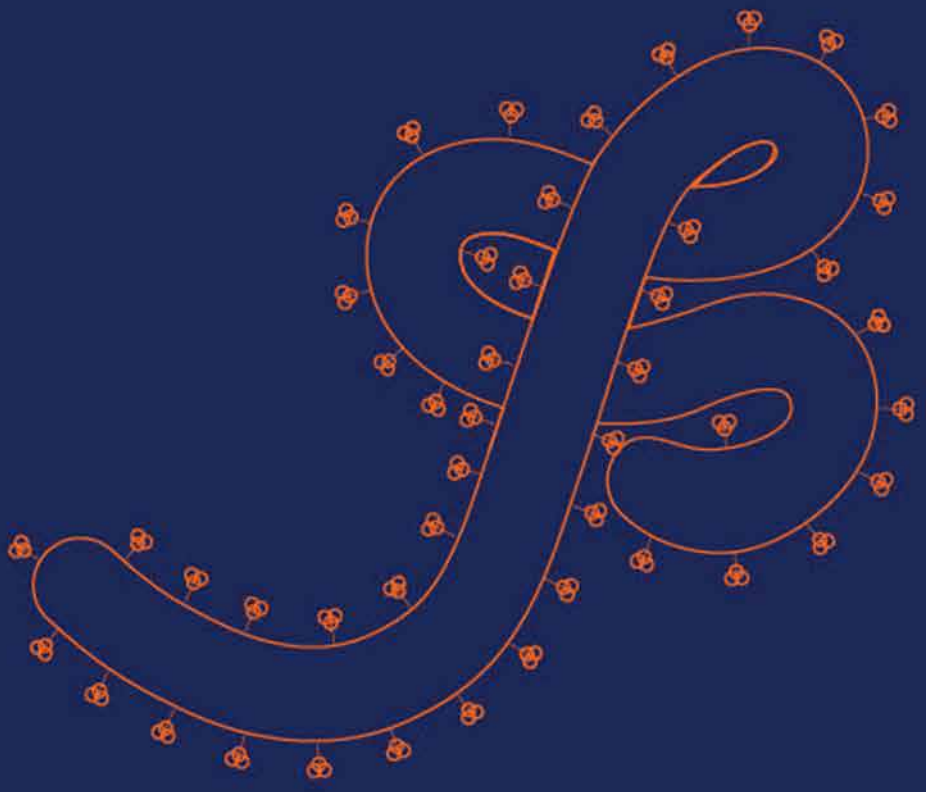
Infection prevention and control guideline for Ebola and Marburg disease

August 2023



World Health Organization

WHO/WPE/CRS/HCR/2023.1

Suggested citation. Infection prevention and control guideline for Ebola and Marburg disease, August 2023. Geneva: World Health Organization; 2023 (WHO/WPE/CRS/HCR/2023.1). Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Contact

WHO Health Emergencies
Infection Prevention and Control
Avenue Appia 20
1211 Geneva 27
Switzerland
WHEIPC@who.int

Contents

1. Foreword

The World Health Organization Health Emergencies Programme has been responding to scores of natural disasters, man-made disasters, armed conflicts and infectious disease outbreaks and pandemics. Experience has shown that these situations, particularly outbreaks of Ebola and Marburg disease, among other Viral Hemorrhagic Fevers, will continue. It is essential that Member States strengthen their capacity for efficient preparedness, readiness and response activities for emerging threats and outbreaks as they occur.

As we continue to respond to outbreaks of Ebola and Marburg, it is evident that strong infection prevention and control (IPC) programmes and response activities enable provision of safe patient care and protect health and care workers. IPC plays a critical role in readiness and response to health emergencies and most importantly, saves lives.

This guideline provides IPC recommendations for Ebola and Marburg disease outbreaks. While focusing on IPC in health-care facilities the guideline also considers the broader context of health delivery in community settings.

When engaging in readiness or response activities for these outbreaks we encourage Member States, decision and policy makers, partners and stakeholders to follow this guideline for the implementation of IPC measures to protect the health and care workforce and ultimately save lives.

Lastly, we call upon partners, stakeholders and researchers to invest in, and engage in, research activities that will continue to improve IPC response for Ebola and Marburg disease.

Dr Nedret Emiroglu

Director, Country Readiness and Strengthening

2. Acknowledgements

WHO would like to thank the following groups and individuals for their support and contribution to this guideline.

WHO Core Team responsible for this document:

April Baller (Medical Officer, IPC lead, Health Emergencies Programme, Country Readiness and Strengthening), Devika Dixit (Medical Officer, Health Emergencies Programme, Country Readiness and Strengthening); Victoria Willet (Technical Officer, Health Emergencies Programme, Country Readiness and Strengthening).

WHO Steering Committee Members: Kamal Ait-Ikhelf (Team Lead, Logistics, Health Emergencies Programme); Benedetta Allegranzi (Technical Lead, Infection Prevention and Control Hub and Task Force, Quality of Care); Lisa Askie (Scientist, Methods); Simon Bagumaho (Medical Officer, Staff Health and Wellness); Landry Cihambanya (Infection Prevention and Control Officer, Emergency preparedness, WHO Regional Office for Africa Region, Brazzaville, Republic of Congo); Janet Diaz (Network Leader, Health Emergencies Programme, Country Readiness and Strengthening); Joanna Esteves Mills (Technical officer, Water, Sanitation, Hygiene and Health); Pierre Formenty (Team Lead, Health Emergencies Programme, High Impact Epidemics); Luca Fontana (Technical Officer, Health Emergencies Programme, Health & Technical Logistics), Bruce Gordon (Coordinator, Water, Sanitation, Hygiene and Health), Shirin Heidari (Gender, Equity and Human Rights); Anaïs Legand (Technical Officer, Health Emergencies Programme, High Impact Epidemics), Ying Lin (Technical Officer, Health Emergencies Programme, Operations Support & Logistics-Medical Devices); Sophie Maes (Health Emergencies Officer, Health Emergencies Programme); Francis Mulemba (Health Emergencies Programme, Logistician, Operations Support & Logistics); Babacar Ndoye (Expert IPC, Emergency Preparedness and Response, WHO Regional Office for Africa Region, Brazzaville, Republic of Congo); Dorothy Ngajilo (Consultant, OWH, Environment, Climate Change and Health); Maria Clara Padoveze (Technical Officer, Health Care Readiness and Strengthening, Health Emergencies Programme); Joao Toledo (Technical Officer, Quality of Care); Nahoko Shindo (Unit Head, Health Emergencies Programme, Emergency Preparedness); Adriana Velazquez Berumen (Senior Adviser, Medical Devices and Diagnostics).

Steering Committee members from UN agencies: Nagwa Hasanin-observer (Senior Adviser, Health, United Nations Children's Fund (UNICEF)-Geneva, Switzerland-Supply Division); Raoul Kamadjeu-observer (Health Specialist, Public Health Emergencies UNICEF, New York, United States); Pierre-Yves Oger (Technical Officer, Water, Sanitation, Hygiene and Health, UNICEF on secondment to Health Emergencies Programme, New York, United States).

Special thanks to the following former members of the Steering Committee:

Miranda Deeves, (Technical Officer, Quality of Care); Marta Lado Castro-Rial (Medical Officer, Health care readiness, Health Emergencies Programme, Country Readiness and Strengthening); Stacey Mearns (on secondment to Health Emergencies Programme, Health care readiness, UK Public Health Rapid Support Team, UK Health Security Agency, London, United Kingdom); Daniel Youkee (Medical Officer, Health care readiness, Health Emergencies Programme, Country Readiness and Strengthening).

Guideline development group: Maya Chávez (Médecins Sans Frontières, Barcelona, Spain); May Chu (Colorado School of Public Health, Denver,United States), Nizam Damani (Southern Health & Social Care Trust, Belfast, Northern Ireland, United Kingdom); Claire Dorion (Médecins Sans Frontières, Geneva, Switzerland); Gwen Eamer (International Federation of the Red Cross and Red Crescent Societies, Geneva, Switzerland); Robert Fowler (Department of Medicine and Interdepartmental Division of Critical Care Medicine, University of Toronto, Toronto, Canada); Joost Hopman (Radboud University Medical Center, Nijmegen, The Netherlands); Emilio Hornsey (UK Public Health Rapid Support Team, UK Health Security Agency, London, United Kingdom); Richard Kojan (Alliance for International Medical Action (ALIMA), Kinshasa, Democratic Republic of the Congo); Daniele Lantagne (Tufts University, Boston, United States); Gillian McKay (London School of Hygiene and Tropical Medicine, London, United Kingdom); Shaheen Mehtar (Infection Control Africa Network, Cape Town, South Africa); Mercy Njeru (Centers for Disease Control and Prevention, Nairobi, Kenya); Tochi Okwor (Nigeria Centre for Disease Control, Lagos, Nigeria); Sorie Samara (Patient Representative, Freetown, Sierra Leone); Sridhar Venkatapuram (King's Global Health Institute, London, United Kingdom), Katie Wilson (US Centers for Disease Control and Prevention, Atlanta, United States).

Methodologists: Elie Akl (American University of Beirut, Beirut, Lebanon); Joanne Khabsa (American University of Beirut, Beirut, Lebanon).

GDG Co-Chairs: Dan Bausch (FIND, Geneva, Switzerland); Dale Fisher (National University Hospital, Singapore); Folasade Ogunsala (College of Medicine, University of Lagos, Lagos, Nigeria).

Special thanks to former GDG members who contributed to the initial development (and prioritization of the PICOS) guideline: Eric Barte de Sainte Farte (Alliance for International Medical Action (ALIMA), Paris, France), Harriet Johnson (Community Representative, Monrovia, Republic of Liberia), Garrison Kerwillain, Ministry of Health, Monrovia, Republic of Liberia), Abdulaziz Mohammed (Africa Centers for Disease Control, Addis Abbaba, Ethiopia).

Special thanks to the following collaborators:

For systematic reviews: SPOR Evidence Alliance and University of Ottawa Knowledge Synthesis and Application unit, Ottawa, Canada: Nicole Shaver, Ba' Pham, Alexandria Bennett, Andrew Beck, Niyati Vyas, Becky Skidmore, Maura R. Grossman, Gordon V. Cormack, Sharmistha Mishra, Adrienne Chan, Lan Xu, David Moher, Melissa Brouwers, Andrea C. Tricco, Julian Little.

For rapid evidence reviews of the key background questions: J. Daniel Kelly (University of California, San Francisco, United States of America), Raphael Frankfurter, (University of California San Francisco School of Medicine, San Francisco, United States of America).

For the "In-depth interview study assessing contextual factors related to infection prevention and control measures for Ebola Virus Disease"; Gladys Honein, (American University of Beirut, Beirut, Lebanon).

Special thanks to the external reviewers: Amy Elizabeth (E-beth) Barrera-Cancedda (Resolve to Save Lives, Cape Town, South Africa); Kerry Dierberg (Médecins Sans Frontières-Paris, France), Syra Madad (NYC Health + Hospitals, New York, United States of America); Eva Niederberger (Anthrologica, France), Diamantis Plachouras (European Centre for Disease Prevention and Control, Solna, Sweden).

WHO Regional IPC Focal points for their review of and feedback on the guideline: Ana Paula Coutinho Rehse (WHO Regional Office for the European Region), Iman Heweidy (WHO Regional Office for the Eastern Mediterranean Region), Zhao Li (WHO Regional Office for the Western Pacific Region), Pilar Ramon-Pardo (WHO Regional Office for the Pan American Region), Aparna Shah (WHO Regional Office for the South East Asia Region),

Thanks are due to the China International Centre for Economic and Technical Exchanges (CICETE) for providing financial support for this guideline.

3. Glossary

Care workers: People who provide direct personal care services in the home, in a health-care or residential setting, assisting with routine tasks of daily life and performing other tasks of a simple and routine nature. This term comprises:

- Health-care assistants: Institution-based, personal-care workers who provide direct personal care and assistance with activities of daily living to patients and residents in a variety of health-care settings, such as hospitals, clinics and residential nursing-care facilities. They generally implement established care plans and practices under the direct supervision of medical, nursing or other health professionals or associate professionals.
- Home-based personal care workers: who provide routine personal care and assistance with activities of daily living to persons who are in need of such care due to effects of ageing, illness, injury, or other physical or mental conditions, in private homes and other independent residential settings *[2][1]*.

Cleaning: The physical removal of foreign material (e.g. dust, soil) and organic material (e.g. blood, secretions, excretions, microorganisms). Cleaning physically removes rather than kills microorganisms. It is accomplished with water, detergents and mechanical action. Cleaning is the first step in the decontamination process *[3][4]*.

Contact transmission: The spread of an infectious agent caused by physical contact of a susceptible host with people or objects. This can occur via direct or indirect contact. Direct contact involves direct body-surface-to-body-surface contact and physical transfer of microorganisms between an infected or colonized person and a susceptible host. For example, unprotected touching of blood or other body fluids from a person infected with *Ebolavirus* or *Marburgvirus*. Indirect contact involves contact of a susceptible host with a contaminated intermediate object (e.g. a contaminated hand) that carries and transfers the microorganisms. For example, physical contact with objects contaminated by a patient with Ebola disease or Marburg disease and/or their body fluids (the environment, patient-care equipment, etc.)*[5]*.

Decontamination: The removal of soil and pathogenic microorganisms from objects so they are safe to handle, subject to further processing, use or disposal. There are several steps to effective decontamination of medical devices and personal protective equipment (PPE), including but not limited to: cleaning, disinfection and sterilization *[6]*.

Disinfection: A process to reduce the number of viable microorganisms to a less harmful level. This process may not inactivate bacterial spores, prions and some viruses.

Droplet transmission: The spread of an infectious agent caused by the dissemination of droplets. Droplets are primarily generated from an infected (source) person during coughing, sneezing and talking. Transmission occurs when these droplets that contain microorganisms are propelled (usually < 1 metre) through the air and deposited on the conjunctivae, mouth, nasal, throat or pharynx mucosa of another person. Most of the volume (> 99%) comprises large droplets that travel short distances (< 1 metre) and do not remain suspended in the air *[5]*. Thus, special air handling and ventilation are not required to prevent droplet transmission.

Ebola disease (EBOD): Formerly known as Ebola haemorrhagic fever, EBOD is a severe, often fatal illness affecting humans and other primates, and is caused by different species. Case fatality rates range from 25%-90%.The virus is transmitted from wild animals (such as fruit bats, porcupines and non-human primates) to people; it then spreads in the human population through direct contact with the blood, secretions, organs or other body fluids of infected people, and with surfaces and materials (e.g. bedding, clothing) contaminated with these fluids *[7]*.

Fomite: an object (such as a dish, doorknob, or article of clothing) that may be contaminated with infectious agents (such as bacteria or viruses) and serve in their transmission *[8]*.

Health worker: Anyone primarily engaged in actions with the primary intent of enhancing health *[9]*. This document uses the phrase "health and care worker" to represent both health workers and care workers.

Hygiene kits: Kits provided to families and those identified as part of an IPC ring (including churches, schools, communities) to prevent *Ebolavirus* transmission. These kits typically include personal and hand hygiene resources (e.g. hand soap, laundry soap) and educational and awareness materials.

Infection Prevention and Control (IPC): a practical, evidence-based approach to preventing patients and health and care workers from being harmed by avoidable infections *[10]*.

