Health workers need to be adequately trained in the use of PPE; refresher training should be available.
- All health workers with symptoms of EVD should seek rapid medical attention. They should avoid working, in order to avoid transmitting infection to colleagues. Employers are responsible for notifying the labour inspectorate of cases of occupational diseases.

This topic is addressed in more detail elsewhere (14)

5. Evidence assessment

5.1 Biology and mode of transmission of Ebola virus

The Ebola virus is a small negative-sense RNA virus, with a host-derived lipid envelope. Negative-sense RNA is of opposite polarity to mRNA: this means that the viral genome must first be transcribed to produce mRNA before it can be used to make proteins. The virus replicates only within living cells and is stable in the environment for between a few hours and a few days, depending on conditions such as viral load, presence of biological fluids, humidity and temperature. The virus is destroyed by a variety of disinfectants.

Severity of disease is correlated with the level of virus in the blood and thus infectivity. The virus load in an infected person is highest in blood. Other body fluids, such as vomit, faeces, sweat, saliva, urine, amniotic fluid, breast milk, cerebrospinal fluid and semen, also contain virus and may be involved in transmission. The majority of patients with filovirus infection develop vomiting and/or diarrhoea as the disease progresses (15-17). Bleeding is usually seen in approximately 50% of patients (15, 16), though it seems to have been less frequent in the 2013–16 Ebola outbreak in western Africa (17).

The main route for transmission of filovirus infection is through contact between blood or other body fluids of infected individuals and the mucous membranes of the mouth, nose and eyes. Transmission can occur through direct contact with these body fluids, or through contact with fomites (infected inanimate objects and surfaces), such as the floor, utensils and bedlinen that has recently been contaminated with infected body fluids. Transmission through intact skin has not been documented; however, infection can be transmitted through non-intact skin and through penetrating injuries of the skin, such as needle-stick injuries.

During the expert technical consultation, the GDG discussed the biology and mode of transmission of Ebola virus and concluded that the mucosae – mouth, nose and eyes – need to be protected from contaminated droplets and fluids to prevent transmission. Hands are known to carry pathogens to other parts of the body, including the face, and to other individuals. Appropriate hand hygiene and use of gloves can both protect the health worker and prevent transmission to others. Gowns or coveralls, protective footwear, and head covers also help to prevent transmission through non-intact skin and inadvertent contamination of mucosae from soiled skin.

5.2 Rapid literature review

An independent consultancy team (see Annex 1) was contracted to carry out a rapid review on the effectiveness of various types of PPE. The research question for the rapid review was: "*What are the benefits and harms of double gloves, full face protection (e.g. shield and mask vs goggles and mask, shield vs mask and shield), head cover, impermeable coveralls, particulate respirators, and rubber boots as PPE when compared with alternative less robust PPE for health workers caring for patients with filovirus disease?*"

The "population, intervention, comparator, outcome (PICO)" elements of the question were defined as follows.

Population.
Health workers caring for patients who have or are suspected to have contracted filovirus. Because evidence was sparse, studies addressing Crimean-Congo virus and Lassa fever were also included.

Intervention and comparator.
Protective equipment, used either individually or in combination:

- double vs single gloving;
- full facial protection vs exposed skin (e.g. shield and mask vs goggles and mask, shield vs mask and shield);
- highly impermeable vs permeable gown;
- highly impermeable gown vs coverall;
- immediate gown change vs delayed change;
- particulate respirator vs other or no respirator;
- rubber boots vs closed shoes;
- rubber boots vs closed shoes and shoe cover.

Outcomes

- Virus transmission to health care providers
- Virus transmission to patients
- Dexterity (gloves)
- Adverse effects of using equipment (e.g. inconvenience, discomfort, injuries, reduced visibility, temperature)

The review team searched the literature in English and French published since 1967, when filovirus disease emerged. The limited timeframe in which the review had to be carried out did not permit peer review of the search strategy or verification of all data extracted. The risk of bias of the included studies was not assessed.

The titles and abstracts of 1215 retrieved studies were screened. Full-text reports of 318 studies were reviewed. Twelve full-text articles that met the criteria could not be retrieved and were excluded, as were 28 studies not in English or French. Thirty studies of non-comparative design (cohort and cross-sectional) and case reports were included in the qualitative synthesis. Of these 30 studies, 11 reported on filoviruses, two on unspecified haemorrhagic fevers, 11 on Crimean-Congo haemorrhagic fever and six on Lassa fever. Data on viral transmission were given in 27 of these studies, which were conducted in Africa (15), Europe (10), the Eastern Mediterranean (1) and North America (3). The majority of studies (22) were of contact-tracing of health workers who had cared for a patient, but case-reports of health workers and cross-sectional and cohort studies of health workers were also included. Sample sizes and the proportion of health workers in a cohort of contacts were not consistently reported.

All studies were non-comparative with respect to PPE use. Most reports were on small numbers of health workers using combinations of PPE. The combinations and the PPE protocols varied across studies and also within studies, between health workers and in terms of duration of use. Reporting on adherence to PPE protocols and the specifications of PPE was poor. Information was often missing on the quality or characteristics of PPE components (e.g. disposability and permeability) and the quantity (e.g. single or double gloves); in some cases, there was no reference to PPE and instead terms such as "protective clothing", "barrier techniques" or "standard precautions" were used. This poor reporting limited the usability of the data. Because the included studies were so heterogeneous, pooling of effect estimates from individual studies was considered inappropriate. Hence the review summarized results as proportions with 95% CI for the different studies (18).

While some studies and case reports reported on transmission events, it was not possible to conclude that these were directly related to specific

PPE failures. Using the GRADE framework, the quality of the body of evidence for all outcomes was assessed to be very low. The review concluded that there was insufficient comparative evidence to allow conclusions to be drawn regarding the effectiveness and harms of robust PPE compared with alternative PPE for health workers caring for patients with filovirus disease (18).

5.3 Literature review of values and preferences of health workers

Because the rapid review found little evidence of the effectiveness of different types of PPE, the GDG considered other information. The values and preferences of health workers in relation to PPE were thought to be important. A WHO Collaborating Centre for Occupational Health (Annex 1) carried out a literature review of the values and preferences of health workers regarding the use of PPE (McDiarmid M et al, University of Maryland School of Medicine, unpublished data available upon request, 2014). There was found to be little information in the literature on PPE use in the context of Ebola, and therefore peer-reviewed studies of the use of PPE in the context of other infectious diseases, e.g. hepatitis B virus infection, human immunodeficiency virus (HIV) infection and severe acute respiratory syndrome (SARS) were included. Guidelines from frontline practitioner organizations, such as *Médecins sans Frontières* (MSF), were also considered. Other collaborating centres for occupational health were requested to submit materials for review.

Pubmed, Google and Google Scholar were searched for the key words (compliance, attitudes, beliefs, use, values, perception) combined with at least one of the following: infection control, Ebola, health care workers, gloves, gowns, hazmat suits, Tyvek suits, coveralls, impermeable gowns, surgical gowns, rubber boots, shoe covers, face shields, goggles, medical mask, surgical mask, respirator, N-95, personal protective equipment.

The team specifically documented values and preferences related to:

- single versus double medical gloves;
- impermeable gown versus coverall or hazardous material (hazmat) suit;
- rubber boots versus shoe covers;
- face shields versus goggles; and
- medical mask versus respirator (N95 type).

It should be noted that this was not a systematic review of the literature. A total of 56 references were identified, including two personal communications (McDiarmid M et al, University of Maryland School of Medicine,

unpublished data available upon request, 2014). The literature review identified five main domains that affect health worker compliance with PPE requirements. These are: (1) beliefs and values, such as risk perception and safety climate; (2) interference with work activities and impaired mobility; (3) comfort, such as weight of PPE and heat stress; (4) work factors, such as number of patient encounters; and (5) use, including difficulty of dressing and undressing, training and availability. In one study that compared face shields with goggles, face shields were preferred by health workers because they were more comfortable and fogged less easily, and the perceived protection was higher. Patients also preferred face shields, since they were able to see the health worker better. Masks were found to be more usable, and to cause less discomfort, fatigue and odour than respirators. Warmth and wetness around the face were also identified as a problem with respirators. The main identified problems with double-gloving were discomfort, decreased dexterity and decreased tactile sensation, which could be overcome over a few days of use. Impermeable gowns and coveralls caused increased heat stress and thus considerably limited the time (to one or two hours) a health worker could wear them. Very little information was available on gum boots and rubber boots, but the need to have the correct size and for cultural acceptability were noted.

5.4. Online survey of values and preferences of health workers

In addition to the literature review, an online survey was carried out among health workers who used PPE in the western African countries affected by the Ebola outbreak (Den Boon S, Vallenas C, Beller-Ferri M, Norris S, World Health Organization, unpublished data available upon request, 2014). The survey was developed by an independent contractor with help from the WHO responsible technical officer and a member of the GDG and input from the GRC secretariat (Annex 1).