Marburg disease (MARD): A highly virulent disease that causes haemorrhagic fever, with a case fatality rate of up to 88%. *Marburgvirus*, which causes MARD, is in the same family as the virus that causes Ebola disease. Human infection with *Marburgvirus* results from prolonged exposure to mines or caves inhabited by Rousettus bat colonies. Once a person is infected with the virus, it can spread through human-to-human transmission via direct contact (through broken skin or mucous membranes) with the blood, secretions, organs or other body fluids of infected people, or through indirect contact with surfaces and materials (e.g. bedding, clothing) contaminated with any of these fluids [11].

No-touch technique: A technique in which health and care workers conducting screening activities maintain at least 1 metre of distance from persons being screened and, through the use of engineering controls, do not touch those persons.

Personal protective equipment (PPE): Specialized equipment used to prevent or minimize exposure to hazards such as biological hazards, chemical hazards, radiological hazards, electrical hazards or mechanical hazards. PPE protects health and care workers from two main hazards, radiological and biological *[12]*.

Reprocessing: All steps needed to prepare a contaminated, reusable medical device for reuse. These steps may include cleaning, functional testing, packaging, labelling, disinfection and sterilization *[6]*.

Screening: A process in which an individual is evaluated to see whether that person meets a standardized case definition *[13][14]*.

Standard Precautions: Precautions that aim to protect both health and care workers and patients by reducing the risk of transmission of microorganisms from both recognized and unrecognized sources. They are the minimum standard of infection prevention and control (IPC) practices that should be used at all times and in all settings by all health-care workers during the care of all patients. When applied consistently, standard precautions can prevent the transmission of microorganisms between patients, health and care workers and the environment *[15]*.

Spray: To project spray or something resembling spray onto or into a surface, item, or a device (such as an atomizer or sprayer) by which a spray is dispersed or applied *[8]*.

Transmission-based precautions (TBP): Precautions used in addition to standard precautions for patients with known or suspected infection or colonization with transmissible and/or epidemiologically significant pathogens. The type of TBP assigned to a patient depends on the transmission route of the microorganism: contact, droplet, or airborne *[5]*.

Triage: The process of sorting patients into categories based on the need for time-sensitive treatment using validated tools. Triage identifies those who require immediate medical intervention, and those who can safely wait. Triage may occur at a health post, primary health center, clinic or emergency unit. It typically requires close physical contact (within 1 metre) with the patient during the assessment *[13]*.

Wipe: To clean or dry by rubbing with a cloth/paper towel. In health-care facilities, surfaces are wiped with cloths soaked with water/detergent, then rinsed and wiped again in a systematic manner with an approved disinfectant *[8]*.

Zoonotic transmission: The natural transmission of any disease or infection from vertebrate animals to humans *[16]*.

4. Abbreviations and acronyms

Abbreviations and acronyms

AIDS	Acquired immunodeficiency syndrome
ABHR	Alcohol-based hand rub
CI	Confidence interval
DOI	Declaration of interest
DRC	Democratic Republic of the Congo
EBOD	Ebola disease
EBOV	Ebola virus (specifically *Zaire ebolavirus*)
ECDC	European Centre for Disease Prevention and Control
EPRG	External peer review group
EID	Emerging infectious disease
ETC	Ebola treatment centre
ETU	Ebola treatment unit
EU	European Union
EVD	Ebola virus disease caused by EBOV
GDG	Guideline Development Group
GPS	Good practice statement
HAI	Health care-associated infection
HCF	Health-care facility
HIC	High-income countries
HIV	Human immunodeficiency virus
HW	Health and care worker
IPC	Infection prevention and control
KQ	Key question
LMIC	Low- and middle-income countries

MARD	Marburg disease
MARV	Marburg virus
MOD	Modified odds ratio
MOR	Matched odds ratio
MVD	Marburg virus disease caused by Marburg virus (MARV) or Ravn virus (RAVV)
MSF	Médecins Sans Frontières (Doctors Without Borders)
NGO	Non-governmental organization
NIOSH	National Institute for Occupational Safety and Health
OR	Odds ratio
PAPR	Powered Air Purifying Respirator
PICO	Population, intervention, comparator, outcome
PPE	Personal protective equipment
PPR	Prevalence proportion ratio
PVC	Polyvinyl chloride
RAVV	Ravn virus
RNA	Ribonucleic acid
RT-PCR	Real-time reverse transcription polymerase chain reaction (RT-PCR) test
SAR	Secondary attack rate
SOP	Standard operating procedure
SUDV	Sudan ebolavirus
TC	Treatment centre- includes ETC, ETU, and centres/units for Marburg treatment
UN	United Nations
UNICEF	United Nations Children's Fund
US CDC	Centers for Disease Control and Prevention (of the United States of America)
WASH	Water, sanitation and hygiene
WHO	World Health Organization

5. Executive Summary

Ebola disease and Marburg disease outbreaks continue to occur in Africa, with increased frequency. In addition to resulting in high mortality and morbidity, the outbreaks generate fear and mistrust about the response activities within the communities affected.

Infection prevention and control (IPC) is a key pillar in the outbreak response; adherence to IPC practices can prevent and control transmission of infections to health and care workers, patients and their family members.

During the 2014-2016 West African Ebola disease outbreak, there was an urgent need for rapid IPC guidance to help support ministries of health, health-care providers and non-governmental organizations (NGOs). In response, WHO produced several documents related to the outbreak based on expert opinion, including IPC-specific documents and documents on clinical management that also referenced key IPC principles and practices. Since that time, many practices in the field have become institutionalized.

Three documents formed the basis for WHO's IPC recommendations for Ebola and Marburg disease:

- *WHO Personal protective equipment for use in a filovirus disease outbreak: Rapid advice guideline* (2016) *[17]*
- *Guideline on hand hygiene in health care in the context of filovirus disease outbreak response: rapid advice guideline* (2014) *[18]*
- *Interim infection prevention and control guidance for care of patients with suspected or confirmed filovirus haemorrhagic fever in health-care settings, with focus on Ebola* (2014) *[19]*

Since the publication of these documents, multiple outbreaks of Ebola disease and Marburg disease have occurred that have given policy-makers, health administrators and health and care workers more experience in managing these diseases from an IPC perspective. In 2021, the WHO Health Emergencies (WHE) IPC team reviewed existing WHO documents and identified a need to re-evaluate and update guidance. Hence, a WHO Guideline Development Group (GDG) has been working since mid-2021 to update the 2014 WHO interim IPC guidance on filovirus haemorrhagic fever with a focus on Ebola disease and Marburg disease. This update consists of a consolidated WHO guideline that follows the Grading of Recommendations Assessment, Development and Evaluation (GRADE) and evidence-to-decision (EtD) methodology.

The objective of these guidelines is to provide clarity on key IPC recommendations as they pertain to settings that pose different risks to the health and care worker, including screening, triage and providing care to patients with Ebola disease or Marburg disease. In addition to preparing this guideline, the GDG Is creating tools to assist in the implementation of these guidelines.

IPC considerations within Treatment Centres (TCs) may differ from IPC considerations within other health-care facilities (HCFs), both in the training/knowledge of the workers and access to appropriate supplies. This guideline aims to prepare members in all types of HCFs to prepare for Ebola disease or Marburg disease cases and to respond in a manner that protects the infected patients, health and care workers as well as any other patients/visitors/family members who may be in these facilities.

WHO's IPC GDG for Infection Prevention and control for Ebola and Marburg disease met via several virtual meetings and in person from 25-27 October 2022 in Geneva, Switzerland.

The recommendations set forth in this guideline will be updated as more evidence becomes available. The focus of this first publication is on recommendations regarding the health-care facility setting. Future areas of focus will include community settings as well as settings used by special populations. The recommendations related to health-care settings that included discussions on community settings have been included here. While many recommendations have been updated in this version, some previous recommendations from the 2014 and 2016 IPC guidelines *[19] [18] [17]* have also been included. If a previous recommendation has been included in this current guideline, it has been flagged as such. **A summary of nine previous recommendations** that have been carried forward into this guideline is included in Table 1 (these are not included in the new recommendation summary table [Table 2] below).

Table 1: Summary of previous IPC recommendations (included verbatim) **in the guideline**

Recommendation	Strength
WHO recommends performing hand hygiene, by using either an alcohol-based hand rub or soap and running water, applying the correct technique recommended by WHO. Alcohol-based hand rubs should be made available at every point of care (at the entrance and within the isolation rooms/areas) and are the standard of care. If alcohol-based hand rubs are unavailable, hand hygiene should be performed with soap and running water whenever necessary. When hands are visibly soiled, hand hygiene should always be performed with soap and running water.	Strong
In settings where bleach/chlorine solutions are currently used for hand hygiene, WHO recommends implementing a strategy to change to alcohol-based hand rub or soap and water.	Strong
Bleach/chlorine solutions currently in use for hand hygiene and glove disinfection may be used in the interim period in emergency situations until alcohol-based hand rubs or soap and water become available.	Conditional

The mucous membranes of eyes, mouth and nose should be completely covered by PPE.	Strong
Use either a face shield or goggles.	Strong
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
Use a fluid-resistant particulate respirator during procedures that generate aerosols of body fluids.	Strong
Nitrile gloves are preferred over latex gloves.	Strong
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

This first edition of this guideline, which addresses IPC in health-care settings, contains **11 new recommendations** and **10 new good practice statements, all of which are summarized** in **Table 2.** Details and further explanation including, but not limited to, remarks and implementation considerations for each recommendation can be found in the body of the document.

Table 2: Summary of new IPC recommendations and good practice statements

Recommendation	Strength
WHO **suggests** using the Infection Prevention and Control (IPC) ring approach in health-care facilities and communities during the management of cases of Ebola disease (EBOD) or Marburg disease (MARD).	Conditional
In geographic areas where *Ebolavirus* or *Marburgvirus* is circulating, all persons (patients, visitors, health and care workers) should be **screened** using a no-touch technique at the first point of contact with any health-care facility to enable early recognition of suspected cases and rapid implementation of source control measures.	Good practice statement
All patients, including those presenting for surgery, obstetrics or other invasive procedures, who are suspected of having Ebola disease or Marburg disease should be **triaged** to determine the severity of their illness and identify those in need of immediate care (and prioritize their care delivery).	Good practice statement
Patients with suspected or confirmed Ebola disease or Marburg disease should be isolated, preferably in a single room, and health and care workers should wear appropriate PPE.	Good practice statement
Once patients with suspected or confirmed Ebola or Marburg disease have been isolated, interaction with family and visitors should be facilitated to promote their well-being while providing education and preventing direct physical contact with others.	Good practice statement
All health and care workers who work in areas with patients who are suspected of having or confirmed to have Ebola or Marburg disease should wear medical scrubs (as opposed to personal clothing) and closed-toe shoes during their shift.	Good practice statement
In the context of an outbreak of Ebola disease or Marburg disease, where infection prevention and control measures (including adequate engineering and administrative controls) can be maintained, **PPE is not required** during **screening activities in health-care settings** where **a distance of at least 1 metre can be guaranteed and a no-touch approach is strictly followed.**	Good practice statement
WHO **suggests** that health and care workers conducting **screening** for Ebola disease or Marburg disease, and **not able to maintain a distance of least 1 metre,** wear: • A medical mask in combination with eye protection[1] (versus wearing eye protection[1] alone) • A fluid-resistant gown (versus a fluid-resistant coverall) • One pair of gloves [1] Eye protection means the use of a face shield or goggles.	Conditional
WHO **suggests** that health and care workers conducting **triage** for patients with suspected or confirmed Ebola disease or Marburg disease wear:	Conditional

• A medical mask in combination with eye protection[1] (versus wearing eye protection[1] alone) • A fluid-resistant coverall (versus a fluid-resistant gown) • Two pairs of gloves [1] Eye protection means the use of a face shield or goggles.	
WHO **suggests** that health and care workers with contact with patients who have Ebola or Marburg disease wear: • A medical mask in combination with eye protection[1] (versus wearing eye protection[1] alone) • A fluid-resistant coverall (versus a fluid-resistant gown) ◦ A head-and-neck covering (as part of their PPE in addition to covering their mucous membranes) if a gown is being used instead of a coverall • Two pairs of gloves • Either a disposable or reusable apron to cover the coverall (or gown, if used) [1] Eye protection means the use of a face shield or goggles.	Conditional
Cleaners/hygienists[1] and mortuary/burial workers[2] should wear the same PPE recommended for other health and care workers, with the exception that 1) the outer pair of gloves should be heavy duty (utility) gloves, 2) aprons should be heavy duty, and 3) their shoes should be waterproof boots. [1]Cleaners/hygienists includes health and care workers handling linens or waste, cleaning the environment. [2] Mortuary/burial workers include health and care workers involved in handling dead bodies.	Good practice statement
WHO **suggests** that health and care workers with direct contact and/or indirect contact with patients with Ebola disease or Marburg disease wear eye protection (goggles or a face shield) **under** the head-and-neck covering versus over the head-and-neck covering.	Conditional
WHO **recommends against** the spraying of health and care workers who have direct or indirect contact with patients who have Ebola disease or Marburg disease during the removal of personal protective equipment.	Strong
WHO **suggests** that health and care workers providing direct and/or indirect care to patients with Ebola disease or Marburg disease in health-care facilities, including Treatment Centres (TCs), **wash/ disinfect the outer pair of gloves, remove the outer pair of gloves and wash/disinfect the inner pair of gloves and put on a new outer pair of gloves between patients** instead of: • Washing and disinfecting the outer glove only or • Washing and disinfecting the outer glove only, removing it and putting on a new outer glove.	Conditional
Any health and care worker with an occupational exposure[1]to Ebola disease or Marburg disease should immediately be assessed for exposure risk, including other potential exposures (e.g. HIV, HBV, HCV), and managed accordingly. [1]Occupational exposure: unprotected contact, including with non-intact skin; percutaneous or muco-cutaneous exposure to blood, body fluids, secretions, or excretions, from a patient with a suspect or confirmed Ebola disease or Marburg disease; or unprotected exposure to contaminated equipment or surfaces that may result from or be related to the performance of an employee's duties.	Good practice statement

WHO **suggests** health and care workers who have had an exposure to *Ebolavirus* or *Marburgvirus* be excluded from work for 21 days.	Conditional
WHO **suggests** disinfecting **surfaces** in health-care facilities, TCs, isolation centres or community settings providing care to patients with Ebola disease or Marburg disease by using the **wiping** method over the **spraying** method.	Conditional
WHO **suggests** that heavily soiled linens resulting from care of patients with Ebola disease or Marburg disease in health-care facilities, TCs or community settings be safely disposed of (e.g. incinerated) following existing WHO guidelines on waste management, rather than disinfected/ decontaminated.	Conditional
All waste generated from the care of a patient with suspected or confirmed Ebola disease or Marburg disease, including waste generated during decontamination processes, should be treated as infectious waste.	Good practice statement
The handling of human remains of deceased individuals with suspected or confirmed Ebola disease or Marburg disease should be done safely, in a culturally sensitive manner, and only when necessary to reduce exposure and transmission.	Good practice statement
WHO **suggests** that disinfection of a dead body suspected or confirmed to be infected with *Ebolavirus* or *Marburgvirus* is not required prior to handling or placing the body into a body bag.	Conditional

6. Purpose and target audience

The recommendations made in these guidelines are intended to assist health and care workers to implement effective IPC measures and reduce the risk of transmission of *Ebolavirus* and *Marburgvirus*.

This guidance is to be used by policy-makers, health-care administrators and managers, IPC specialists, logisticians, community workers, burial teams and all health and care workers.

7. Background

*Ebolavirus a*nd *Marburgvirus* are both enveloped RNA viruses*[20]* that are part of the *Filoviridae* family and cause Ebola disease and Marburg disease respectively.

There are six species of *Ebolavirus*, four of which are known to cause disease (Ebola disease) in humans. The four species that cause human disease are *Zaire ebolavirus* (causing Ebola virus disease); *Sudan ebolavirus* (causing Sudan virus disease); *Bundibugyo ebolavirus* (causing Bundibugyo virus disease) and *Taï Forest ebolavirus* (causing Taï Forest virus disease) *[21]*. *Reston ebolavirus* seroconversions have been found in some animal handlers who have worked with infected animals; however, these infections were not associated with clinical disease *[22]*. Based on current data, *Bombali ebolavirus* is not known to be pathogenic in humans*[23]*.

There is only one species of *Marburgvirus;* Marburg virus (MARV) and Ravn virus (RAVV), which are considered distinct viruses belonging to the same species *[21]*.

Case fatality rates for both Ebola disease and Marburg disease are high, averaging about 50% (and can range from 24% to 90%) though can be lowered with treatment and optimized supportive care respectively *[7][11]*. The WHO guidelines for *Optimized supportive care for Ebola virus disease: clinical management standard operating procedures [24]* provide details on clinical management of patients with Ebola disease. Recommendations for specific therapeutics are currently recommended for *Zaire ebolavirus*. The WHO guideline *Therapeutics for Ebola virus disease [25]* provides detailed information about this.

Although patient demographic information is available from past outbreaks, the impact of outbreaks of Ebola disease and Marburg disease across gender or age is not well understood. Societal roles across different genders and ages may play an important role in exposure risk factors *[26][27][28][29]*.

Since the large and protracted 2014-2016 West African EBOD outbreak, WHO has produced several documents, including IPC-specific documents as well as documents on clinical management and others that reference key IPC elements as described in the Executive Summary above.

Since the 2016 publication, several Ebola and Marburg disease outbreaks have occurred, providing health and care workers with more experience regarding the management of Ebola disease from an IPC perspective. Based on this and on review of existing interim guidance, WHO has identified the need to re-evaluate previous recommendations and guidance in order to develop a more robust guideline according to the GRADE methodology.

This updated, consolidated guideline will be developed in three phases: Phase 1 focuses on IPC and WASH measures in health-care settings, including treatment centres (TCs); Phase 2 will focus on IPC and WASH measures in community settings; and Phase 3 will focus on special populations and settings, such as maternal, child, survivors and surgical settings.

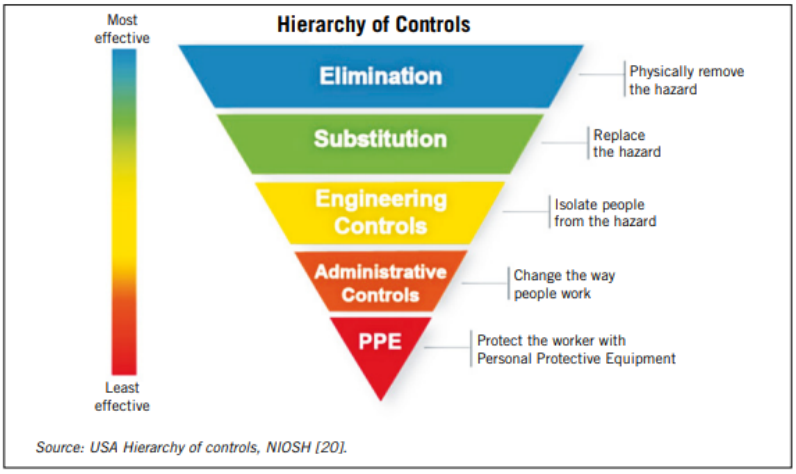
Adapted from the WHO 2016 PPE guideline *[17]*, the following guiding IPC principles are important to keep in mind:

1. General IPC and PPE recommendations (standard and transmission-based precautions) should be adhered to.
The aim should be to achieve the best possible protection against filovirus infection while allowing health and care workers to provide optimal care to patients with maximum ease, dexterity and comfort and minimum heat-associated stress.

1. Disposable items are preferred to minimize handling of potentially contaminated PPE.
2. Ease of removal, availability, ease of training and cultural acceptability are important factors.
3. 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 and care worker safety, the guidelines focus on providing options with acceptable minimum standards.

Another important guiding principle is the hierarchy of infection prevention and control (IPC) principles that should be adhered to and that include engineering, environmental and administrative controls*[30]*. Figure 1 is a pictorial representation of the hierarchy of controls. PPE is one element of the IPC measures required to care for EBOD/MARD patients. Details on the hierarchy of controls for IPC can be found in Section10 of this document.

Figure 1. The hierarchy of control *[31][30][32]*



The GDG also agreed to the following principles when discussing the evidence presented for each PICO:

1. Guidance needs to align with scientific evidence while also recognizing the experiences and sentiment in the field and giving opportunities to build on that advice in the field based on a risk assessment.
2. What is currently happening in practice, in particular for Ebola disease outbreak responses, may not be based on best science and yet may have become institutionalized. This is an opportunity to align advice with accepted, evidence-based standards and transmission-based precautions. For example, evidence indicates that excessive PPE may lead to increased self-contamination, yet excessive PPE is commonly used.
3. In situations where there is limited-to-no evidence, a detailed discussion among the GDG members is important if a proposed recommendation differs substantially from existing guidance; the discussion is intended to ensure that the proposed change is justified, well documented and well understood.

The systematic literature reviews, undertaken as part of the guideline-development process, highlighted that the evidence base for Ebola disease (EBOD) and Marburg disease (MARD) infection prevention and control practices in the context of outbreaks is generally limited to low or very-low certainty evidence. Few studies, if any, met the research questions' inclusion criteria in the evidence base for this document. To address this evidence gap, WHO carried out a mixed-methods study on health workers' (HWs) perceptions related to infection prevention and control (titled “Mixed methods study assessing contextual factors related to infection prevention and control measures for Ebola disease”). It included a survey component as well as in-depth interviews, which provided information to facilitate GDG members’ decision-making regarding IPC recommendations. The data from this study are not yet published.

The guideline development process adhered to the *WHO handbook for guideline development, 2nd ed [33]*. All members completed declarations of interest (DOI) and no conflicts were identified. Information about GDG members is available here.

Questions were formulated in the Population Intervention Comparator Outcome (PICO) format. For each PICO question, extensive discussions followed by voting were used to reach consensus on the judgements for each of the nine criteria of the Evidence to Decision framework under consideration (desirable effects, undesirable effects, values, balance of effects, resources required, cost-effectiveness, equity, acceptability and feasibility); a final vote determined the direction and strength of the recommendation. The systematic review used the GRADE methodology to determine the certainty of evidence. For this document, several statements were identified as foundational, actionable and reflecting best practices in infection prevention and control and were therefore formulated into good practice statements.

Research and development

During the in-person GDG meeting, members advocated for identifying research needed to strengthen the certainty of evidence for future recommendations development. This led to a research prioritization exercise that was conducted through the Infection Prevention and Control Public Health Emergencies Working Group. Research gaps have been identified throughout the document and can be found in the “More info” tabs within the recommendations.

8. Methods

WHO Guideline Development Group (GDG) and External Peer Review Group (EPRG):

The GDG convened to review the available evidence and to formulate the recommendations, good practice statements (GPSs) and implementation considerations that are contained in this document.

The GDG was made up of a gender-balanced group of individuals with broad expertise spanning multiple specialties (e.g. infection prevention and control, infectious diseases, public health, tropical medicine, environmental health experts, water, sanitation and hygiene specialists, emergency response, ethics and health equity, anthropology) from different WHO regions. Additional information on the GDG member profiles can be found here. An external peer-review group (EPRG) was identified for specific technical areas and provided complementary review of the guideline. The EPRG also made suggestions that were reviewed and incorporated into the guideline. The guideline was also circulated to the WHO Regional Office Focal Points (ROFPs). The technical officer leading the development of the guidelines collected and assessed the declarations of interests (DOI) from GDG members and the external peer reviewers for any potential conflicts.

In general, if a conflict of interest is identified, appropriate actions are taken in accordance with the *WHO Handbook for guideline development [33]*. These can include removal of the member from the GDG or recusal of the member from voting or discussion about a particular recommendation. Neither of those actions was required for any of the GDG members or external peer reviewers for this guideline.

Guideline Review Committee (GRC)

This guideline was reviewed and approved by the WHO GRC prior to publication.

Methods for developing the recommendations:

The certainty of evidence for each question was assessed using Grading of Recommendations, Assessment, Development and Evaluation (GRADE) *[34]* as outlined in the *WHO Handbook for guideline development [33]* (Table 1 provides the definitions for the four levels of certainty of evidence). The GRADE assessment considers the risk of bias/study limitations, inconsistency, imprecision, indirectness and publication/reporting biases.

Table 1: GRADE certainty of evidence

Certainty level	Definition
High	The Group is very confident in the estimate of effect and considers that further research is very unlikely to change this confidence.
Moderate	The Group has moderate confidence in the estimate of effect and considers that further research is likely to have an important impact on that confidence and may change the estimate.
Low	The Group has low confidence in the estimate of effect and considers that further research is very likely to have an important impact on that confidence and is likely to change the estimate.
Very low	The Group is very uncertain about the estimate of the effect.

When reviewing the topics for inclusion in this guideline, the GDG Secretariat and Steering Committee consulted several existing guidance documents. Members of the Steering Committee and the GDG agreed to include some existing recommendations from two guidelines. First, recommendations from the *Guideline on hand hygiene in health care in the context of filovirus disease outbreak response: rapid advice guideline, November 2014 [18]* have been incorporated into this guideline. The three recommendations it contains follow the 2009 *WHO Guidelines on Hand Hygiene in Health Care [35]* and were based on a systematic review of three key research questions followed by a GDG meeting, which was held in November 2014. In summary, the systematic reviews conducted for the 2014 guideline yielded no comparative studies using the use of bleach/chlorine solutions versus alcohol-based hand rub or soap and water for hand hygiene or glove disinfection. Very limited evidence was available on adverse reactions resulting from the use of bleach/chlorine solutions for hand hygiene, but more information could be derived from reports about the use of this disinfectant for other purposes. Only one study was identified on the effect of chlorine solutions on glove permeability, and it showed no permeation. No data were available from the literature on the values and preferences of health and care workers regarding the use of bleach/chlorine solutions for hand hygiene. Advice was gathered on the values and preferences of GDG members, including some professionals with field experience from the recent Ebola disease outbreak, as well as some who had extensive clinical experience from previous outbreaks of EBOD.

The second guidance document is the 2016 *Personal protective equipment for use in a filovirus disease outbreak: rapid advice guideline [17]*. This document was developed following the GRADE methodology process and in consultation with a GDG. Several PICO questions were developed and rapid literature reviews were undertaken, with no comparative studies found. As the rapid review found little evidence of the effectiveness of different types of PPE, the GDG considered other information, including the values and preferences of health workers in relation to PPE. A WHO Collaborating Centre for Occupational Health carried out a literature review of the values and preferences of health worker PPE, but found little information on PPE use in the context of Ebola disease *[36]*. As a consequence, 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. This 2016 document specifically targeted health and care workers, such as doctors, nurses and others who provide clinical care or take samples from patients with suspected, probable or confirmed filovirus infection.

All recommendations in the existing guidelines as well as the interim guidance were reviewed and a prioritization exercise was conducted with the GDG to identify those that would be developed into new, formal recommendations or good practice statements, and those existing recommendations that would be carried forward verbatim into the new, updated guideline. For the recommendations that were carried forward verbatim, updated reviews of literature were not conducted as there was agreement during the guideline development process that it was unlikely there would be new evidence at this time and to focus on those areas determined to be higher priority.

Methods for developing good practice statements

Good practice statements are necessary, actionable and clear guideline statements *[37]*. For this document, several statements were identified as foundational, reflecting best practices in infection prevention and control. The GDG considered the good practice statements as essential to add clarity and specificity to certain practices required to maintain safe patient care. The GDG reviewed these statements and agreed to include them in this document as good practice statements.

Background questions:

During the development of the PICO questions, five key background questions arose, and a rapid review of the literature was conducted to address them. While the background questions may not result in recommendations, they may inform the GDG decision-making process and have implications for implementation considerations. The five background questions were:

1. What are the existing systems to classify the level of risk of exposure of a health and care worker to *Ebolavirus* and *Marburgvirus*, respectively?
2. What is the chlorine concentration and contact time required to disinfect materials or surfaces soiled with *Ebolavirus* and *Marburgvirus*, respectively?
3. What is the survivability of the *Ebolavirus* and *Marburgvirus* in the environment (e.g. water, septic systems, dirt) and on surfaces?
4. Should chlorine with 0.05% or with 0.1% concentration be used for low-temperature laundry (manual or mechanical)?
5. At what frequency should horizontal, high-touch surfaces in facilities providing care to patients be cleaned and disinfected?

A comprehensive search string with terms that included combinations of Medical Subject Headings (MeSH) and text words for Ebola and Marburg viruses was created. This search strategy was applied against the following information sources: PubMed, Embase, Google Scholar, internet-based sources of international health organizations (e.g. WHO, CDC), references of the included literature, and grey literature.

During the selection process, two reviewers independently screened titles and abstracts of the results of the search strategy for potentially relevant articles. While the studies included in the rapid review were all original research articles, the external team also reviewed grey literature for background information. Both the references included in this grey literature and the references of studies found through the systematic database searches were reviewed for additional studies that met inclusion criteria.

All studies found through the review that related to the background questions were either 1) descriptive, real-world studies (i.e. environmental audits of various surfaces in operational ETCs) or 2) controlled, laboratory studies (e.g. experimental studies on the survivability of the *Ebolavirus* in controlled conditions). Since there are no validated risk-of-bias assessment tools for descriptive or controlled, experimental studies, the approach drew on both the Quality in Prognosis Studies (QUIPS) Risk-of-Bias tool when possible and an instrument developed by the reviewers to systematically review the evidence and implications of observational and experimental studies.

Rapid Reviews:

The WHO/HQ Country Readiness Strengthening department, Health Care Readiness unit, Infection Prevention and Control team formulated and finalized the key questions (KQs) and PICOS for each KQ with involvement from the Knowledge Synthesis Team. Key questions were related to three themes on infection prevention and control measures for filoviruses: (i) transmission/exposure, (ii) personal protective equipment (PPE), and (iii) decontamination and disinfection.

The Knowledge Synthesis Team first searched for systematic reviews that met the criteria for each of the key questions. Because the team did not find any systematic reviews that met the criteria, they conducted *de novo* rapid reviews of comparative primary studies for all research questions.

The search strategy was developed by an experienced medical information specialist in consultation with the review team, with the Embase search strategy peer-reviewed by another librarian using the Peer Review of Electronic Search Strategies (PRESS) checklist. There were no time limits or language restrictions on the literature search. Data sources included Medline, Embase, bioRxiv and medRxiv pre-print servers, Global Index Medicus, Epistemonikos, China National Knowledge Infrastructure (CNKI) and Wangfang Data. Records from these data sources were merged into a single database and searched using an automation tool (CAL® tool). This tool was used to search and select potentially relevant systematic reviews and primary comparative studies simultaneously for title/abstract screening.

Following a calibration exercise, a single reviewer screened titles and abstracts within the CAL® tool. Full-text screening, data extraction, risk-of-bias assessment, and the rating of the certainty of evidence following the GRADE approach were completed by a single reviewer, with verification by an additional reviewer.