The survey had two objectives: (1) to gain an understanding of health workers' experiences wearing different types of PPE, and (2) to determine the perspective of health workers on PPE, including their preferences, and the feasibility and acceptability of different types of PPE. The survey questions addressed issues such as comfort, ease of use, and perceived protection (safety) of various types of PPE. An email with a link to a consent form and the online survey was sent to health workers recruited by WHO and MSF to care for patients with EVD. Data were collected between 23 September and 15 October 2014.

The survey on health workers' values and preferences included a total of 44 health workers, deployed in 2014 during the epidemic to provide care for Ebola patients. Approximately half of the respondents (48%) were women and the majority (73%) were under 44 years of age. Most respondents (84%) had been deployed by MSF. A quarter were nurses, the others were physicians. (At the time of the expert meeting only 38 health workers had responded; the detailed results in the annex tables are therefore based on these 38 responses. The remaining six responses did not make a difference to the survey results.)

For eye protection, 42 respondents (95%) had experience with goggles, while seven (16%) had used face shields (some respondents had experience with both types of eye protection). Most reported that the goggles were uncomfortable (69% vs 29% for face shields, $P = 0.03$) and affected their ability to provide care. Some respondents commented that fogging affected visibility, and reported poor fit and slipping of the goggles while care was being provided. For nose and mouth protection, 33 (75%) had used respirators and 14 (32%) had used masks. Comfort and ability to provide care were rated better with masks, though the difference was not significant. Both respirators and masks were reported as getting wet and adhering to the mouth and nose, which affected comfort and breathability, and had the potential for inadvertent touching of the item. Difficulty in communication was reported as a problem by both groups (30% for those with masks and 64% for respirators, $P = 0.07$). All 44 respondents had used double gloving while providing care and found this comfortable; 61% reported that it did not significantly affect dexterity. The main problem reported was that the gloves could slip down, allowing fluids to come into contact with the skin. Many respondents solved this problem by taping the gloves to the coverall, but this led to other difficulties, including tearing of the gloves or coverall. It was also mentioned that gloves were not long enough or tore easily. Thirty-one respondents (70%) had used a coverall and 16 (36%) had used gowns while providing care. Detailed information about the materials from which the body coverings were made, their permeability, and whether a head cover was attached to the gown or coverall was not collected. The health workers were also not asked whether they used an apron in addition to the gown or coverall. Both groups reported stress from heat and dehydration (69% and 84%, respectively, $P = 0.27$). All 44 respondents had worn boots, which were considered comfortable and did not affect ability to provide care. There were comments on the time needed to disinfect and clean boots. Head covers were used by four respondents and hoods by 42. Heat stress was reported by 64% of those who used hoods and none of those who used head covers ($P = 0.01$).

The survey concluded that the main concerns for health worker safety and well-being in the western African setting were heat-associated stress,

fogging of eyewear affecting vision, and the masks and respirators getting wet. Many responses highlighted the need for training, quality products, and comfortable equipment of the correct size that does not slip.

5.5 Guiding principles for decision-making

Several guiding principles were considered fundamental to the decision-making.

- General IPC recommendations on PPE to reduce risk of exposure to pathogens are applicable to filovirus disease. Basic IPC interventions, such as hand hygiene, are important and should always be used in addition to PPE.
- A fundamental principle guiding the selection of PPE is the need to achieve the best possible protection against filovirus infection while allowing health workers to provide optimal care to patients with maximum ease, dexterity and comfort, and minimum heat-associated stress. Discomfort may reduce health workers' concentration and hence potentially increase the risk of injuries and inadvertent exposure to contaminated fluids. Discomfort also limits the length of time a health worker can effectively provide care to patients and the capacity to make critical decisions.
- Disposable items are preferred, to minimize handling of potentially contaminated PPE.
- Ease of removal, with minimum risk of inadvertent contamination of mucosae, is an important consideration. Availability, ease of training and cultural acceptability are also important factors.
- In the current situation, while evidence is still being collected on what works best in an effective sustainable way, it was considered prudent to provide options with acceptable minimum standards and to completely avoid substandard options. There is no evidence that any one of the options recommended is superior or inferior to any other recommended options in terms of health worker safety.

5.6 GRADE assessment and evidence-to-decision tables

The rapid review of effectiveness of various types of PPE assessed the body of evidence for all outcomes to be of very low quality. In developing the recommendations, therefore, greater emphasis was put on the values and preferences of health workers, virus characteristics and knowledge about

modes of transmission. Evidence-to-decision tables were developed according to the GRADE methodology, containing the following elements: quality of evidence for desirable and undesirable effects, values and preferences, and resource implications. Elements from the DECIDE (Developing and Evaluating Communication Strategies to Support Informed Decisions and Practice Based on Evidence (http://www.decide-collaboration.eu)) project were also used. The evidence-to-decision framework included the following criteria to be considered in making the recommendations: feasibility, applicability, implementation considerations, and research priorities. Evidence-to-decision tables were developed for the following PPE: gloves, boots, head cover, clothes and covering to clothing (gowns and coveralls), eye protection, and nose and mouth protection (Annex 3).

6. Recommendations

The following recommendations are for use by health workers providing clinical care for patients with filovirus disease in order to prevent virus exposure.

6.1 Mucous membrane protection

Recommendation 1
The mucous membranes of eyes, mouth and nose should be completely covered by PPE.
Strong recommendation; high quality evidence for protecting mucous membranes compared with no protection.

Recommendation 2
Use either a face shield or goggles.
Strong recommendation; very low quality evidence comparing face shields and goggles.

Rationale and remarks

Protection of the mucous membranes of the eyes, nose and mouth is an integral part of standard and droplet precautions (6, 19, 20). Droplet precautions consist of IPC measures that aim to prevent infection with pathogens that can be transmitted by large-particle droplets (larger than 5 μm in size). Contamination of mucous membranes is probably the most important mode for filovirus transmission. Hence, PPE to protect mucosae is essential to prevent transmission. Because of the lack of effective viral-specific treatments and

the high case–fatality rate, the GDG was of the opinion that a strong recommendation was warranted.

There is currently no scientific evidence on the comparative effectiveness of face shields and goggles for the prevention of filovirus transmission to health workers (18). The GDG therefore assumed equal effectiveness. Although both the literature review and the online survey of health workers' values and preferences indicated a preference for face shields (greater visibility, greater comfort and less fogging), the GDG decided that it was important to provide a choice and that either device may be used. Factors such as the personal preference of the health worker and local availability of good quality items meeting the technical specifications may determine the ultimate choice. Face shields and goggles should not be used together, as this does not offer additional protection and causes more discomfort and fogging affecting vision.

Several considerations may influence the choice between face shields and goggles.

- Fogging**.** This affects both face shields and goggles, although it probably affects face shields to a lesser degree (Den Boon et al, World Health Organization, unpublished data available upon request, 2014). Fogging reduces visibility and may thus compromise both the ability of the health worker to provide patient care and his or her safety. Industrial-type anti-fogging sprays may be useful but may be less effective in hot and humid climates. Goggles with ventilation may have less fogging, but it is essential that the vents do not allow blood and other body fluids to contaminate the internal surface of the goggle or the eye.
- Visibility**.** Face shields do not conceal the face, facilitating communication and interaction between patients and health workers (Den Boon et al, World Health Organization, unpublished data available upon request, 2014). Face shields provide a wider field of view for the health worker, which may be safer. Goggles that allow panoramic vision offer a similar advantage.
- Prescription glasses**.** Health workers who wear prescription glasses should be given the choice between goggles and face shields; an adequate fit should be ensured and anti-fogging spray should be used.

Implementation

- When health workers are removing PPE, those items that protect the mucous membranes should be taken off as late as possible, preferably at the end, to prevent inadvertent exposure of the mucous membranes when other potentially contaminated PPE components are being removed.

- When reusable goggles or face shields are used, appropriate decontamination procedures need to be in place.

Technical specifications

- The critical factors in developing the technical specifications were the need to completely cover the eye mucosa (e.g. for goggles: good seal, cover eyes and surrounding areas, adjustable band, compliant with existing quality standards) while providing sufficient visibility (e.g. fog- and scratch-resistant, accommodating prescription glasses, indirect venting) and creating no discomfort to the health worker (e.g. flexible frame).

Goggles
Good seal with the skin of the face.
Flexible frame that easily fits all face contours without too much pressure.
Cover the eyes and surrounding areas and accommodate prescription glasses.
Fog- and scratch-resistant
Adjustable band that can be firmly secured and does not become loose during clinical activity.
Indirect venting to reduce fogging.
May be reusable (provided appropriate arrangements for decontamination are in place) or disposable.
Quality compliant with standards: • EU standard directive 86/686/EEC, EN 166/2002, or • ANSI/ISEA Z87.1-2010 or equivalent.


Face shield
Made of clear plastic and provides good visibility to both the wearer and the patient.
Adjustable band to allow good fit around the head and snug fit against the forehead.
Fog-resistant (preferable).
Completely covers the sides and length of the face.
May be reusable (made of material that can be cleaned and disinfected) or disposable.