The Knowledge Synthesis Team used study design-specific tools for risk of bias assessment. For randomized, controlled trials, they used the Cochrane Risk of Bias 2 Tool; for non-randomized studies, they used the Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) tool; and for observational, comparative studies, they used the Newcastle-Ottawa Scale. The results and the certainty of evidence were presented using GRADE, including GRADE Evidence Profiles and Summary of Findings tables. Due to a lack of data that would enable pooling, a descriptive summary of the patient characteristics, study characteristics, and risk of bias/methodological quality results was presented. Contextual data on cost effectiveness, equity, acceptability, resources required, and feasibility were captured and summarized narratively.

Review on modes of transmission of Ebola disease and Marburg disease:

In addition to the rapid reviews, the WHO/HQ Country Readiness Strengthening department, Health Care Readiness unit, Infection Prevention and Control team requested a review of EBOD/MARD modes of transmission.

What is currently understood about the modes of transmission of Ebola and Marburg diseases from individuals infected with Ebola virus or Marburg virus?

To respond to this question, the Knowledge Synthesis Team carried out a rapid scoping review. Data sources included Medline, Embase, bioRxiv and medRxiv pre-print servers, Global Medicus Index, and Epistemonikos. The CAL® tool was used to identify potentially relevant systematic reviews and primary studies for title/abstract screening; for possible aerosol transmission, all study designs were considered. Full-text screening and data extraction were completed independently by a single reviewer with verification by an additional reviewer. Any disagreements were resolved by consensus, with arbitration by a third reviewer, when needed. As the review was scoping in nature, no quality assessments of included studies were performed nor was the evidence for each outcome assessed for the overall certainty of evidence. Data were charted against the known modes of direct or indirect transmission and narratively synthesized by modes of transmission (contact - direct and indirect/fomite, droplet, sexual, vertical, airborne and zoonotic).

Mixed-Methods study:

A survey and in-depth interviews were conducted to assess valuation of outcomes and contextual factors related to infection-control and prevention-control measures for Ebola disease regarding the recommendations that would be made. This study was titled “Mixed-methods study assessing valuation and contextual factors related to infection prevention and control measures for Ebola Disease.”(Honein-Abou Haidar G, Khabsa J, Willet V, Mearns S, and Akl E, . World Health Organization, unpublished, data available upon request, 2023). The perspective of the potential users on how much they value the outcomes considered in the key questions and on contextual factors aims to improve the overall quality of the guideline.

User perspective is important for several reasons, including cultural factors, social and community factors, organizational factors, including feasibility, and individual factors influencing preferences for specific measures based on previous experience with the disease.

This mixed-methods study was based on a quantitative, online survey and an in-depth qualitative survey, both guided by the Evidence to Decision (EtD) framework. It provided a comprehensive understanding of the following: 1-valuation of outcomes relevant to IPC measures in the context of an EBOD outbreak; 2-contextual factors related to decontamination and disinfection in the management of Ebola patients; 3-contextual factors related to PPE use in the management of Ebola patients.

For the valuation of outcomes, three main outcomes of interest were discussed with participants:

Outcome 1: Transmission of Ebola virus

Outcome 2: Adverse effects from chlorine exposure

Outcome 3: Adverse events associated with PPE use

For each PICO question, the participants were asked about four contextual factors: acceptability, feasibility, resource use (including health-care resources, and patient and informal caregiver resources), and impact on equity (i.e. what groups would be at a potential disadvantage when trying to implement the guidelines).

Participants included key stakeholders mainly from African countries, such as the Democratic Republic of the Congo, Guinea and other West African countries, who have had experience in Ebola management. In addition, some participants were from Europe. Participants included decision-makers, WHO and UNICEF staff, representatives of NGOs, and health and care workers with experience in Ebola disease management. Convenience sampling followed by snowball sampling was adopted to recruit participants. Hence, members of the GDG and UN agencies were asked to share the invitation with members of their network who fit the inclusion criteria to participate in both the online survey and the in-depth interview. In addition, responders to the online survey were asked to contact the team via email if they were willing to be involved in the in-depth review. Ethics approval was obtained from the Ethics Review Committee (ERC) at WHO.

The online survey was conducted first, and from there participants were invited to semi-structured interviews. There were 73 survey responses (41 males [56%] and 32 females [44%]) and six in-depth interviews conducted that were available for review during the GDG meetings. An additional 10 in-depth interviews (cumulative: 16) were conducted after the meeting but data from these were not available at the time of the Guideline Development Group meeting and therefore were not included for this guideline. Of the total number of individuals interviewed, nine were male (56%) and seven were female (44%). These data have not yet been published.

Data analysis: Descriptive and bivariate analyses and framework thematic analyses based on the Evidence to Decision (EtD) for the online survey and in-depth interview respectively.

Evidence to Decision tables methodology:

Following presentations from the Knowledge Synthesis team for each PICO question as well as results from the mixed- methods study, the GDG held discussions to formulate recommendations.

GradePRO software was utilized to capture polling that occurred during the GDG discussions and to build consensus among GDG members. The polling was used to support the GDG judgements on elements of the evidence to decision tables, including evidence on health effects (desirable effects, undesirable effects, certainty of evidence, values, balance of effects) and evidence on contextual factors (resources required, cost effectiveness, equity, acceptability, feasibility). After all criteria were considered, a final recommendation and its strength were determined.

During the discussions, research gaps were identified, which led to the further development of the IPC research agenda and research prioritization work that is currently in progress.

Readership cues for statements:

Table 2 presents the readership cues used for the statements in this living guideline. The green checkmark and red X symbols reflect statements that are developed using the GRADE evidence assessment methodology and the use of the evidence to decision framework to inform a recommendation or a GPS. The grey bar refers to implementation considerations that support statements through practical advice and are the product of expert consensus.

Table 2. Readership cues used for statements in the living guideline

	The GREEN checkmark symbol denotes a recommendation or a good practice statement in favour of an intervention.
	The RED X denotes a recommendation or good practice statement against an intervention.

9. Modes of transmission and communicability period

Modes of transmission

The modes of filovirus (*Ebolavirus and Marburgvirus*) transmission provide the rationale for the IPC transmission-based precautions and recommendations and therefore an evidence review was undertaken to review the modes of transmission.

Evidence review and synthesis

During the rapid scoping review, 680 studies were screened at the title/abstract stage and 188 at the full-text review stage. In all, the rapid scoping review included 47 articles, seven of which were reviews that addressed both the direct and/or indirect modes of transmission. Four systematic reviews addressed viral persistence, sexual transmission and vertical transmission and three systematic reviews examined factors for transmission of *Ebolavirus* or *Marburgvirus* among health and care workers and among the general population.

No systematic reviews or primary studies in humans were found that directly captured data on aerosol transmission. To fill these gaps, seven narrative reviews and three experimental studies on animals/particle dynamics were included.

Entry into human circulation via zoonotic transmission

Historically, *Ebolavirus* and *Marburgvirus* have been introduced into humans circulation through animal-to-human transmission (zoonotic transmission).

The typical pattern of transmission of Ebola or Marburg disease which triggers an outbreak is a single primary virus introduction into humans from a wild animal source followed by human-to-human transmission *[38] [39]*. The presence of IgG antibody against Ebola virus indicating previous exposure has been associated with zoonotic exposures (including contact with bush meat), although the animal species associated with the highest rates of seroreactivity varied between studies and *Ebolavirus* species *[40][41][42]*. In 2018, a seropositivity study done in Uganda showed that touching duikers (small- to medium-sized brown antelope native to sub-Saharan Africa) was significantly associated with the presence of antibodies against EBOV, and that hunting primates and touching and/or eating cane rats was significantly associated with the presence of antibodies against SUDV (Sudan ebolavirus) *[41]*. Conversely, an earlier seroprevalence study in a pygmy population in the Watsa region of the Democratic Republic of the Congo (DRC) showed no association between contact with rats, bats, monkeys or entry into caves and presence of IgG antibodies against EBOV *[42]*. The authors of this study noted that this might be explained by not accounting for the level of exposure between participants *[42]*.

Once *Marburgvirus* enters into the human population via zoonotic exposure, transmission patterns often show seasonal surges with multiple, short, independent chains of human-to-human transmission *[43] [44] [38]* .

An accumulating body of evidence suggests that the Egyptian fruit bat (Rousettus aegyptiacus) is the reservoir of *Marburgvirus*, with exposure to these bats associated with several outbreaks, such as a 2007 outbreak in four Ugandan gold miners who were exposed to Egyptian fruit bats *[45]*. Marburg virus RNA and IgG antibodies have been isolated in Egyptian fruit bats in Gabon *[46]* and Marburg virus (RNA, antibodies or virus isolation) has been found in 2.5% and 5.0% of Egyptian fruit bats in Sierra Leone and Uganda respectively *[47] [48]*. Analysis of liver and spleen tissue from Egyptian fruit bats from a popular tourist attraction known as Python Cave in Queen Elizabeth National Park in Uganda found that 2.5% of 1622 captured bats were actively infected with Marburg virus and that the virus is genetically similar to virus isolated from infected tourists who had visited the cave *[49]*.

Miners and other individuals with prolonged exposure in caves or mines inhabited by bats have been identified as a risk group for *Ebolavirus* and *Marburgvirus* infection. In 2020, a retrospective study found that Ugandan gold miners who worked in bat-inhabited caves were at 5.4 times higher risk of being seropositive for filoviruses compared to an unexposed control group in central Uganda *[50]*. In 2017, an epidemiological investigation of a Marburg disease outbreak in the Kween District of Eastern Uganda concluded that rock salt mining in a cave with bats resulted in spill-over into humans and thereby person-to-person transmission *[51]*.

Human-to-human transmission via contact (direct/indirect) transmission

Human-to-human transmission occurs via contact (direct or indirect, also known as fomite transmission) with an infected person during the period of acute illness. Since splashes/spray of blood and body fluids can occur (e.g. from vomiting), the mucous membranes should also be used in addition to skin protection from direct/indirect contact. Sexual transmission can also occur from males who had previously been infected (see below). High-risk exposures for transmission included having had direct contact with an individual with confirmed or probable Ebola disease or Marburg disease, including through exposure to body fluids *[52][51][50][53][54][55][56][57][58] [54]*; participation in funeral practices that entailed exposure to the corpse; *[59][52][56][60][61][62][63]* touching bodies of a deceased person, *[50][51][58][61][63][57]* and care provision *[54][58][60][61][62][63]*. Studies reported higher transmission rates from direct exposure and when the primary contacts had wet rather than dry symptoms *[58][64]*.

A systematic review on risk factors for *Ebolavirus* and *Marburgvirus* transmission identified three behavioural patterns associated with increased risk of infection in the community: (1) close contact with individuals in the later stages of Ebola disease or Marburg disease, when viral loads in body fluids are usually highest, including activities such as sharing a meal, a bed or sleeping mat and touching body fluids; (2) caring for an individual with Ebola disease or Marburg disease; and (3) preparing a recently deceased body for burial *[65]*. In this study *[65]* of household contacts who reported directly touching a case, the attack rate was 32% [95% confidence interval (CI) 26%–38%]. Risk of disease transmission between household members without direct contact was low (1%; 95% CI 0%–5%).

Another systematic review on Ebola virus transmission and pathogenicity among household contacts showed that the overall secondary attack rate (SAR), based on nine studies, was 12.5% (95% CI: 8.6%-16.3%). Immediate family members were at greatest risk, which was highest in those exposed to infectious body fluids while providing nursing care (SAR = 48% [95% CI: 25.5%-70.9%) *[66]*.

In health and care workers, a lack of properly implemented IPC measures, including PPE; inappropriate risk assessment; and lack of environmental/engineering controls, such as lack of electricity or running water; poor waste management methods, including lack of sharps disposal boxes; and lack of supplies, such as soap and disinfectants (chlorine), were cited as significant risk factors for infection. Insufficient staffing of health and care workers and lack of IPC protocols were also contributing risk factors *[67]*.

Evidence regarding fomite transmission, such as from clothing or linens contaminated with blood and/or other body fluids, is limited (fomite transmission) *[54][53]*. There have been reports of persistence of Ebola virus RNA in the vicinity of patients, such as the patient's bed, mattress and clothes/linens *[68][69]*.

Blood appears to be the most infectious body fluid due to high viral loads, although Ebola and Marburg viruses have also been reported in most other body fluids, including breast milk, saliva, semen, sputum, stools, sweat, tears, urine and vomit. With the exception of delayed virus clearance in a few immunologically protected body sites, virus is cleared rapidly as the patient convalesces. Blood was seldom positive for the virus after 16 days post onset of illness *[70]*.

Although EBOV and SUDV transmission reports exist in which the mode of transmission was not specified and there was no apparent direct physical contact with a body fluid, no epidemiological or laboratory studies suggest respiratory or airborne transmission of filoviruses between humans *[71] [72][73][74]*. In a study that looked at 23 household contacts of a patient with Ebola disease, none contracted the virus *[74]*. Use of a surgical [medical] mask that covers the oral mucosa has been shown to prevent nosocomial transmission of Ebola *[75]*.

Various narrative and non-systematic reviews have discussed the possibility of inadvertent spread via droplets through coughs or sneezes *[76]* and the potential for aerosol filovirus spread under laboratory conditions based on animal model studies *[77]*. While this aligns with some of the biological principles of aerosol transmission outlined by Jones et al *[71]*, evidence from animal studies is inconsistent and aerosol filovirus spread has not been observed in human studies. A 2022 experimental study of EBOV transmissibility reported that aerosol EBOV-Makona-exposed non-human primates (NHPs) did not succumb to infection or demonstrate any observable signs of disease *[78]*. Additionally, although laboratory-based particle dynamic studies have suggested that some EBOV strains may remain viable for some time *[79][80]*, there is limited research on the viability of filoviruses as respirable particles outside of controlled laboratory environments or in real-world, clinical situations.

Taking all these findings into consideration current evidence indicates that filovirus transmission in humans does not naturally occur via the airborne route or via the respiratory droplet route. Although no studies address Ebola or Marburg virus transmission during aerosol-generating procedures, extra precautions are recommended for this, given the high pathogenicity, morbidity and mortality of filoviruses.

Viral persistence as a mechanism of transmission, including sexual transmission

A 2018 review of the 2014-2016 Ebola disease outbreak reported that, in half of the ongoing chains of transmission, sexual intercourse was the most likely transmission route from male survivors who were confirmed or suspected to be persistently infected *[81]*. Viable EBOV has been shown to persist for up to 284 days, although persistence of this duration is not the norm *[82]*. A primary cohort study with 220 participants noted median EBOV RNA persistence in semen of 204 days *[83]*. Because virus persistence has been recorded in human semen, Ebola disease survivor programmes emphasize semen testing and safer sex practices, including consistent condom use, in order to prevent sexual transmission.

While RNA has been detected by a real-time reverse transcription polymerase chain reaction (RT-PCR) test in vaginal fluid from one woman 33 days after symptom onset, infectious virus has to date not been isolated from vaginal fluids *[82]*. Data remain limited and it is unknown how long the virus typically persists in *[84]* vaginal fluids or whether it can be sexually transmitted *[85]*. More information on Ebola survivors can be found in WHO's 2016 publication titled *Clinical care for survivors of Ebola virus disease interim guidance*, *Interim advice on the sexual transmission of Ebola virus disease,* and the 2018 document *International meeting on persistence of Ebola virus RNA in semen and implications for public health* *[86][85][87]*. There are two published reports of Ebola virus persistence or reactivation in sentinel sites (e.g. central nervous system, eye) neither of which led to further transmission *[88]*. However, Ebola virus transmission in an individual who had a relapse of infection has been reported *[89]*.

Additional research is required to better understand the dynamics of filovirus persistence in different body fluids to better quantify risk

and prevent transmission from survivors.