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Quality compliant with standards:
- EU standard directive 86/686/EEC, EN 166/2002, or
- ANSI/ISEA Z87.1-2010

or equivalent

Recommendation 3

Use a fluid-resistant medical or surgical mask with a structured design that does not collapse against the mouth (e.g. duckbill or cup shape).

Strong recommendation; low quality evidence comparing medical or surgical mask with particulate respirator

Rationale and remarks

The GDG considered the biology and mode of transmission of Ebola virus when developing this recommendation. The purpose of the medical or surgical mask is to protect the nasal and oral mucosa from splashes and droplets of infectious material. Since filoviruses are not transmitted via the airborne route, respiratory protection with a particulate respirator is not required, except during aerosol-generating procedures. A strong recommendation is appropriate in view of the mode of transmission, lack of available treatment and high case–fatality rate of EVD.

In hot and humid climates, masks may become wet through respiration or transpiration. In these conditions, a structured (e.g. duckbill or cup shape) mask that does not collapse against the mouth is safer and more comfortable than other designs.

Implementation

A medical or surgical mask should always be worn with appropriate eye protection (either with face shield or goggles; see recommendations 1 and 2). If used with goggles, the mask should be fluid-resistant. Fluid resistance is not essential if the mask is used together with a face shield. Wearing more than one mask at the same time does not provide additional protection and is not recommended.

Technical specifications

The biology and mode of transmission of Ebola virus informed the development of the technical specifications. The online survey of values and preferences of health workers indicated the importance of masks providing good breathability. The personal experience of GDG members with unstructured masks collapsing against the mouth contributed to the technical specification of a structured design.

Fluid-resistant medical or surgical mask
High fluid resistance.
Good breathability.
Internal and external faces should be clearly identified.
Structured design that does not collapse against the mouth (e.g. duckbill or cup shape).
Quality compliant with standards, including for fluid resistance level and breathability (differential pressure): • EN 14683 Type IIR performance, or • ASTM F2100 level 2 or level 3, or equivalent.
 Duckbill or pouch
  Moulded or non-collapsible, with a half-sphere or cup shape.

Recommendation 4
Use a fluid-resistant particulate respirator during procedures that generate aerosols of body fluids.
Strong recommendation; moderate quality evidence, when evidence on protection against other pathogens during aerosol-generating procedures is also considered.

Rationale and remarks

An aerosol-generating procedure is a medical procedure that can induce the production of aerosols of various sizes, including small (< 5 μm) particles. While surgical masks provide barrier protection against droplets, sprays and splashes of body fluids, they do not protect from exposure to airborne particles. Particulate respirators provide protection from exposure to particles, including small particle aerosols and droplets, provided

that the respirator is fit-tested and a seal check is done when the respirator is put on. While filovirus-specific evidence is lacking, there is a lot of evidence regarding other pathogens (e.g. Crimean-Congo haemorrhagic fever, SARS) indicating the need for a particulate respirator during aerosol-generating procedures (21, 22).

Implementation

When a disposable particulate respirator is put on, it should be fit-tested and a seal check should be done. If used with goggles, the particulate respirator should be fluid-resistant. Fluid resistance is not required if the particulate respirator is used together with a face shield. Not all particulate respirators are fluid-resistant; for example, N95 respirators are fluid-resistant only if they are labelled as "surgical N95 respirator".

Technical specifications

The evidence informing the technical specifications was similar to that for face masks, i.e. breathability was important as well as a structured design that does not collapse easily.

Particulate respirator (fluid-resistant)
Shape that will not collapse easily.
High filtration efficiency.
Good breathability.
Quality compliant with standards for surgical N95 respirator: • NIOSH N95, EN 149 FFP2, or equivalent Fluid resistance: minimum 80 mmHg pressure based on ASTM F1862, ISO 22609, or equivalent
 Duckbill or pouch
  Half-sphere or cup shape
 Flat-fold
Flexwing (not pictured)

Particulate respirator (non-fluid-resistant)
Only to be used together with a face shield. Quality compliant with standards for particulate respirator worn with face shield: • NIOSH N95, EN149 FFP2, or equivalent.
 Duckbill or pouch
  Half-sphere or cup shape
 Flat-fold
 Cup shape with valve
Flexwing (not pictured)

6.2 Gloves

Recommendation 5
Use double gloves
Strong recommendation; moderate quality evidence comparing double gloves to single gloves.

Rationale and remarks

Double gloves are recommended over single gloves, to decrease the potential risk of virus transmission to the health worker as a result of glove perforations and damage to gloves from disinfectants, such as chlorine. Double-gloving may also reduce risk from needle-stick injuries and contamination of hands when removing PPE. Confidence in the estimate of effectiveness was assessed as moderate, on the basis of accumulated evidence of transmission of other bloodborne pathogens, such as HIV and hepatitis B and

C viruses (23). While there is some degree of decreased tactile sensation, impaired dexterity, and discomfort related to double-gloving, studies have demonstrated that, in most cases, the impaired tactile sensation is overcome within a few days, even when delicate surgery is being performed (23, 24). Consideration of the balance of benefits and harms led to a strong recommendation in favour of double gloves.

More than two gloves on each hand has the potential to interfere with dexterity and add complexity to glove removal, and is therefore not recommended.

Sterile gloves are not required, except when a sterile procedure is being performed, as per standard IPC recommendations. The gloving procedures described below also apply to specific surgical and obstetric procedures.

Implementation

- Preferably, the outer glove should have a long cuff, reaching well above the wrist, and ideally to the mid-forearm. To protect the wrist area from contamination, the inner glove should be worn under the cuff of the gown or coverall (and under any thumb or finger loop), whereas the outer glove should be worn over the cuff of the gown or coverall.
- Gloves should not be attached to gowns or coveralls with tape, as this may interfere with safe removal of the gown or coverall and gloves, because of the need for additional manipulation and the risk of tearing of the gown or coverall, potentially resulting in contamination.
- Best IPC practice dictates that gloves should be changed between patients. However, in certain outbreak settings this may not always be feasible, for example, if clean gloves and waste disposal are not available in the patient treatment and isolation area. Because of this, the GDG did not reach agreement on whether gloves should be changed between patients inside the clinical area. Nine members were in favour of changing gloves between patients, two were against, and two members abstained. The following two-step procedure could help facilitate the safe changing of gloves while providing clinical care for many patients with filovirus disease during outbreak situations: (1) disinfect the outer gloves before removing them safely, and (2) keep the inner gloves on and disinfect them before putting on a fresh outer pair. Alcohol-based hand rubs are preferred for disinfecting hands and gloved hands. If a glove becomes compromised, it should be changed using the procedure described above. If it is not possible to change gloves between patients, the outer pair of gloves should be disinfected between patients.

Recommendation 6
Nitrile gloves are preferred over latex gloves.
Strong recommendation; moderate quality evidence on health worker tolerance of nitrile gloves compared with latex gloves

Rationale and remarks

Nitrile gloves are recommended because they resist chemicals, including certain disinfectants, such as chlorine, and because nitrile is more environmentally friendly than latex. There is a high rate of allergies to latex and contact dermatitis among health workers. Estimates vary, but up to 12% of health workers experience a range of reactions to latex, including skin irritation, local itching, burning sensation and allergic symptoms (25, 26). If nitrile gloves are not available, latex gloves may be used. Non-powdered gloves are preferred to powdered gloves.

Technical specifications

In the survey on values and preferences, health workers indicated that sometimes gloves were not long enough or slipped down, leading to possible exposure to fluids. This provided the rationale for recommending that outer gloves should reach mid-forearm. Powder-free gloves are preferred because powder may cause sensitivity and can contaminate the environment.

Gloves
Nitrile
Non–sterile
Powder-free
Outer gloves should preferably reach mid-forearm (minimum 280 mm total length)
Different sizes
Quality compliant with standards: • EU standard directive 93/42/EEC Class I, EN 455 • EU standard directive 89/686/EEC Category III, EN 374 • ANSI/ISEA 105-2011 • ASTM D6319-10 or equivalent.


6.3 Clothing and covering for clothing

Recommendation 7
Use protective bodywear in addition to regular on-duty clothing (e.g. surgical scrubs).
Strong recommendation; high quality evidence for using protective bodywear compared with not using protection, based on accumulated evidence from other infections with similar modes of transmission.

Recommendation 8
The choice of PPE for covering clothing should be either a disposable gown and apron, or a disposable coverall and apron; the gown and the coverall should be made of a fabric that has been tested for resistance to penetration by blood and other body fluids or by bloodborne pathogens.
Conditional recommendation; very low quality evidence comparing gowns and coveralls.

Rationale and remarks

Protective bodywear is recommended as part of contact precautions based on IPC principles and is applicable to filovirus disease. Because of the high case–fatality rate and lack of effective viral-specific treatments for EVD, a strong recommendation was issued for the use of protective bodywear. There is a lack of evidence on the comparative effectiveness of coveralls and gowns in reducing transmission of filovirus to health workers. The literature review on the values and preferences of health workers found that gowns are more comfortable as long as there is limited bending and lifting. However, the online survey did not show any significant differences in comfort, perceived safety, ability to communicate, ability to provide patient care, heat stress and dehydration. It was therefore concluded that coveralls and gowns are equally acceptable forms of body protection and that the decision on which to use should be based on availability and health worker preference.

Several considerations may influence the choice between gowns and coveralls.

- Gowns are considerably easier to put on and, in particular, to take off, making them safer when being removed. Health workers are generally more familiar with gowns and are hence more likely to use and remove them correctly. These factors also facilitate training in their correct use.
- Heat stress may be lower for gowns, and they are more likely to be available in areas commonly affected by filovirus disease.
- In some cultures, gowns may be more acceptable than coveralls for women.

Implementation

Surgical scrubs may be worn under the protective clothing. These are considered regular on-duty wear and not PPE. Details are, however, provided below to facilitate the procuring of these items.

Technical specifications

Protective bodywear must be fluid-resistant to reduce the likelihood of infected body fluids penetrating and contaminating the underlying clothes or skin, with possible subsequent transmission of the virus via the hands to the mucous membranes of the eyes, nose or mouth. On the advice of the medical anthropologist in the GDG, the Group specified that culturally unacceptable colours should be avoided. The specification to have thumb or finger loops to anchor sleeves in place was informed by the values and preferences survey, in which respondents indicated that without them sleeves may ride up and leave skin exposed.

Disposable gown
Single use
Mid-calf length, to cover the top of the boots
Avoid colours that are culturally unacceptable, e.g. black Prefer light colours to allow better detection of possible contamination
Thumb or finger loops to anchor sleeves in place
Quality compliant with either of two standards, depending on resistance of materials: • option 1: tested for resistance to fluid penetration : EN 13795 high performance level, or AAMI level 3 performance, or equivalent; or • option 2: tested for resistance to bloodborne pathogen penetration: AAMI PB70 level 4 performance, or equivalent


Disposable coverall
Single use
Avoid colours that are culturally unacceptable, e.g. black Prefer light colours to allow better detection of possible contamination
Thumb or finger loops to anchor sleeves in place
Different sizes available – large size especially important
Quality compliant with either of two international standards, depending on resistance of materials: • option 1: tested for resistance to blood and body fluid penetration: meets or exceeds ISO 16603 class 3 exposure pressure, or equivalent; or • option 2: tested for resistance to bloodborne pathogen penetration: meets or exceeds ISO 16604 class 2 exposure pressure, or equivalent. Note: for each of the options mentioned above, different products may be available. The coverall material described in option 2 is associated with higher heat stress and less breathability; this reduces continuous wearing time and results in more frequent changes than option 1.


Surgical scrubs (trousers and tops)
Tightly woven
Minimum linting
Non-sterile, reusable or single use
Top or tunic: short sleeves
Trousers: drawstring waist enclosure
Different sizes


Recommendation 9
The choice of apron should be, in order of preference: **1. a disposable, waterproof apron** **2. if disposable aprons are not available, a heavy-duty, reusable waterproof apron, provided that it is appropriately cleaned and disinfected between patients.**
Strong recommendation; very low quality evidence comparing disposable and reusable aprons.

Rationale and remarks

Information on aprons was not specifically collected in the rapid systematic review, in the values and preferences literature review, or in the online survey on values and preferences. The recommendation is therefore based on expert opinion. The rationale for wearing an apron over the gown or coverall is that the risk of splashes from patients' vomiting, diarrhoea or bleeding is high, and that it is easier to remove and replace a soiled apron than a gown or a coverall. The guiding principles for decision-making (section 5.5) specify that disposable items are preferred, to minimize handling of potentially contaminated PPE. This recommendation is strong, based on the known route of transmission of Ebola virus, the high case–fatality rate and the lack of available treatment.

Implementation

- An apron should be worn for the entire time the health worker is in the treatment area.
- If an apron is visibly soiled, it should be removed and changed.
- Feasibility issues, such as the availability of new aprons and waste disposal in isolation areas, should be addressed.
- Reusable aprons should be removed in the undressing or decontamination area for cleaning and disinfection, after the health worker has left the ward. The apron should be removed according to undressing procedures.

Technical specifications

The apron should provide sufficient coverage of the body and should be waterproof, to protect the health worker from splashes of body fluids.

Waterproof apron
Disposable or single use
Made of polyester with PVC-coating or other waterproof material
Straight apron with bib
Minimum basis weight: 250 g/m^2
Covering size : approximately 70–90 cm width x 120–150 cm length, or standard adult size
Option 1: adjustable neck strap with back fastening at the waist Option 2: neck strap allowing for tear-off with back fastening at the waist


Heavy-duty apron
Heavy-duty non-woven apron
Straight apron with bib
Fabric: 100% polyester with PVC coating, or 100% PVC, or 100% rubber, or other fluid-resistant material
Waterproof, sewn strap for neck and back fastening
Minimum basis weight: 300 g/m^2
Covering size : approximately 70–90 cm width x 120–150 cm length
Reusable (provided that appropriate arrangements for decontamination are in place)


6.4 Footwear

Recommendation 10
Use waterproof boots (e.g. rubber or gum boots).
Strong recommendation; very low quality evidence comparing boots with closed shoes with or without shoe covers.

Rationale and remarks

People with Ebola often have diarrhoea, vomiting and haemorrhaging, leading to the contamination of floors and other surfaces with faeces, vomit and blood. Solid footwear is therefore important. Waterproof boots are preferred over closed shoes, because they are easier to clean and disinfect and because they provide optimal protection when floors are wet. In addition, rubber boots can protect from sharps injuries. If boots are not available, health workers should wear closed shoes (slip-ons, without shoelaces, that fully cover the dorsum of the foot and ankle). Shoe covers, nonslip and preferably impermeable, should ideally be used over closed shoes to facilitate decontamination. Although the quality of evidence was considered very low, a strong recommendation was given, based on the fact that there are no obvious harms from wearing boots, the high case–fatality rate and the lack of treatment.

Implementation

Boots need not be removed when the health worker leaves the PPE removal area provided that they have been cleaned and disinfected; the same pair of boots can be worn throughout the working day or shift.

Technical specifications

In the survey of values and preferences, health workers indicated that a range of boots in different sizes was not always available, which meant that they sometimes had to wear boots that were too big. A variety of sizes is required. The boots should be knee-high, to provide sufficient coverage.

Waterproof boots
Nonslip, with a PVC sole that is completely sealed
Knee-high, to be higher than the bottom edge of the gown
Optional light colour, for better detection of possible contamination
A variety of sizes, to improve comfort and avoid trauma to the feet


6.5 Head cover

Recommendation 11
Use a head cover that covers both head and neck.
Conditional recommendation; low quality evidence comparing head covers with no head cover.

Recommendation 12
It is suggested that the head cover is separate from the gown or coverall, so that it can be removed separately.
Conditional recommendation; low quality evidence comparing different types of head cover.

Rationale and remarks

These recommendations were based on the known modes of transmission of Ebola virus. The purpose of head covers is to protect the skin and hair of the head and neck from virus contamination and the possibility of subsequent virus transmission to the mucosae of the eyes, nose or mouth.

Recommendation 11 is conditional, since there is no evidence to support the use of either a head cover that also covers the shoulders or a hair cap for preventing contamination or transmission of infection. The need to cover all skin surfaces, including the back of the neck, was discussed in detail during the GDG consultation. There was no consensus: nine experts were of the opinion that all skin surfaces should be covered, three disagreed and one was absent during voting.

Recommendation 12 is conditional, since there is no evidence of the comparative effectiveness of a separate head cover and a head cover that is part of the coverall in preventing viral transmission. When a separate head cover is not available, a coverall with integrated hood may be worn, provided that the hood is put on after eye, nose and mouth protection, so that the mucosae remain protected while the hooded coverall is being removed.

Implementation

Hair and hair extensions need to fit inside the head cover.

Technical specifications

Single-use head covers are preferred, in line with the guiding principles for decision-making (section 5.5). Head covers should be fluid-resistant, in order to prevent exposure to splashes of body fluids. Other specifications were determined by the need for the hood to be secured in place and to provide sufficient coverage of skin surface.

Head cover
Single use
Fluid-resistant
Adjustable, and should stay securely in place once adjusted
Facial opening constructed without elastic Cover reaches the upper part of the gown or coverall
 Head cover  Hood (reaching below the shoulders)

7. Implementation

Several issues need to be considered in order to ensure that these recommendations are adopted and effectively implemented. They include the existing capacity and practices in different health care settings. Settings with a relatively low capacity are likely to face more challenges in adhering to the guidance, while it may be difficult to change practices already in use. Guidance and protocols on appropriate use should be developed and adapted to local settings as a priority.

It is essential to adhere to the technical specifications and quality standards specified in this document when procuring and using PPE.