Mother-to-child (vertical) transmission

Evidence of mother-to-child transmission of Ebola virus remains limited, although infection during pregnancy has been associated with adverse outcomes for both mother and child, including elevated risk of maternal and neonatal death, miscarriage, stillbirth and preterm delivery *[90]*. In 2021, WHO published *Guidelines for the management of pregnant and breastfeeding women in the context of Ebola virus disease [91]*. Please refer to these guidelines for more information.

Transmission during funeral practices

Viral loads of body fluids tend to be higher in the later stages of Ebola or Marburg disease and at the time of death. A systematic review showed that contact (including non-intimate contact) with deceased individuals or individuals in the later stages of Ebola disease or Marburg disease poses some risk of infection even after adjusted for direct contact *[65]*. Visiting or caring for an individual who was actively ill with a filovirus increased risk of transmission, with an OR of 13.33; (95% CI; 3.2-55.6) among people who cared for patients at home until the patients died *[65]*.

A systematic review conducted by Brainard et al (2016) attempted to examine behaviours and quantify odds of acquiring infection with Ebola virus or Marburg virus. For example, direct contact with a corpse, its body fluids or soiled items, (OR 38.5 (4.2-352.1)) or preparing a recently decreased body for burial were noted as a high risk for transmission, whereas funeral attendance itself, without adjustment for other forms of contact, showed inconsistent risk (MOR 3, 95% CI: 1 .2-7.6; unadjusted OR 0.86, 0.41-1.79 *[65]*). One study reported that viewing the body at a funeral (without touching) increased risk of transmission (PPR 4.8), but this risk was attenuated after adjustment for direct physical contact during illness and contact with body fluids (PPR 1.6, CI: 0.5-4.9). Similarly, another study reported that sharing a communal meal as part of a funeral was not associated with risk of transmission after estimates were adjusted for contact with the deceased patient while alive (PPR 1.5, 95% CI: 0.98-2.28) *[65]*.

Funeral-related activities that involved direct contact with the body showed a wide range of effect sizes across five studies, ranging from an OR of 1.07 (CI: 0.63-1.82) for preparing the cadaver to 38.5 (CI: 4.2-352.1) for direct contact with the corpse, its body fluids or soiled items. The strength of association was attenuated in the three studies that adjusted for other routes of exposure (e.g. contact with a live patient, providing care during illness), ranging from an OR of 1.16 (CI: 0.54-2.49) for ritual handwashing to 3.83 (CI: 1.78-8.23) for washing and dressing the body.

These findings suggest that, if funeral attendance is associated with increased risk of transmission, routes of exposure other than proximity to the corpse – such as direct contact with the body or body fluids or contaminated objects -- could account for the increased risk.

Summary of *Ebolavirus* and *Marburgvirus* transmission:

Based on the scoping review, *Ebolavirus* and *Marburgvirus* enter into circulation among humans via zoonotic transmission. Human-to-human transmission then occurs via direct or indirect contact with blood or other body fluids of infected individuals. This chain of events is usually more sustained with *Ebolavirus* (more prolonged, resulting in ongoing transmission chains once humans are infected) than with *Marburgvirus*, suggesting that *Marburgvirus* is inherently less infectious.

Although all body fluid can contain the virus, the highest-risk body fluids are blood and other body fluids contaminated with blood.

Human-to-human transmission occurs via exposure to blood and other body fluids via contact (direct and/or indirect) and/or splashes or sprays of blood or other body fluids.

Certain high-risk activities increase the risk of human-to-human transmission. Examples of **high-risk activities** include:

- Exposure of mucous membranes (e.g. eyes, mouth) to *Ebolavirus/Marburgvirus* in the absence of appropriate PPE
- Exposure of broken skin to *Ebolavirus/Marburgvirus* in the absence of appropriate PPE
- Needlestick/sharps injuries with equipment contaminated with *Ebolavirus/Marburgvirus*
- Close contact (unprotected) with individuals in later stages of Ebola disease or Marburg disease, including caring for a sick person with Ebola disease or Marburg disease without appropriate PPE.
- Preparing a recently deceased body for burial (washing, dressing and preparing for the funeral) without appropriate PPE, though evidence was inconsistent.

Other important modes of transmission include sexual transmission, mother-to-child transmission and transmission during breastfeeding, though control of these modes of transmission is not the focus of this guideline. The previously published WHO guideline *[91]* provides recommendations to prevent the spread of EBOD during pregnancy and breastfeeding.

Communicability period

The communicability period (the period when a patient infected with *Ebolavirus* or *Marburgvirus* is infectious or contagious) starts on the day of symptom onset. Neither *Ebolavirus* nor *Marburgvirus* is known to be transmissible prior to symptom onset. The duration of communicability, and therefore the duration of the IPC recommendations (which include PPE recommendations), lasts until the patient is ready for discharge from the TC *[92]*.

Recommended criteria for discharge:

When three or more days without fever or any significant symptoms have passed:

Symptoms that suggest ongoing shedding of virus (e.g. diarrhoea, bleeding, etc.) should have completely stopped. Soft stools are not regarded as an ongoing shedding of virus in children < 5.

Viral shedding known to occur in the semen of male patients and breast milk of lactating females need not preclude discharge, but must be taken into consideration when providing discharge instructions to the patient.

AND

Significant improvement in clinical condition.

AND

In relatively good condition: independently feeding and able to carry out other activities of daily life, like washing and walking, without assistance, taking into account any previous disabilities.

AND

Where laboratory testing is available, a negative blood PCR on day three or later following the resolution of symptoms.

Note: Although the virus is no longer present in the blood, it may show persistence in sites including testes (semen), eyes and brain, in addition other body fluids (such as breast milk).

10. The role of infection prevention and control during outbreaks and routine service delivery

Infection prevention and control is crucial in mitigating and containing the spread of *Ebolavirus* and *Marburgvirus*. If appropriate IPC measures are not taken, transmission of these viruses can be amplified via health care-associated (nosocomial) infections within facilities. This can result in further spread into communities and across borders, resulting in increased morbidity and mortality. To prevent that, public health officials should ensure that robust IPC measures and practices accompanied by Water, Sanitation and Hygiene (WASH) services are in place at all health-care facilities, as well as in all communities. During an outbreak, support for IPC should include all relevant points of health-seeking practices within the local context, including government health facilities, private facilities, traditional healers and centres, such as treatment centres (TCs), established to manage the care of patients suspected of having or confirmed to have the pathogen of interest during an outbreak.

Health-care facilities and communities may be at different emergency phases (preparedness, readiness, response, or recovery) of the outbreak, depending on their geographic location (proximity) to the *Ebolavirus/Marburgvirus* transmission area(s). Strengthening IPC preparedness and operational readiness will lead to more robust responses, contain outbreaks and prevent health systems from becoming overwhelmed. When an outbreak is imminent or underway, it is crucial to start the response by evaluating the existing IPC capacity to identify the critical areas that are missing or that need development. Thus, categorizing geographic zones and corresponding health-care facilities according to the emergency phase facilitates planning of IPC activities and support requirements. Additional information can be found in the *Framework and toolkit for infection prevention and control for outbreak preparedness readiness and response at the National Level* *[93]* and the *Framework and toolkit for infection prevention and control in outbreak preparedness, readiness and response at the health-care facility level* *[94]*.

IPC outbreak management is optimal where national or subnational IPC programmes have already been established, with dedicated support and trained IPC teams at the national, local and health-care facility level. Achieving the IPC minimum requirements *[95]* as well as more robust and comprehensive IPC programmes according to the WHO core components *[96]* across the whole health system in all countries is essential to sustain outbreak response efforts. The IPC core components help plan, organize and implement an IPC programme and should be implemented at both national and health-care facility levels in line with the priorities of the IPC programme and the resources available.

Although *Ebolavirus* and *Marburgvirus* have some specific IPC considerations, it is important to follow the IPC hierarchy of controls *[31]* as well as standard and transmission-based precautions when caring for patients suspected of having or confirmed to have Ebola or Marburg disease. The hierarchy of controls is used by IPC programmes as a framework to categorize different actions to reduce exposure risks *[31][32]*.

Engineering controls include modifying equipment or infrastructure (ventilation, water and sanitation). Implementing engineering controls such as isolation rooms with ensuite bathrooms and designing facilities that promote a unidirectional flow to encourage movement of personnel and equipment from “clean” to “dirty” zones and prevent cross contamination.. Adequate access to water and sanitation is also an important element of engineering controls *[31][32]*.

Administrative controls establish work practices that reduce the duration, frequency, or intensity of exposure risk and include training of health and care workers, implementation of policies and protocols and monitoring of practices. Examples include policies on hand hygiene and cohorting of suspect or confirmed patients. Concerns with cohorting suspect or confirmed cases together have been noted in the field during several Ebola disease outbreaks. Not all individuals in these categories present with the same epidemiological risk and therefore **should not** be mixed (or cohorted) with one another, as they may ultimately be found to have an alternate diagnosis or might have Ebola and coinfection with other pathogens, such as malaria. These individuals must not be mixed (or cohorted) together while awaiting laboratory confirmation. Different holding areas in health-care facilities or TCs are required for these individuals, and it is critical that the infrastructure needed to separate these individuals exist *[31][32]*.

The lowest level of the hierarchy of control is the use of PPE, worn to protect health and care workers from exposure to blood and body fluids or equipment and environmental surfaces that may be contaminated. While PPE can be effective, this is only when it is worn, used and removed correctly and consistently.

11. General IPC measures during Ebola or Marburg disease outbreaks

This section of the guideline focuses on general infection prevention and control measures that would apply to all health-care settings in the event of an outbreak of Ebola disease or Marburg disease. Subsequent sections focus on specific areas, tasks or specific health-care settings that may require different actions to be undertaken.

During an outbreak, the IPC pillar must work collaboratively with other pillars in the response and attention must be paid to the cross-cutting nature of IPC when implementing these guidelines. Some of the pillars with which IPC works regularly during an outbreak include clinical management, epidemiology/surveillance, WASH, logistics and risk communications, to name a few. It is important that IPC messaging be consistently communicated and followed by the different pillars.

11.1 IPC ring approach

The IPC ring approach is a strategy in which rapid, intensive and short-term IPC support is delivered to health-care facilities and community settings in areas of active Ebola virus transmission to help break the chain of transmission and prevent health care-associated infections (HAIs). Once a case is identified at a health-care facility and/or the high risk area and associated health-care facilities are identified, a bundle of interventions is implemented that includes decontamination of affected health-care facilities and/or households; rapid assessment of IPC measures at health-care facilities using a standardized tool (e.g. IPC Ebola and Marburg scorecard) *[97][98][99]* followed by development of an improvement plan; IPC/WASH supply kit distribution; health and care worker (HW) IPC briefings; and a risk assessment of health and care workers who may have been exposed to *Ebolavirus* or *Marburgvirus*. This is then followed up with regular supportive supervision and mentorship and periodic re-evaluations. This approach was used in the West African Ebola disease outbreak of 2014-2016 *[100]* and in the Ebola disease outbreaks in DRC (2018-2020), Uganda in 2022 and the Marburg disease outbreak in Equatorial Guinea in 2023.

Conditional recommendation for , Very low certainty evidence

WHO **suggests** using the Infection Prevention and Control (IPC) ring approach in health-care facilities and communities during the management of cases of Ebola disease (EBOD) or Marburg disease (MARD).

Remarks:

- *The IPC ring approach requires the establishment of a governance structure such as an IPC Task Torce.*
- *The ring approach may be more useful in health systems that are vulnerable and do not have the resources to scale for an outbreak response.*
- *The ring approach may be more beneficial in primary care centres with limited resources.*
- *The IPC ring approach should not replace existing efforts of partners supporting IPC activities or long-term existing IPC efforts; rather, it is additional support in the context of outbreak response.*
- *Caution should be exercised to ensure resources are not diverted from existing efforts when implementing the IPC ring approach.*

Practical Info

Implementation considerations:

- A governance structure for the IPC ring intervention, such as an IPC Task Force led by the Ministry of Health, should be established and/or activated to coordinate IPC ring activities amongst other outbreak-response activities.
- A systematic implementation of the IPC ring approach following standard operating procedures would prioritize resources and thereby help maximize the benefits of this approach during an outbreak. Successful implementation of the IPC ring approach is dependent on sensitization on the ring approach, contact tracing and screening/triage capacities to identify cases promptly; therefore, these need to be functional if the IPC ring approach's benefits are to be maximized.
- Depending on the phase of the outbreak and the geography of the location affected (e.g., proximity to the outbreak epicenter), the benefits of the ring approach might vary.
- As the IPC ring approach comprises a bundle of interventions, the magnitude of its benefit will depend on baseline circumstances and resources available prior to its activation.
- Logistical systems should be in place for mapping of health facilities and community sites and transport of supplies and staff to perform IPC ring activities.
- There are four steps within the IPC ring approach with key interventions in each phase (see box below). Activities are done

within an identified ring area according to a definition and within a specified timeframe.
- PPE supplies for health and care workers and patients seeking help at target health facilities should be made available in appropriate quantities.
- Training of health and care workers on screening, triage, isolation and PPE use is an important element of the IPC ring approach.

Step 1-Preparations: Establish an IPC Task Force to coordinate the IPC ring approach (if one is not already functioning); once a case has been identified, activate the IPC ring; define the parameters (geographic area) of the ring based on where the case is located; identify health facilities, households and public places within the ring; establish teams to dispatch; coordinate logistics, security, etc.; communicate with health facilities, community leader(s) and households.

Step 2-Health-care facility interventions: Decontaminate (clean and disinfect) surfaces and equipment; provide IPC kits, health and care worker briefings; conduct IPC rapid assessments (Scorecard); and create an improvement plan.

Step 3-Household interventions: Decontaminate; distribute standardized hygiene and prevention kits; carry out health promotion activities.

Step 4-Public places (community) interventions: Decontaminate public places within the ring; engage with the community by heightening awareness and sensitization in public places that the case may have been associated with such as markets, churches and schools; carry out a rapid water sanitation and hygiene (WASH) assessment; provide hygiene kits to households and community sites.

Timelines IPC and additional considerations for IPC ring interventions

- The process of setting up IPC rings around target health facilities should be initiated as soon as possible and with a target of less than 24 hours after recognition that a facility provided care to a case.
- Timelines are not necessarily linear; given the availability of sufficient resources, many interventions may occur simultaneously in both health facilities and community settings and are dependent upon resource availability. However, decontamination should be the first intervention when there has been a confirmed case.

Evidence To Decision

Benefits and harms

No comparative studies were identified that evaluated the IPC ring approach. One non-comparative study looked at the implementation of the IPC ring approach in 10 health-care facilities in Liberia, where one out of 166 exposed health workers developed Ebola virus disease *[101]*. Overall, the study found that IPC ring efforts appeared to be associated with an increase in identification and isolation of suspected or probable EVD patients, but triage was not always completely successful. Another study during the Ebola disease outbreak in Liberia reported that the average period from symptom onset to hospitalization was five days, whereas isolation of infected individuals who were in critical condition within four days of symptom onset could facilitate disease elimination (reduce transmission) *[102][100]*.

The GDG members judged that the desirable effects of the ring approach were large for the outcome of *Ebolavirus* infection.

The systematic review did not identify any evidence on adverse effects of the IPC ring approach. However, the GDG judged that the undesirable effects of the IPC ring approach were small. The GDG members felt that, in most circumstances, a systematic approach to enhancing IP measures may be of benefit.

On the balance of benefits and harms, the GDG members judged that they were probably in favour of the IPC ring approach.

Certainty of the Evidence

Very low

The certainty of evidence was judged to be very low due to risk of bias (lack of a comparator group and systematic data collection) and imprecision.