Administrative, engineering and environmental controls are also essential in the implementation of the recommendations. Administrative controls include, among others: mandatory training and mentoring on PPE use, frequent supportive supervision, resource management, and protocols for the reporting of a breach in PPE materials or use. Engineering and environmental controls include: ensuring adequate supplies of water and disinfectants, adequate cleaning and disinfection, and adequate management of reusable and disposable PPE items.

Before engaging in any clinical care of patients with confirmed or suspected filovirus disease, all health workers should receive thorough training in the use of PPE; this should be followed by mentoring for all users. The training should be adapted for different categories of health workers, including supervisors, and should take into account local customs and cultural sensibilities. Adequate resources – human, material and financial – need

to be made available. Posters explaining how to put on and remove PPE are available on the WHO website (9) and in Annex 4.

Cooling and rehydrating facilities for use by health workers taking off PPE are also essential.

Resource management includes stock management, making sure that different sizes and recommended shapes of PPE are available, having items easily accessible, controlling the quality of items purchased, and setting up a system to prevent, or ensure early reporting of, shortages. Written protocols need to be in place for the management of used and potentially contaminated medical devices, including safe discarding and decontamination and reuse, if recommended by the manufacturer.

8. Gaps in knowledge and research agenda

The GDG identified several gaps in knowledge about the protection provided by different PPE components. Areas for further research are listed below.

- Determine risk factors and modes of transmission of Ebola virus in health care settings, both within and outside Ebola treatment units.
- It may not be possible to collect data on the comparative effectiveness of individual PPE components in protecting from transmission of Ebola in clinical settings. Detailed case descriptions of transmission to health workers, including issues such as protocols in use when transmission occurred, adherence to such protocols, and types of PPE used, will improve understanding of PPE use and limitations.
- Basic and operational research is needed on technical specifications for materials, fabrics and design of different PPE items, to ensure effectiveness while affording optimum comfort in the provision of care to patients and protecting patient safety.
- Studies are needed to determine whether it is necessary to protect all skin, including that of the back of the neck, from exposure to prevent transmission.
- Research is needed on the optimum method (benefits versus harms) of disinfecting reusable PPE items, such as face shields, goggles, aprons, and boots.
- Research is needed on the effect of disinfecting PPE items (gloves, apron) while in use in relation to protection of the health worker and other patients; the potential for causing visible or invisible damage to these items and the consequent risk to the user should also be investigated.
- Effective disinfection processes are needed for non-PPE items, such as bedlinen and surfaces, to reduce the risk of indirect transmissions.

9. Dissemination, evaluation and plans for updating

A summary of this guidance has been widely disseminated, primarily through electronic means, including publication on the WHO website and informing of major networks and stakeholders through email databases. Guidance on putting on and removing PPE was updated as a priority, to align it with the recommendations in this document. Posters explaining how to put on and remove PPE are available on the WHO website (9). Training materials on the appropriate use of PPE and on EVD transmission and prevention have been developed. WHO also conducted training of trainers and health workers involved in the 2013-16 epidemic.

The impact of this guidance will be evaluated through surveys on the use of PPE in the field. Health worker exposures, infections and risk factors – including those related to PPE use – will be documented and analysed.

WHO continues to evaluate emerging evidence on the different aspects considered in the preparation of these guidelines. It is likely that the 2013–16 Ebola outbreak in western Africa will provide new data and evidence on PPE effectiveness and acceptability. This evidence will be reviewed and the current recommendations updated whenever necessary.

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Annex 2. Declarations and management of interests

In accordance with WHO policy, the secretariat reviewed and assessed the declarations submitted by the GDG members participating in the consultation. All GDG members were experts attending in their personal capacity, as independent experts, not to represent the views of their organizations. Their declared interests were assessed accordingly.

Three GDG members were considered to have interests of a professional nature (Table A2.1). These were noted, but were not considered sufficient to preclude participation in the consultation. The remaining GDG members were considered not to have any conflicting professional interests. The WHO Steering Group concluded that none of the members had interests that represented a significant conflict with the objectives of this meeting.

Table A2.1. Management of potential conflict of interest

Name	Region	Country	Affiliation	Declaration of interest received	Any conflicts declared	Professional interests	Links to companies with relevant interests	Links to companies - other subjects	Noncommercial interests or grants	Meeting restriction
Emma AARONS	Europe	United Kingdom	Public Health England (PHE)	Yes	No	0	0	0	0	No
Daniel BAUSCH	Americas	USA	Tulane University	Yes	No	0	0	0	0	No
An CALUWAERTS	Europe	Belgium	Médecins sans Frontières	Yes	No	Yes	0	0	0	No
Bryan CHRISTENSEN	Americas	USA	CDC	Yes	No	Yes	0	0	0	No
Chad DOWELL	Americas	USA	CDC	Yes	No	Yes	0	0	0	No
Alain EPELBOIN	Europe	France	Centre national de la Recherche scientifique	Yes	No	0	0	0	0	No
Mauricio FERRI	Americas	USA	Princeton University	Yes	No	0	0	0	0	No
Shaheen MEHTAR	Africa	South Africa	Stellenbosch University	Yes	No	0	0	0	0	No
Robert MUSOKE	Africa	Uganda	Ministry of Health	Yes	No	0	0	0	0	No
Babacar NDOYE	Africa	Senegal	Infection Control Africa Network	Yes	No	0	0	0	0	No
Didier PITTET	Europe	Switzerland	University Hospital of Geneva	Yes	No	0	0	0	0	No
Charles SENESSIE	Europe	Switzerland	Afro-European Medical and Research Network (AEMRN)	Yes	No	0	0	0	0	No
Bassim ZAYED	Eastern mediterranean	Oman	Ministry of Health	Yes	No	0	0	0	0	No

Annex 3. Evidence-to-decision tables

These tables were presented to the Guideline Development Group on 6 and 7 October 2014, at which point 38 health workers had responded to the survey on values and preferences. After the technical consultation, an additional six health workers responded, giving a total of 44 survey participants (as noted in the main text of the guideline). The six additional responses did not make a difference to the survey results.

Eye protection	
Background	Human-to-human transmission of filovirus results from contact between broken skin or mucous membranes, such as in the mouth, nose and eyes, and virus-containing body fluids of a symptomatic infected person. It is therefore important to protect the eyes from coming into contact with such body fluids.
PICO	What are the benefits and harms of full-face protection compared with goggles for health workers caring for patients with filovirus disease? **Population:** health workers in health care facilities **Intervention:** goggles **Comparator:** face shield **Outcomes:** see below
Evidence of effectiveness: desirable effects	**Outcome 1:** prevention of virus transmission to health care provider No comparative evidence. No estimate of effectiveness.
Evidence of effectiveness: undesirable effects	**Outcome 2:** fogging, reduced visibility. No evidence found. **Outcome 3:** inadvertent touching of face No evidence found

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Eye protection	
Values and preferences	**Literature review** One study found that barriers to use of protective eyewear, in general, included complaints of somatic effects (headaches and dizziness), interference with prescribed eyewear, and impaired vision related to fogging and scratches on the eyewear. A study reporting on an Ebola outbreak found that face shields were preferred to goggles by community members because they were considered less frightening, since they allowed the health worker to be recognized. They were also preferred by the health workers involved in an Ebola outbreak because they were thought to: (1) offer better protection, by covering the nose and mouth; (2) be more comfortable; and (3) fog less easily than goggles. **Survey questionnaire** Of 38 respondents, 7 had experience with face shields and 36 with goggles. Of those using goggles, 8 (22%) felt at high risk or extremely high risk compared with no one in the group using the face shield. Nine of those using goggles (25%) considered them to be a major impairment to communication compared with none in the group using face shields. In the goggles group, 75% thought there was an important or major reduction in their ability to provide patient care compared with 47% in the face shield group. Personal discomfort (heat stress and dehydration) was a major issue or unbearable for 12 (34%) of the respondents in the goggles group compared with none in the face shield group. Six people in the goggles group (17%) reported that the goggles were very uncomfortable, compared with none in the face shield group. In summary, a greater proportion of goggle wearers than face shield wearers felt at increased risk. Goggles were also considered less comfortable, led to lower levels of well-being, and reduced ease of communication and of providing patient care. **Issues mentioned** The biggest problem with the goggles was fogging. Fogging may increase the risk of accidental exposure to virus, reduce ability to provide patient care, and reduce the time that can be spent in the high-risk area. Goggles were the wrong size or fitted badly. Goggles were of poor quality. Goggles moved easily or slid off. Difficulty of wearing goggles together with glasses. The fact that the face shield is worn outside the hood resulted in lower eye and face protection when the suit was being removed.
Resource use	Average cost of goggles, US$ 4.3 Average cost of disposable full-face shield, US$ 2.70
Feasibility	Both options seem feasible. Consideration should be given to how face shields and goggles can be combined with other elements of PPE (e.g. do goggles prevent a good fit of the respirator, should face shields be worn over or under a head cover, etc.) It might be difficult to combine goggles with prescription glasses.

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Eye protection	
Applicability	This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.
Implementation considerations	Specifications Anti-fogging product (anti-fog spray) may be useful when using goggles Training in use of PPE Quality criteria WHO to develop training materials for PPE use WHO to develop protocols for safe disposal or decontamination prior to reuse, as appropriate
Research priorities	Surveys of barriers to use, effectiveness studies comparing different products.

Nose and mouth protection	
Background	Filovirus infection can be transmitted by infectious droplets coming into contact with the mucosa of the nose and mouth. Appropriate protection is needed for these surfaces.
PICO	What are the benefits and harms of particulate respirators compared with medical or surgical masks for health care workers caring for patients with filovirus disease in health care facilities? **Population:** health workers in health care facilities **Intervention:** particulate respirators (N95 or equivalent mask) for use by staff for whom the respirators have been fit-tested, who are medically cleared and trained. **Comparator:** medical (surgical) mask. **Outcomes:** see below
Evidence of effectiveness: desirable effects	**Outcome 1:** prevention of virus transmission to health care providers No comparative evidence. No estimate of effectiveness **Outcome 2:** transmission of virus to and between patients No comparative evidence. No estimate of effectiveness.
Evidence of effectiveness: undesirable effects	**Outcome 3:** comfort and dexterity with use under conditions of high ambient temperature. No comparative evidence. No estimate of effectiveness.

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Nose and mouth protection	
Values and preferences	**Literature review** Factors that were reported to negatively influence acceptability of medical masks and respirators included increased fatigue, impaired critical mental ability, discomfort, anxiety of the user, and difficulty communicating. In general, surgical masks were preferred over respirators, because of their greater usability and lower associated discomfort, fatigue and odour; however, they offer limited protection during aerosol-generating procedures. Warmth and wetness around the face were often cited as a problem when using particulate respirators and can lead to increased anxiety for the user. However, there are some ways of decreasing the heat burden of protective facemasks, including the promotion of nasal breathing and the use of exhalation valves. **Survey questionnaire** Ten survey respondents had experience using medical masks and 30 using N95 respirators. Two participants who had used an N95 mask felt at high risk or extremely high risk; all other respondents (both medical mask and N95 respirator) felt at low or extremely low risk. **Communication impairment:** this was considered to be more of a problem with the N95 respirator: no or minor impairment: medical mask, 33%; N95 respirator, 11%; major impairment: medical mask, 11%; N95 respirator, 39%. **Ability to provide patient care:** this was more reduced for the N95 respirator: no or minor reduction: medical mask, 100%; N95 respirator, 70%; important or major reduction: medical mask, 0%; N95 respirator, 30%. **Personal well-being (heat stress and dehydration):** perceived to be a greater issue for the N95 respirator: no or minor issue: medical mask, 75%; N95 respirator, 48%; significant or major issue or unbearable: medical mask, 25%; N95 respirator, 52%. **Comfort:** N95 mask was reported as less comfortable: comfortable or fairly comfortable: medical mask, 76%; N95 respirator, 39%; uncomfortable or fairly uncomfortable: medical mask, 25%; N95 respirator, 61%. Issues mentioned Respondents found it hard to breathe when the mask or respirator was wet with condensation. Two respondents thought that the N95 was excessive for Ebola. There was an impact on communication, both verbal and non-verbal.
Resource use	Respirators, half-sphere, duckbill or folded (N95/FFP2), US$ 1.53 Mask, surgical with splash resistance, flat, rectangular with folds, US$ 0.01
Feasibility	Feasibility, both in terms of availability and acceptability to users, needs to be considered.
Applicability	This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.

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Nose and mouth protection	
Implementation considerations	Training for health workers in appropriate use Provisions for ensuring continuous availability of items for use Protocol for reuse of items or waste disposal, as appropriate WHO to develop training materials on use WHO to develop recommendations for disposal
Research priorities	Comparison of masks with respirators and other alternatives, cross-sectional studies in different settings to understand protective effects, compliance surveys, perceptions of barriers. Further research into mode of transmission of Ebola: can Ebola be transmitted via airborne particles?

Gloves	
Background	Human-to-human transmission of filovirus results from contact between broken skin or mucous membranes, such as in the mouth, nose and eyes, and virus-containing body fluids of a symptomatic infected person. Gloves prevent the hands becoming contaminated. Proper use of gloves will help to prevent transmission via the hands to other parts of the body of the carer, to other patients and to the environment.
PICO	What are the benefits and harms of double gloves or heavy-duty rubber gloves compared with single gloves for health workers caring for patients with filovirus disease? **Population:** health workers in health care facilities **Intervention 1:** double gloves **Intervention 2:** heavy-duty rubber gloves **Comparator:** single gloves **Outcomes:** see below
Evidence of effectiveness: desirable effects	**Outcome 1:** prevention of virus transmission to health care provider No comparative evidence. No estimate of effectiveness. **Outcome 2:** prevention of transmission of the virus to and between patients No comparative evidence. No estimate of effectiveness.
Evidence of effectiveness: undesirable effects	**Outcome 3:** glove perforation No comparative evidence. No estimate of effectiveness. **Outcome 4:** manual dexterity of the user No evidence available **Outcome 5:** tactile sensitivity No evidence available

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Gloves	
Values and preferences	**Literature review** (not restricted to filovirus or haemorrhagic fevers) The majority of reports relating to double-gloving focus on the use of double gloves in surgical wards. These reports have identified decreased tactile sensation, impaired dexterity, and discomfort as the main issues related to double-gloving. One study found that, in most cases, after two days, surgeons no longer had a feeling of impaired tactile sensation when using double gloves. In two studies, surgeons preferred using larger gloves on the inside and "normal" size gloves on the outside. **Response to survey questionnaire** All 38 respondents had experience with double-gloving, one respondent had experience with single gloves and six with rubber gloves. The one person who had experience with both single- and double-gloving felt at high risk with the single gloves and at low risk with the double gloves, and experienced no difference in heat stress, comfort or ability to provide care. **Perception of risk:** extremely low or low: double gloves, 97%; rubber gloves, 100%. **Dexterity while providing care:** double gloves: no or minor reduction, 68%; important or major reduction, 32%. **Personal discomfort due to heat and dehydration:** double gloves: no or minor issue, 84%; significant issue, 16%. **Comfort:** double gloves: comfortable or fairly comfortable, 94%. Issues mentioned with regard to single- and double-gloving: Quality of the gloves. Gloves not strong enough, thus tearing easily. Gloves not long enough, or tending to slide down, exposing skin. Rubber gloves: hard to see whether there are holes. Gloves (including rubber gloves) more friable when being removed as a result of exposure to chlorine solution. Gloves were frequently mentioned as the item of PPE that health workers felt least confident about.
Resource use	Double gloves are more expensive than single gloves (but not twice as expensive, because inner glove may be changed less frequently).
Feasibility	The options of single and double gloves are both feasible to implement. Rubber gloves are more likely to influence dexterity during patient care; quality is widely variable between manufacturers and difficult to control; discarding after use (waste management) will pose problems.
Applicability	This recommendation is applicable to health workers in direct contact with patients suffering from filovirus disease.

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Gloves	
Implementation considerations	Hand hygiene should be performed according to WHO guidelines (6). Gloves should be used in combination with other elements of PPE and in compliance with general infection prevention and control measures. Ensure safety of injections and phlebotomy procedures and management of sharps. Use correctly sized gloves. All gloves should comply with quality criteria. As recommended in the WHO guidance mentioned above, gloves should be put on when the health worker enters the patient care area. They should be changed between tasks and procedures on the same patient after contact with potentially infectious material. They should also be changed if heavily soiled with blood or any body fluids, or when they are torn or damaged. Gloves should be removed after use, before the health worker touches non-contaminated items and surfaces, and before going to another patient. Careful hand hygiene should always be performed immediately after removal. Since 4–17% of health workers have an allergic reaction to latex, gloves made of other materials should be available. Health workers should be trained in putting on and taking off the recommended PPE, including gloves.
Research priorities	Comparative studies on different glove materials, observational studies of compliance, staff surveys of perceived comfort, barriers to compliance, innovative low-cost materials for elbow-length gloves.

Gown or coverall	
Background	Splashing of contaminated fluids onto non-intact skin surfaces can transmit filovirus.
PICO	What are the benefits and harms of highly impermeable gowns compared with other items that cover exposed skin? **Population:** health workers caring for patients with filovirus disease in health care facilities **Intervention:** impermeable gown **Comparator 1:** surgical gown **Comparator 2:** coverall **Outcomes:** see below
Evidence of effectiveness: desirable effects	**Outcome 1:** prevention of virus transmission to health care provider No comparative evidence. No estimate of effectiveness.