Values and preferences

No substantial variability expected

The systematic review did not identify any evidence about the value of the outcomes. The GDG judged that there was probably no important uncertainty or variability in how much people value the main outcomes, despite an absence of evidence.

Resources

The systematic review did not identify any evidence on resources. Despite a lack of evidence, the GDG judged that there were moderate costs associated with the IPC ring approach. This was thought to be because the IPC ring approach requires extra staff time, supervision and training time, transportation time and supplies, such as thermometers and personal protective equipment (PPE). Although limitations in both supplies (PPE and infrared thermometers) and human resources (appropriately trained personnel) might inhibit a timely response to initiating IPC activities, the IPC ring approach might be used to prioritize allocation of these limited resources.

From a cost-effectiveness perspective, although the systematic review identified no directly relevant information, the GDG judged that it probably favours the IPC ring approach.

Equity

The GDG members noted that an impact on equity would depend on whether there is a diversion of resources; they therefore judged that they did not know what the impact on equity could be.

Acceptability

The systematic review did not identify any evidence on acceptability. The IPC ring approach has been accepted when initiated in multiple settings in past outbreaks. For example, in Liberia, three febrile HWs were identified when screened for work; all were properly isolated and transferred to an ETC for testing. Sierra Leone integrated an IPC ring around clusters of Ebola patients in three districts. Guinea focused on minimizing transmission by rapidly investigating infected HWs and remediating IPC lapses *[100][103]*.

In the 2018-2020 Ebola disease outbreak in eastern DRC, the IPC ring approach was endorsed as a key element of the response by the Ministry of Health and implemented across all the affected provinces by all IPC-implementing partners (NGOs and INGOs) *[99]*.

A study from Uganda in 2014 found that the work of community-appointed Village Health Teams, which supported outbreak-response activities, contributed to the quick containment of Ebola and Marburg disease epidemics. This strategy of strong community mobilization also increased community acceptance of taking patients to isolation facilities *[104]*.

GDG members judged that the IPC ring approach was probably acceptable to key stakeholders.

Feasibility

Flexibility in response to the changing epidemic and development of the IPC ring approach was essential in containing Ebola disease spread in July 2014–September 2015 *[105]*.

Although no directly relevant information was identified during the systematic review, the GDG judged that the IPC ring approach was probably feasible to implement. Field experience during the 2022-2023 Uganda outbreak highlighted the importance of readily available resources (supplies, human and financial) as well as health and care worker and partner knowledge and training in order to successfully implement the IPC ring approach.

Justification

No comparative studies were identified to evaluate the IPC ring approach. One non-comparative study looked at the implementation of the IPC ring approach in 10 health-care facilities (HCFs) in the St. Paul Bridge Cluster (Liberia), where one of 166 HWs exposed to Ebola virus developed the disease *[100]*.

Contextual data were limited and operating procedures for the implementation of the IPC ring intervention were not available in published literature, although WHO has provided such standard operating procedures (SOPs) to countries experiencing outbreaks. Providing rapid, intensive and short-term (21days) support to health-care facilities and communities in areas of active Ebola transmission had a good impact in Guinea and Liberia outbreaks *[100][106]* and more recently in the DRC.

A potentially relevant conceptual framework that explores health-system building blocks to achieve and maintain preparedness was also found *[107]*. The IPC ring approach is based upon the premise that early cluster detection can trigger a rapid, localized response in the high-risk radius around one or several health facilities to reduce transmission sufficiently to contain an outbreak or limit its spread. This premise is the operating principle in case-area targeted interventions (CATI) during cholera outbreaks.

The GDG members judged that the IPC ring approach offered a systematic approach to implementing IPC interventions during an outbreak of Ebola disease or Marburg disease and may be of benefit in vulnerable health systems. Some GDG members noted that the efforts of partners supporting health systems should continue during an outbreak and complement the IPC ring approach while being mindful of potential diversion of resources.

11.2 Isolation and management of suspect or confirmed cases

Maintaining human rights principles that are balanced with public health principles is important to ensuring isolation is done in a safe but also dignified manner for patients, HWs and family members/visitors*[108]*.

While special populations (including children and pregnant women) will be discussed in future guideline iterations, some preliminary considerations apply to the isolation of children. These considerations include but are not limited to how to isolate children in a way that promotes their development and sense of safety; where to isolate – together versus separately -- a child and mother who are both infected; and how to design "child-friendly" isolation facilities.

It is important to acknowledge that patients and communities that are subject to isolation/containment measures might experience negative feelings and that escapes from TCs have been reported during outbreaks*[109]*. TCs can be seen both as positive (e.g. due to their use in the rapid isolation of individuals infected and the quality of care they make possible) and negative (e.g. due to anger towards TC workers, in particular those involved in burials)*[110]*.

11.2.1 Patient placement

Good practice statement

Patients with suspected or confirmed Ebola disease or Marburg disease should be isolated, preferably in a single room, and appropriate PPE be worn by health and care workers.

Practical Info

Implementation Considerations:

- Ideally isolation of individuals with suspected or confirmed Ebola or Marburg disease should be done in single patient rooms. There is a difference between confirmed versus suspected cases (the latter of which meet the case definition but could have a broad differential diagnosis and/or co-infections) and therefore cohorting of suspect and confirmed cases is not advised.
  - If sufficient single isolation rooms are unavailable, and cohorting is required, cohort suspect patients separate from confirmed patients.
- Restrict all non-essential staff from patient care areas to reduce potential exposure to HWs.
- Isolation areas should follow a unidirectional flow to encourage movement of personnel and equipment from “clean” to “dirty” zones and not vice -versa.
- Isolation rooms/areas should have:
  - clear signage at entrance
  - where the design allows, a separate entrance and exit to the isolation area for staff and patients
  - dedicated hand hygiene stations
    - dedicated cleaning and disinfection supplies
    - items and equipment that are not moved between isolation rooms/areas or into other areas of the HCF

- waste bins
- a sharps container
- a dedicated patient toilet
- a separate area for putting on and taking off PPE for health and care workers that has adequate space to ensure room for a during the process of taking off PPE

  - Items and equipment should not be moved between isolation rooms/areas or into other areas of the HCF.

- Please refer to the section of the guideline on Personal Protective Equipment for details on PPE recommendations

Justification

The GDG noted that the core elements of IPC include the implementation of standard and transmission-based precautions. Transmission-based precautions (TBPs) are used in addition to standard precautions for patients with known or suspected infection or colonization with transmissible and/or epidemiologically significant pathogens *[5]*. This includes physically separating patients with infectious symptoms from others and prioritizing single-patient rooms for patients likely to be most infectious. Due to the infectious nature of *Ebolavirus* and *Marburgvirus*, and the existing principles of IPC, the GDG judged that a good practice statement was appropriate.

Good practice statement

Once patients with suspected or confirmed Ebola or Marburg disease have been isolated, interaction with family and visitors should be facilitated to promote their well-being while providing education and preventing direct physical contact with others.

Practical Info

Implementation considerations:

- In general, visitors should not enter into high-risk zones, except to carry out essential cultural or social functions.
- Visitors should be screened before entering into the HCF, including TCs. If visitors are also considered close contacts (e.g. household members) then they should be allowed to enter into HCFs only with caution, given the high secondary attack rates of Ebola and Marburg disease. That caution should apply even to visitors who do not screen positive for symptoms of Ebola or Marburg disease, since, as close contacts, they are at higher risk of infection with *Ebolavirus* or *Marburgvirus*.
- Where possible, isolation rooms should be created to promote interaction with family members in a safe manner (e.g. in isolation CUBEs --Biosecure Emergency Care Units for Epidemics) as utilized by some NGOs, which have increased visibility for patients and visitors.
- Maintaining human rights principles that are balanced with public health principles are important considerations to ensuring isolation is done in a safe (for patients, HWs and family members/visitors) but also dignified manner*[108]*.
- Promote safe interaction with visitors/family in the built environment:
  - Support communication with visitors/family.
  - Provide education to the family/visitors to support them to follow IPC measures.

- Support for children in isolation is an important consideration. Consider the child's developmental needs, sense of safety and caregiver input when deciding whether to isolate the child. Further updates to this section will be included in the phase for special populations, once available.

Justification

Several GDG members noted negative consequences of isolating patients and restricting visitors. It is well recognized that well-being of patients is essential to their recovery and that making allowances for interaction with family and visitors is essential to promoting well-being. Thus, the GDG determined a good practice statement was appropriate.

11.3 Screening and triage recommendations

During an outbreak, health-care facilities and communities may be at different phases, for example, in response, or in operational readiness phase, depending on their epidemiological situation and geographic proximity to the Ebola disease or Marburg disease transmission areas. Health and care workers should heighten their awareness of symptoms of the infectious disease of concern (e.g. Marburg disease or Ebola disease). Conducting activities to rapidly identify and implement source control for suspect, probable and/or confirmed cases is an infection prevention and control measure that should be implemented to prevent amplification of

transmission.

In the context of an outbreak, screening processes are often implemented that may include observing the person; taking the person's temperature with an infrared (no-touch) thermometer; and asking them questions (e.g. about symptoms and potential Ebola/Marburg contact history) according to a standardized case definition. The key goal of screening is to determine if the person meets the standardized suspect case definition and then to act accordingly (i.e. to isolate the suspect case and to allow non-suspect cases to enter the health-care facility).

11.3.1 Screening and triage activities

Good practice statement

In geographic areas where *Ebolavirus* or *Marburgvirus* is circulating, all persons (patients, visitors, health and care workers) should be **screened** using a no-touch technique at the first point of contact with any health-care facility to enable early recognition of suspected cases and rapid implementation of source control measures.

Practical Info

Implementation considerations

- Ensure staff performing screening maintain a minimum of 1 metre distance when interviewing/interacting with the patient/visitor/staff.
- Engineering controls such as a barrier (plexiglass or clear plastic window) between the person conducting the screening and the person being screened should be used wherever possible to help limit contact. **A minimum** of 1 metre distance can be achieved through the use of a barrier such as a table/desk between the screener and the person being screened.
  - Prevent crowding of individuals who require screening by:
    - maintaining at least 1 metre distance spacing of chairs between individuals waiting for screening;
    - ensuring that the screening area has a unidirectional flow
- Staff should follow a no-touch technique when assessing the patient/visitor/staff.
- Use of a thermometer that requires no contact with the skin is recommended for monitoring the temperature of the person being screened (e.g. a non-contact thermometer).
- In instances where the no-touch technique and a minimum 1 metre distance cannot be maintained, despite making every effort to do so, ensure that PPE is available/accessible.
- A standard Ebola disease or Marburg disease questionnaire and algorithm should be developed and made available in the screening area.
- Hand hygiene points should be made available.
- Ideally, alcohol-based hand rub (ABHR) or soap and water should be used for hand hygiene. Soap and water should be used for visibly soiled hands. In situations where neither ABHR nor soap and water are available, a chlorine solution of 0.05% can be used for:
  - staff conducting screening activities
  - individuals being screened in the screening area, at point of arrival
- Use table and chairs made from nonporous material so it is easy to clean and disinfect
- Additional supplies needed for screening areas include:
  - Single-use towels (e.g., disposable paper towels) where soap and water (or 0.05% chlorine solution)will be made available for handwashing
  - Posters depicting hand hygiene techniques
  - Dedicated cleaning and disinfection supplies
  - Waste bins.
- Ensure a mechanism/referral system (including validation, safe transport and temporary isolation) is in place to manage screened persons who meet the suspect case definition.

Justification

The GDG determined that rapid and early identification of suspect cases of EBOD/MARD was essential to enable source control, such as isolation of cases, and to prevent disease transmission. During Ebola disease or Marburg disease outbreaks,

symptoms may be similar to those caused by other circulating illnesses, such as malaria.

Some indirect evidence that emerged from other PICOS was discussed as supporting the need for screening. For example, one study determined that health workers have a high chance of breaking the chain of transmission if they isolate 75% of individuals who are infected with Ebola virus and in critical condition within four days of symptom onset *[102]*. In a report of 62 HWs involved in 10 clusters of infections in Liberia in 2014, 33 HWs were identified as having cared for the source patient in the cluster*[111]*. Early recognition and diagnosis of Ebola in patients who were the likely sources of introduction of the virus to the HWs was missed in four of these 10 clusters as well as in other clusters of HW infections *[112][113]*.

Well established IPC principles in standard and transmission-based precautions emphasise rapid identification and implementation of control measures such as isolation of suspect or confirmed cases*[5]*. Therefore, the GDG judged that screening of all persons at the first point of contact with any healthcare facility, according to established case definitions, was essential to enable rapid implementation of IPC measures for transmission prevention.

Good practice statement

All patients, including those presenting for surgery, obstetrics or other invasive procedures, who are suspected of having Ebola disease or Marburg disease should be **triaged** to determine the severity of their illness and identify those in need of immediate care (and prioritize their care delivery).

Practical Info

Implementation considerations:

- In some settings, screening and triage are implemented together within the same physical space and by the same person. In other settings (particularly large facilities), screening and triage are performed separately, by different people.
- Every health-care facility in areas where *Ebolavirus* or *Marburgvirus* is circulating should have a dedicated, well-equipped triage area that includes the following:
  - At least 1 metre spacing between bed/assessment spaces;
  - Sufficient space for putting on and taking off PPE, including space for a buddy to be present during the procedure for taking PPE off;
  - Hand hygiene stations;
  - Sufficient patient care equipment to allow cleaning and disinfection between uses;
  - Bins with lids for waste, as well as sharps containers.

Justification

The GDG judged that triage is an established process for quality of care that should continue during outbreaks and for patients suspected of having symptoms of a pathogen of concern, such as *Ebolavirus* or *Marburgvirus*, to ensure safe, essential care is delivered.

12. Personal protective equipment (PPE)

This section contains Personal Protective Equipment (PPE) recommendations. PPE that is provided for health and care workers should meet the preferred product characteristics as outlined in the WHO document, *Preferred product characteristics for personal protective equipment for the health worker on the frontline responding to viral hemorrhagic fevers in tropical climates [114]*.

For example, gowns and coveralls should meet the fluid-resistance standards described in the document for protection against blood and other body fluids. If a gown or coverall is not designed to have high fluid resistance at its front, then an apron should be added.

Fluid-resistant medical or surgical masks with a structured design that does not collapse against the mouth are preferred *[17]*. This is because medical masks tend to collapse when wet and fluids may then permeate. Availability of such masks tends to be only in the form of respirators, which are often dome-shaped, cup-shaped, duckbill-shaped or flat-paneled. Some manufacturers are now providing medical masks in a vertical fold, which may be more rigid but still quite breathable. In some cases, due to the desirability of an off-the-face design, and not for protection from aerosols, respirators may be selected for use instead of medical masks *[114]*.

Risk of transmission based on activities conducted:

The activities that a health and care worker perform may affect their risk of exposure to *Ebolavirus* or *Marburgvirus* and subsequent transmission. Following IPC recommendations, which include PPE recommendations, will reduce the risk to the health and care worker. In this guideline, screening where at least 1 metre distance and a no-touch policy can be maintained is considered to present the lowest risk; this is the rationale for why PPE is not required. In the suboptimal situation, where at least 1 metre distance and a no-touch policy cannot be maintained during the screening process, the risk can be increased and is the basis for the PPE recommendations outlined in this guideline. For those who have contact (either direct or indirect) with individuals who are suspected of having or confirmed to have Ebola disease or Marburg disease (for example those who are providing direct clinical care), PPE recommendations include additional items than are recommended for those who are screening. Although triage does involve contact with individuals suspected and/or confirmed to have Ebola disease or Marburg disease, the risk is considered lower than among those providing patient care (this is why this guideline specifically covers those conducting triage).