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Gown or coverall	
Evidence of effectiveness: undesirable effects	**Outcome 2:** personal well-being (heat stress, dehydration, hyperthermia, heat stroke, pre-syncope and syncope) No comparative evidence. No estimate of effectiveness. **Outcome 3:** dexterity, ability to perform procedures and tasks, and ability to move No comparative evidence. No estimate of effectiveness. **Outcome 4:** maximum tolerated time to wear the equipment and thus be available to care for patients. No comparative evidence. No estimate of effectiveness.
Values and preferences	**Literature review** Interference with work activities and heat stress were cited as issues related to the use of impermeable gowns and impermeable suits or coveralls. The MSF guidelines report that gowns are more comfortable as long as there is limited bending and lifting, and that gowns are more acceptable in environments where it is culturally inappropriate for women to wear trousers. Coveralls allow easier movement than surgical gowns; however, both may pose a significant threat of hyperthermia. One way of combating the risk of hyperthermia is to limit the amount of time an individual wears impermeable clothing. A literature review by Health Sciences Laboratory suggested that the tolerance time for individuals wearing protective coveralls and engaging in moderate physical activity at 20 °C is approximately two hours; however, most of the studies reviewed did not take into account other factors that contribute to heat stress, such as the use of a respirator. **Survey questionnaire** Most survey participants (28) had experience with coveralls, followed by impermeable gowns (12) and surgical gowns (2). Five respondents mentioned the use of other types of gown, including aprons, disposable aprons, and a yellow hazardous material suit with thick apron. **Risk of transmission:** survey participants generally felt at low or very low risk, irrespective of the gown they were wearing (coverall, 88%; impermeable gown and surgical gown, 100%). **Communication:** this was more frequently considered to be impaired when using the coverall (42%) than the impermeable gown (18%), as was ability to provide patient care (41% vs 27 %). **Personal well-being (heat stress and dehydration) and comfort:** there was considerable variability among health workers for both the coverall and the impermeable gown. **Quality and requested specifications of the gown** A number of respondents commented that the coveralls and suits were often too small, leading to potentially dangerous situations, such as exposed skin and difficulty undressing. One participant mentioned that a thumb or finger loop with elastic at the hand-opening should be used to keep the suit in place, otherwise gloves tended to slip out of the suit because of sweat. One participant mentioned that metal hooks and clip systems on the aprons should be avoided (also because of possible tearing of gloves) and that slipknots were the easiest to undo. Suits with attached foot covers were thought to be a problem, because the foot covers were much longer than the boots, causing risk of tripping.

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Gown or coverall	
Resource use	Average cost of coveralls with elastic wrists, ankles, hood, hidden zipper, disposable: type 3, US$ 11.37 type 4, US$ 5.34 type 5 and 6, US$ 5.00 Average cost of reusable heavy duty aprons, US$ 7
Feasibility	Heat and humidity severely reduce the time that health workers can wear the coveralls, especially the type 3 coverall.
Applicability	This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.
Implementation considerations	Specifications Training in use Quality criteria Protocols for reuse or disposal Different organizations have a preference for different types of coverall, which may lead to confusion among users Putting on and taking off
Research priorities	There is a strong need for research on PPE materials. Suits that are lighter but stronger and that allow heat exchange (moisture evaporation, ventilation system) are urgently needed. Research is also needed on how suits can provide more integrated protection, e.g. by including a hood and mouth protection.

Boots	
Background	Human-to-human transmission of filovirus results from contact between broken skin or mucous membranes, such as in the mouth and eyes, and virus-containing body fluids of a symptomatic infected person. People suffering from Ebola virus disease often have diarrhoea, vomiting and haemorrhage, leading to contamination of floors and other surface areas with faeces, vomit and blood. Solid footwear is therefore an important part of any PPE used by health workers in contact with Ebola patients.
PICO	What are the benefits and harms of rubber boots compared with closed shoes with or without shoe covers for health workers caring for patients with filovirus disease? **Population:** health workers caring for patients with filovirus disease in health care facilities **Intervention:** rubber boots **Comparator:** closed shoes with or without shoe cover **Outcomes:** see below

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Boots	
Evidence of effectiveness: desirable effects	**Outcome 1:** prevention of virus transmission to health care providers No comparative evidence. No estimate of effectiveness. **Outcome 2:** prevention of transmission of the virus to and between patients No comparative evidence. No estimate of effectiveness.
Evidence of effectiveness: undesirable effects	**Outcome 3:** increased body temperature No evidence available. **Outcome 4:** difficulty in movement No evidence available.
Values and preferences	**Literature review** There is little documentation on the preference of health workers for rubber boots or shoe covers. However, one study found that laundry workers in a hospital preferred not to use boots as they were reported to be ill-fitting (too large, especially for women) and uncomfortable, and slowed the workers' movements during work activities. One individual with experience in the Ebola outbreak reported that gumboots were preferable, as workers had to balance on one foot to remove boot covers. **Survey questionnaire** Only one person had experience with closed shoes; the other 38 survey participants wore boots. The person who had worn closed shoes did not comment on perceived safety, personal well-being, comfort or the impact on being able to provide patient care. **Those wearing boots provided the following answers:** **Safety:** low or very low risk, 38 (100%) **Ability to provide patient care:** no or minor reduction, 36 (95%); important reduction, 2 (5%) **Personal well-being (heat stress and dehydration):** no or minor issue, 33 (89%); significant issue, 4 (11%) **Comfort:** comfortable or fairly comfortable, 32 (89%); fairly uncomfortable or uncomfortable, 4 (11%) Some issues mentioned Boots are sometimes too big or a poor fit, and not enough sizes are available. Big boots are clumsy and increase the risk of tripping. It is difficult to remove the coverall over the rubber boots: coveralls could get stuck on the rubber boots during removal; if the extremes of the coverall legs are too loose, they could be dragged under the boots; there is a risk of touching the boots with hands. There is a preference for not re-using boots, or for having a personal pair. Time is needed to decontaminate reusable items, including boots, which may not be dry when needed. Foot covers attached to suits were much longer than the boots, and hung 5–8 cm beyond the toes, leading to a risk of tripping.

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Boots	
Resource use	Boots, rubber, pair, any colour, US$ 12 Shoe covers, no information available (may sometimes be attached to the coverall) Closed shoes, no information available (these should be strong closed shoes, that should only be worn while caring for patients in the health centre, and should not be worn outside the health centre)
Feasibility	Both options seem feasible. Boots are most commonly used and well tolerated, provided that sufficient sizes are available.
Applicability	This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.
Implementation considerations	Specifications Training of staff in proper use Protocol for decontamination, storage and reuse Making available sufficient numbers for all staff needing PPE WHO should develop specifications and training materials on the use of PPE by health workers
Research priorities	Surveys of perceived barriers to compliance, cross-sectional studies on protection afforded.

Head cover	
Background	Human-to-human transmission of filovirus results from contact between broken skin or mucous membranes, such as in the mouth and eyes, and virus-containing body fluids of a symptomatic infected person. A head cover will help protect the scalp from exposure to such body fluids.
PICO	What are the benefits and harms of a hood compared with a hair cover for health workers caring for patients with filovirus disease? **Population:** health workers in health care facilities **Intervention:** head cover or hood **Comparator 1:** hair cover **Comparator 2:** no head cover. **Outcomes:** see below
Evidence of effectiveness: desirable effects	**Outcome 1:** prevention of virus transmission to health care providers No comparative evidence. No estimate of effectiveness. **Outcome 2:** prevention of transmission of the virus to and between patients No comparative evidence. No estimate of effectiveness.
Evidence of effectiveness: undesirable effects	**Outcome 3:** discomfort and heat affecting performance No comparative evidence. No estimate of effectiveness.

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Head cover	
Values and preferences	**Literature review** This was not included in the literature review. **Survey questionnaire** Four participants had experience of wearing a hair cover, and 36 had experience of wearing a hood. The four participants who had worn a hair cover felt at low or very low risk. The hair cover did not impair communication. One of the four participants thought the hair cover led to an important reduction in patient care, while the other three thought there was no reduction. The hair cover was thought to be comfortable or fairly comfortable by all and did not lead to a reduction in personal well-being in terms of heat or dehydration. Participants who had worn a hood responded as follows. **Safety:** low or very low risk, 33 (92%); high risk, 2 (5%). **Communication:** no or minor impairment, 17 (47%); some or major impairment, 19 (53%) **Ability to provide care:** no or minor reduction, 26 (73%); important or major reduction, 10 (28%) **Heat and dehydration:** no or minor issue, 14 (39%); significant or major issue, 24 (61%) **Comfort:** comfortable or fairly comfortable, 23 (63%); uncomfortable or fairly uncomfortable, 13 (37%) **Some suggestions for improvement were made**. Hood and respiratory protection could be designed in one piece. The head cover could incorporate eye protection so that goggles are not necessary. Light suits with powered air purifying respirator (PAPR) helmets would probably be more suitable for medical personnel.
Resource use	Hair cover, US$ 0.002 Hood for coverall, US$ 0.68
Feasibility	Combining the hood with a face shield may be challenging. When the face shield is worn under the hood, the angle of the shield to the face may be increased, thus increasing the risk of splashes; however, when the face mask is worn over the hood, it has to be removed early in the undressing procedure, whereas it would be preferable to leave the face shield on until a later stage. Similar potential issues with regard to combining the hood with goggles, surgical or medical mask or particulate respirator were unclear.
Applicability	This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.
Implementation considerations	Specifications Training Waste disposal Availability WHO should develop specifications and training materials on use of PPE and disposal protocols
Research priorities	Observational studies on compliance, staff surveys on perceived comfort and barriers to compliance.