12.1 Medical scrubs and footwear

Good practice statement

All health and care workers who work in areas with patients who are suspected of having or confirmed to have Ebola or Marburg disease should wear medical scrubs (as opposed to personal clothing) and closed-toe shoes during their shift.

Remarks:

- *Waterproof rubber boots are preferred in patient-care areas with suspect/confirmed Ebola disease or Marburg disease.*

Practical Info

Implementation considerations:

Scrubs

- Scrubs are considered regular on-duty wear and are not considered PPE.
- Specification of scrubs (trousers and tops) from 2016 guidance *[17]* is as follows: tightly woven with minimum linting. Can be non-sterile, reusable or single use. The top or tunic should be short sleeved, and the trousers should have a drawstring waist closure.
- Supply chain and access to medical scrubs are important considerations. In these situations, alternatives to scrubs could be considered.
- Patient-contact areas include all areas where a health and care worker might have exposure to a patient. Risk might vary depending on the area of contact. For example, those working in direct clinical care of patients would be at highest risk of patient contact; however, a screener should, in general, not have patient contact. While scrubs might not be available in sufficient quality and quantity, consideration for scrub use should be prioritized for those with the greatest likelihood of patient contact.
- This good practice statement should be seen in the context of the consistent and rigorous application of standard

precautions as well as other general IPC measures.
- Different sizes of scrubs should be available.
- Scrubs worn when caring for suspect or confirmed patients with Ebola or Marburg disease should be removed when soiled or at the end of the shift and laundered at the health facility, they should not be taken home by health and care workers for laundering.

Footwear

- At a minimum, health and care workers should wear closed shoes (slip-ons, without shoelaces, that fully cover the dorsum of the foot and ankle).
- Different sizes of rubber boots should be available for health and care workers.
- Boots need not be removed when the health and care worker leaves the PPE doffing area, provided they have been cleaned and disinfected;
- The same pair of boots can be worn throughout the working day or shift.
- If rubber boots are not available and where health and care workers do not provide direct patient care (e.g. in ETCs), closed-toe coverings that are fluid resistant, cover the dorsum of the foot and ankle and are washable may be used instead.

Technical specifications

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

Justification

The GDG judged that it is accepted practice for health and care workers to wear uniforms or medical scrubs and not personal clothing, particularly during outbreaks. To enhance safety by minimizing exposure to blood or other body fluids and to minimize the risk of injuries from sharps, for example, health and care workers typically wear closed-toe shoes.

Patients with Ebola disease or Marburg disease often experience diarrhoea, vomiting and haemorrhaging, which may contaminate floors and other surfaces with faeces, vomit and blood, causing them to become wet and slippery. Therefore, the GDG noted that, while closed-toed shoes are a minimum requirement, waterproof rubber boots are preferred in settings where care is being provided to suspect or confirmed cases of Ebola disease or Marburg disease. In addition, rubber boots can protect wearers from sharps injuries and may be easier to decontaminate.

12.2 PPE for screening and triage activities for Ebola virus disease or Marburg virus disease

The following is a summary of the PPE that should be worn during **screening and triage activities.** Details are described in the subsequent recommendations:

i) PPE for HWs conducting **screening where a distance of at least 1 metre can be maintained**:

- PPE is not required provided at least 1 metre distance can be maintained and a no-touch technique is followed.

ii) PPE for HWs conducting **screening where a distance of at least 1 metre cannot be maintained**:

- Scrubs
- Closed-toe shoes

- One pair of gloves* (Nitrile)
- Medical mask in combination with eye protection (face shield or goggles)
- Fluid-resistant gown (or fluid-resistant coverall if gowns are not available)

ii) PPE for HWs during **triage**.

- Scrubs
- Closed-toe shoes
- Two pairs of gloves* (Nitrile)
- Medical mask in combination with eye protection (face shield or goggles)
- Fluid-resistant coverall (versus a fluid-resistant gown, although a gown may be considered if a coverall is not available)

*For more details on glove use during screening where a distance of at least 1 metre cannot be maintained and on triage, see recommendation for gloves

12.2.1 PPE when screening for Ebola or Marburg virus disease

Good practice statement

In the context of an outbreak of Ebola disease or Marburg disease, where infection prevention and control measures (including adequate engineering and administrative controls) can be maintained, **PPE is not required** during **screening activities in health-care settings**, where **a distance of at least 1 metre can be guaranteed and a no-touch approach is strictly followed**.

Remarks:

- *Although screening should be undertaken while maintaining a 1 metre distance and a no-touch policy, this may not always be possible. Hence, PPE would be required in the following situations:*
  - *If the screening is closer than 1 metre or it is anticipated that there will be a need to touch the patient (see PPE recommendations for screening and triage);*
  - *If there are other symptoms present based on risk assessment that would indicate the need for other PPE (for example, in the context of the COVID-19 pandemic, where universal masking might be utilized as part of the hospital policy);*
  - *If engineering/administrative controls are not present (examples include plexiglass, physical barriers, appropriate flow of patients, good ventilation).*

Practical Info

Implementation considerations:

- In the instances where the no-touch policy and a minimum 1 metre distance cannot be maintained, it is important to ensure that PPE is available/accessible, though every effort to maintain the 1 metre distance should be made.
- Health and care workers should always conduct a risk assessment to determine if PPE is required and consider the use of a medical mask, eye protection (if mucous membrane exposure is anticipated), gown and single pair of gloves (if physical contact with the patient's body fluids is anticipated) when performing screening activities and distance of 1 metre cannot be maintained.
- Hand hygiene is performed according to the WHO 5 moments *[115]*.
- Continuously wearing PPE (e.g. gloves) without changing them between patient interactions can cause harm as it decreases the emphasis on hand hygiene.
- Paradoxically, wearing excessive PPE can increase a person's risk of infection.
- Individuals conducting screening activities should be properly trained on how to conduct screening and should use PPE as needed (and as described above).
- In order to ensure 1 metre distance is maintained during the screening process, the appropriate directional flow of individuals into and out of the screening facility should be maintained.
- Creation of a 1 metre distance can be achiedved through a variety of engineering controls, from installation of plexiglass or using a table and chairs to create distance between the person screening and the person being screened.

Justification

The GDG considered the Modes of transmission of Ebola or Marburg virus and noted that, when environmental controls are in place, such as maintaining a distance of at least 1 metre, including through use of physical barriers where applicable, and the use of the no-touch techniques, that standard precautions for IPC apply. Based on these principles, the GDG determined that this statement was applicable as a good practice statement.

Conditional recommendation for , Very low certainty evidence

WHO **suggests** that health and care workers conducting **screening** for Ebola disease or Marburg disease and **not able to maintain a distance of least 1 metre** wear:

- A medical mask in combination with eye protection[1] (versus wearing eye protection[1] alone)
- A fluid-resistant gown (versus a fluid-resistant coverall)
- One pair of gloves

[1] Eye protection means the use of a face shield or goggles.

Remarks

- *Facilities implementing screening should ensure that engineering and environmental controls (such as physical barriers and use of no-touch techniques) are in place to ensure that a distance of at least 1 metre can be maintained.*
- *Ensure staff performing screening activities are trained in maintaining distance and a no-touch technique.*

Practical Info

Implementation considerations

During screening activities, gloves (or any other PPE) are not required. However, in cases where the screener is unable to maintain at least 1 metre distance or is unable to follow the "no-touch" policy, the following implementaiton considerations apply for PPE that is worn:

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

- Be attentive to the fact that there may be a misperception about risk by community members if health and care workers use a higher level of PPE than is needed for screening.
- A distance of at least 1 metre should be maintained between the screener and the person being screened for Ebola disease or Marburg disease. If a distance of at least 1 metre can be maintained, PPE is not required for screening (see good practice statements).
- Physical barriers (e.g. use of tables to create distance between the screener and the person being screened) or plexiglass can be used to ensure at least 1 metre distance is maintained.
- Use of non-contact thermometers to facilitate the no-touch technique is important.
- Masks should be changed when wet. If an off-the-face design is not available, use of a respirator may be considered.

Gown versus coverall.

- Depending on availability, accessibility, and cost, coveralls could be considered if gowns are not available.
- If a gown is not fluid-resistant at the front, consider adding an apron.
- Staff should be trained on the use of no-touch technique and maintaining at least 1 metre distance for screening; in such cases, PPE would not be required.
- Where 1 metre distance cannot be maintained, staff should be trained on PPE use, including procedures for putting on and taking off PPE.

Single pair of gloves

- One pair of gloves should be used.
- Gloves should be changed and hand hygiene performed between contact with each person.

Evidence To Decision

Benefits and harms

Small net benefit, or little difference between alternatives

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence for the effects of wearing eye protection (compared to wearing eye protection in combination with a medical mask) on the outcome of infection with Ebola virus or Marburg virus. However, GDG members judged the desirable effects to be small.

The systematic review did not identify any evidence for the effects of wearing eye protection (compared to wearing eye protection in combination with a medical mask) for the outcomes of PPE breaches or compliance and/or breaches (touching face) related to heat/humidity and comfort, human factors and health and care worker confidence. However, GDG members judged the undesirable effects to be small.

On the balance of effects, the GDG judged that it probably favoured the use of eye protection combined with a medical mask over the use of eye protection alone.

Coverall versus gown

The systematic literature review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the outcome of interest: infection with Ebola virus or Marburg virus. However, the GDG judged the desirable effects of wearing a coverall (compared to wearing a gown) to be small.

No evidence was found for the effects of wearing a coverall (compared to wearing a gown) on the outcomes of PPE breaches and compliance related to heat and comfort, human factors and health and care worker confidence. GDG members judged the undesirable effects of wearing a coverall (compared to wearing a gown) to be small despite the lack of evidence.

Single pair of gloves versus no gloves and hand hygiene

The use of a single pair of gloves versus hand hygiene alone was discussed. The systematic review did not find any evidence on benefits or harms of a single pair of gloves versus no glove and hand hygiene for screening activities. Contextual data noted that risk of infection among health and care workers conducting screening activities is unknown and there are no data on effectiveness of PPE for this activity. The GDG judged that if distance of at least 1 metre cannot be maintained, then the use of contact precautions, which routinely include a single pair of gloves, would apply.

Certainty of the Evidence

Very low

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any primary studies that compared the effects of wearing eye protection in combination with a medical mask to wearing eye protection alone. Two non-comparative studies of potential interest were identified as part of contextual data *[116][21][117]*. While the reviews provided some contextual information, none of their included studies met the eligibility criteria. Therefore, the certainty of evidence was judged to be very low.

Coverall versus gown.

The systematic review did not identify any primary studies comparing coveralls with gowns. However, two non-comparative studies were of potential interest and provided contextual data *[116][21][117]*. While the reviews provided some contextual information, none of their included studies met the eligibility criteria. Therefore, the certainty of evidence was judged to be very low.

Single pair of gloves versus no gloves and hand hygiene

No studies were found comparing the use of a single pair of gloves to no gloves and hand hygiene when conducting screening activities. Therefore, the certainty of evidence was judged to be very low.

Values and preferences

No substantial variability expected

Although the systematic review did not identify any evidence for values and preferences for any of the PPE items listed, GDG members judged that there is probably no important uncertainty or variability in how much people value the main outcomes.

Resources

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

While the systematic review did not identify any evidence on resources required, the GDG judged that there would be a moderate increase in costs associated with the use of eye protection combined with a medical mask, compared with the use of eye protection alone.

GDG members did not know the effects of cost effectiveness, since no studies addressed this.

Coverall versus gown.

Although the systematic review did not identify any evidence on costs, the majority of GDG members judged that resources required for the use of coveralls would be moderate.

The GDG judged that, although there was no evidence from the systematic review of the literature, the cost effectiveness probably favours gown use.

Single pair of gloves versus no gloves and hand hygiene

The GDG judged that cost effectiveness probably favours the intervention (no glove use).

Equity

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not find any evidence on equity. GDG members could not judge if there would be an impact on health equity.

Coverall versus gown.

GDG members judged that, although there was no evidence from the systematic review of the literature, equity was probably reduced with the use of coveralls. The GDG discussed that equity might not be affected in high-income countries (HICs), but for low-middle income countries (LMICs), there might be inequities even within one country.

Single pair of gloves versus no gloves and hand hygiene

Although no studies addressed this specifically, the GDG judged this would probably increase equity.

Acceptability

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shfield or goggles) alone.

The systematic review did not find any evidence on acceptability. The GDG members judged that wearing eye protection and a medical mask was probably acceptable.

Coverall versus gown.

Although the systematic review did not find any evidence on acceptability, the GDG judged that coveralls were probably not acceptable for screening activities. The GDG noted that acceptability of coveralls might be higher due to perceived

benefits but lower due to the undesirable effects (e.g., heat, inconvenience). Acceptability of coveralls probably decreases after use (due to discomfort) and might depend on the setting and task (e.g., TC). However, once staff understand the training requirements and complexity of coveralls, they conclude that a gown is generally more acceptable for screening where 1 metre distance cannot be maintained.

Single pair of gloves versus no gloves and hand hygiene
The systematic review did not find any evidence on acceptability, howeverthe GDG judged that a single pair of gloves, as per usual IPC practices for contact precautions, would probably be acceptable.

Feasibility

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence on feasibility, however the GDG members judged that wearing eye protection, in addition to a medical mask, was probably feasible.

Coverall versus gown.

The systematic review did not find any evidence on feasibility, regardless the GDG judged that gowns were probably feasible to implement.

Single pair of gloves versus no gloves and hand hygiene
The systematic review did not find any evidence on acceptability, however. the GDG judged that a single pair of gloves, was probably feasible to implement when a distance of at least 1 metre cannot be maintained.

Justification

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The GDG judged that this should be a conditional recommendation due to the very low quality of evidence while balancing the risk of transmission (low for the screener) with a potential negative community perception and willingness to access health services. The emphasis should be on implementing engineering and environmental controls to reduce the need for use of PPE, recognizing that many individuals who conduct screening activities are not clinicians and may not have adequate training on its use.

No studies met eligibility criteria and no contextual data that directly addressed the question were found. The systematic review team identified research that evaluated the effectiveness of varying levels of PPE, but no studies evaluated the impact of the addition of a medical mask during screening or triage activities. Some simulation studies noted that PPE with more protective gear offered slightly more protection against contamination, but health and care workers found it felt more uncomfortable. The tradeoff between more protection and usability (e.g. to be able to work comfortably for longer hours with the face shield alone) is unclear. Therefore, in the event that adequate engineering controls cannot be implemented, the GDG judged that individuals conducting activities such as screening should utilize additional PPE (i.e. a medical mask) to protect themselves.

Coverall versus gown.

The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: infection with *Ebolavirus* or *Marburgvirus*, PPE breaches, compliance related to heat and comfort, human factors, health and care worker confidence. However, the GDG felt that protection of health and care workers from potential exposure to *Ebolavirus* or *Marburgvirus* when a distance of at least 1 metre cannot be maintained through use of contact and droplet precautions (e.g. use of a gown, gloves, mask and eye protection) was important. It was judged that the risk of exposure to blood and other body fluids during screening was low and use of a gown would provide the protection required and prevent health and care workers from potentially suffering from health exhaustion or dehydration as a consequence of wearing coveralls.