Annex 4. How to put on and how to remove personal protective equipment - posters

Steps to put on personal protective equipment (PPE) including coverall

1 Remove all personal items (jewelry, watches, cell phones, pens, etc.)

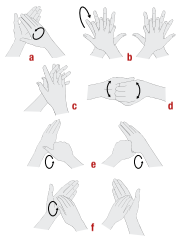
2 Put on scrub suit and rubber boots[1] in the changing room.

3 Move to the clean area at the entrance of the isolation unit.

4 By visual inspection, ensure that all sizes of the PPE set are correct and the quality is appropriate.

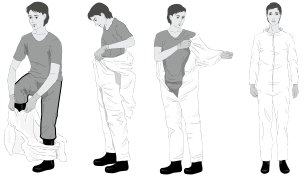
5 Undertake the procedure of putting on PPE under the guidance and supervision of a trained observer (colleague).

6 Perform hand hygiene.



7 Put on gloves (examination, nitrile gloves).

8 Put on coverall.[2]



9 Put on face mask.

10 Put on face shield OR goggles.

11 Put on head and neck covering surgical bonnet covering neck and sides of the head (preferable with face shield) OR hood.

12 Put on disposable waterproof apron (if not available, use heavy duty, reusable waterproof apron).

13 Put on second pair of (preferably long cuff)[2] gloves over the cuff.

1 If boots are not available, use closed shoes (slip-ons without shoelaces and fully covering the dorsum of the foot and ankles) and shoe covers (nonslip and preferably impermeable)

2 Do not use adhesive tape to attach the gloves. If the gloves or the coverall sleeves are not long enough, make a thumb (or middle finger) hole in the coverall sleeve to ensure that your forearm is not exposed when making wide movements. Some coverall models have finger loops attached to sleeves.

World Health Organization

Steps to take off personal protective equipment (PPE) including coverall

1 Always remove PPE under the guidance and supervision of a trained observer (colleague). Ensure that infectious waste containers are available in the doffing area for safe disposal of PPE. Separate containers should be available for reusable items.

2 Perform hand hygiene on gloved hands.[1]

3 Remove apron leaning forward and taking care to avoid contaminating your hands. When removing disposable apron, tear it off at the neck and roll it down without touching the front area. Then untie the back and roll the apron forward.

4 Perform hand hygiene on gloved hands.

5 Remove head and neck covering taking care to avoid contaminating your face by starting from the bottom of the hood in the back and rolling from back to front and from inside to outside, and dispose of it safely.

6 Perform hand hygiene on gloved hands.

7 Remove coverall and outer pair of gloves: Ideally, in front of a mirror, tilt head back to reach zipper, unzip completely without touching any skin or scrubs, and start removing coverall from top to bottom. After freeing shoulders, remove the outer gloves[2] while pulling the arms out of the sleeves. With inner gloves roll the coverall, from the waist down and from the inside of the coverall, down to the top of the boots. Use one boot to pull off coverall from other boot and vice versa, then step away from the coverall and dispose of it safely.

8 Perform hand hygiene on gloved hands.

9 Remove eye protection by pulling the string from behind the head and dispose of it safely.

10 Perform hand hygiene on gloved hands.

11 Remove the mask from behind the head by first untying the bottom string above the head and leaving it hanging in front; and then the top string next from behind head and dispose of it safely.

12 Perform hand hygiene on gloved hands.

13 Remove rubber boots without touching them (or overshoes if wearing shoes). If the same boots are to be used outside of the high-risk zone, keep them on but clean and decontaminate appropriately before leaving the doffing area.[3]

14 Perform hand hygiene on gloved hands.

15 Remove gloves carefully with appropriate technique and dispose of them safely.

16 Perform hand hygiene.

1 While working in the patient care area, outer gloves should be changed between patients and prior to exiting (change after seeing the last patient).

2 This technique requires properly fitted gloves. When outer gloves are too tight or inner gloves are too loose and/or hands are sweaty, the outer gloves may need to be removed separately, after removing the apron.

3 Appropriate decontamination of boots includes stepping into a footbath with 0.5% chlorine solution (and removing dirt with toilet brush if heavily soiled with mud and/or organic materials) and then wiping all sides with 0.5% chlorine solution. At least once a day boots should be disinfected by soaking in a 0.5% chlorine solution for 30 min, then rinsed and dried.

World Health Organization

Steps to **put on** personal protective equipment (PPE) including **gown**

1 Remove all personal items (jewelry, watches, cell phones, pens, etc.)

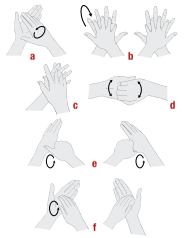
2 Put on scrub suit and rubber boots[1] in the changing room.

3 Move to the clean area at the entrance of the isolation unit.

4 By visual inspection, ensure that all sizes of the PPE set are correct and the quality is appropriate.

5 Undertake the procedure of putting on PPE under the guidance and supervision of a trained observer (colleague).

6 Perform hand hygiene.

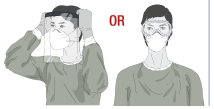


7 Put on gloves (examination, nitrile gloves).

8 Put on disposable gown made of fabric that is tested for resistance to penetration by blood or body fluids OR to blood-borne pathogens.

9 Put on face mask.

10 Put on face shield OR goggles.



11 Put on head and neck covering surgical bonnet covering neck and sides of the head (preferable with face shield) OR hood.

12 Put on disposable waterproof apron (if not available, use heavy duty, reusable waterproof apron).

13 Put on second pair of (preferably long cuff) gloves over the cuff.

[1] If boots are not available, use closed shoes (slip-ons without shoelaces and fully covering the dorsum of the foot and ankles) and shoe covers (non-slip and preferably impermeable)

World Health Organization

Steps to **take off** personal protective equipment (PPE) including **gown**

1 Always remove PPE under the guidance and supervision of a trained observer (colleague). Ensure that infectious waste containers are available in the doffing area for safe disposal of PPE. Separate containers should be available for reusable items.

2 Perform hand hygiene on gloved hands.[1]

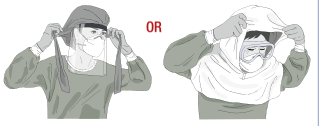
3 Remove apron leaning forward and taking care to avoid contaminating your hands. When removing disposable apron, tear it off at the neck and roll it down without touching the front area. Then untie the back and roll the apron forward.

4 Perform hand hygiene on gloved hands.

5 Remove outer pair of gloves and dispose of them safely.
Use the technique shown in Step 17

6 Perform hand hygiene on gloved hands.

7 Remove head and neck covering taking care to avoid contaminating your face by starting from the bottom of the hood in the back and rolling from back to front and from inside to outside, and dispose of it safely.



8 Perform hand hygiene on gloved hands.

9 Remove the gown by untying the knot first, then pulling from back to front rolling it from inside to outside and dispose of it safely.

10 Perform hand hygiene on gloved hands.

11 Remove eye protection by pulling the string from behind the head and dispose of it safely.

12 Perform hand hygiene on gloved hands.

13 Remove the mask from behind the head by first untying the bottom string above the head and leaving it hanging in front; and then the top string next from behind head and dispose of it safely.

14 Perform hand hygiene on gloved hands.

15 Remove rubber boots without touching them (or overshoes if wearing shoes). If the same boots are to be used outside of the high-risk zone, keep them on but clean and decontaminate appropriately before leaving the doffing area.[2]

16 Perform hand hygiene on gloved hands.

17 Remove gloves carefully with appropriate technique and dispose of them safely.

18 Perform hand hygiene.

[1] While working in the patient care area, outer gloves should be changed between patients and prior to exiting (change after seeing the last patient)
[2] Appropriate decontamination of boots includes stepping into a footbath with 0.5% chlorine solution (and removing dirt with toilet brush if heavily soiled with mud and/or organic materials) and then wiping all sides with 0.5% chlorine solution. At least once a day boots should be disinfected by soaking in ≥0.5% chlorine solution for 30 min, then rinsed and dried.

World Health Organization

These guidelines recognize that health workers must be protected at all times, not only because they are needed to deliver care and save lives during epidemics, but because they may unwittingly transmit pathogens if they are not properly protected.

These guidelines aim to provide the knowledge and advice needed to protect health workers against filovirus infections (Ebola, Marburg, etc.).

Effective protection requires adequate equipment and practices. The West African Ebola outbreak taught public health planners important lessons about how best to protect those providing clinical care. These lessons - of what works, what does not, what is most practical and effective - have been collated, assessed by experts in clinical care and infection control and form the basis for these recommendations. This is an important step forward in evidence-based protection and safety for health care delivery during outbreaks.

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