Single pair of gloves versus no gloves and hand hygiene

The systematic review did not identify any evidence for the outcome of infection with *Ebolavirus* or *Marburgvirus* in health and care workers performing screening if wearing no gloves versus a single pair of gloves. Based on the established mode of transmission and IPC principles for transmission-based (specifically contact) precautions, the GDG judged that a single pair of gloves should be worn in the event that a person conducting screening activities is unable to maintain at least 1 metre distance from individuals being screened.

Research Needs

Simulation studies are needed with an appropriate experimental design to test choices of PPE.

12.2.2 PPE for triage for Ebola or Marburg virus disease

Conditional recommendation for , Very low certainty evidence

WHO **suggests** that health and care workers conducting **triage** for patients with suspected or confirmed Ebola or Marburg disease wear:

- A medical mask in combination with eye protection[1] (versus wearing eye protection alone).
- A fluid-resistant coverall (versus a fluid-resistant gown)
- Two pairs of gloves

[1] Eye protection means the use of a face shield or goggles.

Remarks:

During triage, when at least 1 metre distance can be maintained, PPE is not required, similar to screening.

Practical Info

Implementation Considerations

Health and care workers should be trained on the use of PPE, including procedures for putting on and taking off PPE.

Health and care workers should conduct a risk assessment prior to conducting triage activities to determine PPE requirements, depending on symptoms and contact with the patient.

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

- Masks should be changed when wet. If an off-the-face design is not available, use of a respirator may be considered.
- Anti-fog solution or alternatives to prevent fogging of goggles (e.g. soapy water) should be available for use.

Coverall versus gown.

- Use of a coverall versus a gown might also be dependent upon PPE availability, including the specifications (for example fluid resistance of the available gown or coverall).

Two pair of gloves versus one pair

- Given that quality of gloves may vary in the field, ensuring correct glove selection (following standards and quality control) is important.

- Given that fatigue often results in an increased risk of making errors while removing PPE, it is important that HWs be trained well and that they follow glove-use protocols consistently.
- Well-fitting gloves are important for comfort and ease of use; therefore, multiple glove sizes need to be available for different hand sizes. Loose, ill-fitting gloves are not optimal for inserting lines, etc.
- Glove length is also an important consideration and should follow PPE standards. In some situations, (e.g. obstetrical), longer cuff lengths are required.
- The preferred glove type, based on previous guidance, is nitrile gloves as per the recommendation below.

Evidence To Decision

Benefits and harms

Substantial net benefits of the recommended alternative

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence for the effects of wearing eye protection in combination with a medical mask (compared to wearing eye protection alone) on infection with Ebola virus or Marburg virus. Despite the lack of evidence, the GDG members judged that the desirable effects of wearing eye protection in combination with a medical mask would be moderate for infection of the HW (compared to wearing eye protection alone).

There was also no evidence for the effects of wearing eye protection in combination with a medical mask (compared to wearing eye protection alone) on the outcomes of PPE breaches and compliance and/or breaches (touching face) related to heat/humidity and comfort, human factors, health worker confidence. Despite the lack of evidence, the GDG judgement was that the undesirable effects of wearing eye protection in combination with a medical mask were small (compared to wearing eye protection alone).

On the balance of effects of benefits and harms, the GDG judged that it probably favours wearing a medical mask in combination with eye protection rather than wearing eye protection alone during triage.

Coverall versus gown.

The systematic review of evidence did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the outcome of infection with Ebola or Marburg. The desirable, anticipated effects of wearing a coverall (compared to wearing a gown) on infection of the HW were judged by the GDG to be moderate, despite lack of evidence.

There was no evidence for the undesirable effects of wearing a coverall (compared to wearing a gown) for the outcomes of PPE breaches and compliance related to heat and comfort, human factors, health and care worker confidence. The undesirable effects of wearing a coverall (compared to wearing a gown) were judged by the GDG to be moderate, despite lack of evidence.

On balance of effects, GDG members judged that it probably favoured wearing coveralls.

Two pairs of gloves versus one pair

The systematic review did not identify any evidence on the desirable effects of wearing two pairs of gloves compared to one pair of gloves for the outcome of infection with Ebola or Marburg virus.

None of these studies looked directly at transmission but looked instead at non-compliance and contamination as surrogate measures.

The GDG judged that, despite the lack of evidence, the desirable effects were large for wearing two gloves versus one pair of gloves.

The systematic review of the literature did not identify any adverse effects from PPE use for wearing two pairs of gloves versus one pair of gloves. A narrative study did identify some factors such as reduced dexterity and a cumbersome removal process of the PPE as disadvantages. Therefore, the GDG judged the undesirable effects of wearing two gloves versus one pair of gloves to be small.

GDG members judged that the balance of effects favours the use of two pairs of gloves.

Certainty of the Evidence

Very low

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any primary studies comparing the effects of wearing eye protection in combination with a medical mask to wearing eye protection alone. Two systematic reviews of potential interest were identified. While the reviews provided some contextual information, none of their included studies met the eligibility criteria. Therefore, the certainty of evidence was judged to be very low.

Coverall versus gown

The systematic review did not identify any primary studies comparing the effects of wearing a coverall versus a gown. Two systematic reviews of potential interest were identified. While the reviews provided some contextual information, none of the included studies met the eligibility criteria. Therefore the certainty of evidence was judged to be very low.

Two pairs versus one pair of gloves

No evidence was identified for direct outcomes. Evidence is based on surrogate outcomes from simulation studies and therefore is deemed very low certainty evidence.

Values and preferences

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone

The systematic review did not identify any evidence. However, the GDG judged that there was probably no important uncertainty or variability in how much people value the main outcomes.

Coverall versus gown.

The systematic review did not identify any evidence. However, the GDG members judged that there was possibly important uncertainty or variability in how much people value the main outcomes.

Two pair of gloves versus one pair

The main outcomes are transmission of Ebola or Marburg virus and adverse effects. GDG members judged that there is probably no important uncertainty or variability in how much people value the main outcomes. Glove type was not considered during GDG judgement.

Resources

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

Although the systematic review did not identify any evidence, the GDG judged that the utilization of a medical mask as well as eye protection involved moderate costs.

There were no included studies on cost effectiveness and therefore for this category no GDG judgement was made based on GDG polling results.

Coverall versus gown.

The GDG judged that there were moderate costs associated with wearing a coverall (compared to wearing a gown). Although no studies were presented on cost-effectiveness, GDG members judged that it probably favours coverall use.

Two pairs of gloves versus one pair
The systematic review found no relevant contextual data related to resource use.
The GDG discussed that the cost and resources depend on the type of gloves being used/recommended. The GDG judged that the use of two pairs of gloves was associated with moderate costs (compared with one pair) despite lack of evidence.

There were no included studies for the cost effectiveness of two pairs of gloves versus one pair. Nonetheless, the GDG judged that the cost effectiveness probably favours the use of two pairs of gloves given the high cost/impact of a possibly resulting Ebola or Marburg virus infection if no appropriate measure were used.

Equity

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone .

The systematic review did not identify any evidence and GDG members could not make a judgement on this factor.

Coverall versus gown.
The systematic review did not identify any evidence. However, GDG members judged that there was probably an increased impact on health equity with the use of a coverall compared to use of gowns as all HWs caring for patients with Ebola or Marburg disease would use the same PPE regardless of role, gender.

Two pairs of gloves versus one pair
The systematic review found no relevant contextual data related to equity. The GDG discussed that equity considerations include the size and fit of the gloves with two pairs of gloves versus one pair of gloves, as well as availability in remote areas and urban centres.

The GDG judged that health equity would probably be increased when using two pairs of gloves rather than one pair of gloves, despite lack of evidence.

Acceptability

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone

Although the systematic review did not identify any evidence, the GDG judged that wearing a medical mask as well as eye protection during the triage process was probably acceptable to the key stakeholders.

Coverall versus gown.
The systematic review did not identify any evidence. However, the GDG judged that coverall use was probably be acceptable to key stakeholders.

Two pair of gloves versus one pair
The systematic review found no relevant contextual data related to acceptability.
Despite this, the GDG judged that the use of two pairs of gloves was acceptable compared to one pair of gloves.

Feasibility

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

Although the systematic review did not identify any evidence, the GDG judged that it was probably feasible to implement wearing a medical mask and eye protection during the triage process.

Coverall versus gown.
The systematic review did not identify any evidence. However, coverall use was judged to be probably feasible by GDG members.

Two pair of gloves versus one pair.
One narrative review looked at the advantages and disadvantages of PPE used by health and care workers in high-risk settings, including Ebola disease outbreaks*[118]*. The review found that advantages of double gloves included: 1) decreases in the potential risk of transmission of highly virulent pathogens through glove holes or gloves damaged by disinfectants; 2) reduction in the risk of contamination of hands when removing gloves; 3) reduction in the risk of needlestick injury.

Disadvantages described in this review were 1) decreased tactile sensation and dexterity and 2) a cumbersome removal process.

The GDG judged that it was probably feasible to wear two pairs of gloves versus wearing one pair of gloves.

Justification

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: infection with *Ebolavirus* or *Marburgvirus*, PPE breaches, compliance and/or breaches (touching face) related to heat/humidity and comfort, human factors, health worker confidence.

Some GDG members noted that no studies demonstrated that the face shield designs conferred protection from droplets. Thus, extrapolating from analysis of dispersion of simulated spray from a cough (droplets) in SARS-CoV-2 and subsequent contamination indicated that no face shield provided adequate protection from droplets *[119]*. Protection of the health and care workers' nose and mouth (mucous membranes) may be insufficient with goggles/face shield alone.

As the risk of health-worker exposure to splashes or sprays (e.g. vomit or blood/body fluids) is likely higher during triage activities, the GDG judged that use of a medical mask in combination with eye protection was warranted.

Coverall versus gown

The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: infection with *Ebolavirus* or *Marburgvirus*, PPE breaches, compliance related to heat and comfort, human factors, health-worker confidence.

However, the GDG felt that, during triage, it would be difficult to maintain a 1-metre distance and the risk of exposure of health workers to blood or other body fluids may be higher than during screening activities. For this reason, it was felt that a coverall may be preferred over the use of a gown. However, this may be dependent upon the technical specifications and availability of the PPE.

Two pairs of gloves versus one pair
This PICO question was developed late in the GDG process, and many of the other PICO systematic reviews were done prior to this question being reviewed, and therefore this review was done as part of a secondary analysis of articles already identified from searches for other key questions.

The majority of the evidence and contextual data that were presented were simulation studies and were not likely to directly reflect real-world situations nor were they linked to any specific outbreak. Simulation studies do not assess such factors as stress, fear, heat and humidity. In discussing the simulation scenarios, the GDG noted that they may underestimate the risk

of self-contamination (given that psychological and environmental factors might alter the results) and overestimate risk of self-contamination (given that some studies have very high levels of "inoculum" of the simulated materials, which are unlikely to be encountered in clinical practice).

The GDG discussed the type of gloves used and the difference in quality based on the type of gloves selected (e.g. latex versus nitrile). It was also discussed that double gloves do not prevent needlestick injuries, but rather decrease the inoculum in cases where a needlestick occurs. It was also highlighted by GDG members that microbiological understanding of the amount of inoculum needed for *Ebolavirus* transmission to occur is lacking. Other key reasons for the selection of double gloves included the fact that gloves are not 100% impermeable, and the double-glove recommendation that currently exists is based on minimizing potential contamination during the PPE removal process.

The GDG noted that HWs may be uncomfortable with only one pair of gloves for a number of reasons: 1) if they must remove a pair of gloves while in a TC due to contamination, they may not have not have another pair available; 2) given that the principles of IPC call for removing the dirtiest piece of PPE first, (and that would typically be the gloves), HWs who were wearing only one pair of gloves would find that they were wearing no gloves at all when removing the rest of their PPE, and would therefore risk contamination.

Use of two pairs of gloves is important to the current IPC recommendations in TCs. It was discussed that glove use has two purposes, the first for the protection of the HW and the second for the protection of patients.
The fit and comfort of gloves were discussed and it was noted that it takes about a day for a clinician to become accustomed to wearing two pairs of gloves. An important consideration is having gloves that fit well and available in different sizes.

The GDG therefore judged in favour of a conditional recommendation for the use of two pairs of gloves when caring for suspect/confirmed cases of EBOD or MARD and when at least 1 metre of distance from the patient cannot be maintained.

Research Needs

For all elements of PPE individually and as an ensemble, simulation studies are needed to test different choices of PPE. Research is needed on PPE designs that are suitable to women and men, according to their size, anatomy and hygiene needs (including menstrual hygiene management for women health and care workers).

12.3 PPE for those providing direct and indirect care to patients

Several of these recommendations have been extracted from the 2016 *Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline* *[17]* and are labelled accordingly.

Below is a summary of PPE worn during contact* with patients with suspect or confirmed Ebola disease or Marburg disease:

- Scrubs
- Closed-toe shoes
- Two pairs of gloves (Nitrile)
- Medical mask in combination with eye protection (face shield or goggles)
- Coverall
- Head-and-neck covering. Note: eye protection (face shield or goggles should be worn under the head-and-neck covering)
- Apron (disposable or reusable)

*Contact refers to activities involving direct or indirect contact as described in the definition of contact transmission

Strong recommendation for , High certainty evidence

The mucous membranes of eyes, mouth and nose should be completely covered by PPE.

***Note: This recommendation is extracted verbatim from the 2016 Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline** [17].*

Practical Info

This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.

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.

Implementation Considerations:

- Training for health workers in appropriate size,
- Provisions for ensuring continuous availability of items for use,
- Protocol for reuse of items or waste disposal, as appropriate,
- WHO to develop recommendations for disposal.

Evidence To Decision

Benefits and harms

There was no comparative evidence available.

Certainty of the Evidence

High

Strong recommendation; high-quality evidence for protecting mucous membranes compared with no protection.

Justification

Protection of the mucous membranes of the eyes, nose and mouth is an integral part of standard and droplet precautions *[19][120][121]*. 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.

Strong recommendation for , Very low certainty evidence

Use either a face shield or goggles.

***Note: This recommendation is extracted verbatim from the 2016 Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline** [17].*

Practical Info

Applicability

This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.

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

Evidence To Decision

Benefits and harms

There was no comparative evidence or estimates of effectiveness available for benefits versus harms between a face shield or goggles.

Certainty of the Evidence

Very low

Strong recommendation; very low quality evidence comparing face shields and goggles.

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, seven had experience with face shields and 36 with goggles.

- Of those using goggles, eight (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.

Issues mentioned

The biggest problem with the goggles was fogging. Fogging may increase the risk of accidental exposure to the 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
- were of poor quality
- moved easily or slid off
- were difficult to wear 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.

Resources

In 2016:

- Average cost of goggles, US$ 4.30

- Average cost of disposable full-face shield, US$ 2.70

Acceptability

As noted in the survey, 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.

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?). It might be difficult to combine goggles with prescription glasses.

Justification

There is currently no scientific evidence on the comparative effectiveness of face shields and goggles for the prevention of filovirus transmission to health workers*[116]*. 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 *[36]*. 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 *[36]*. 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

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 Needs

Surveys of barriers to use, effectiveness studies comparing different products.

Strong recommendation for , Low certainty evidence

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).

Note: This recommendation is extracted verbatim from the 2016 Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline [17].

Practical Info

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 level2 or level 3, or equivalent.

Duckbill or pouch

Moulded or non-collapsible, with a half-sphere or cup shape

Evidence To Decision

Benefits and harms

There was no comparative evidence found or estimate of effectiveness for benefits and harms of medical mask (fluid resistant) versus particulate respirators (N95 or equivalent) with a structured design.

The survey conducted noted respondents found it hard to breathe when the mask or respirator was wet with condensation.

There was an impact on communication, both verbal and non-verbal.

Certainty of the Evidence

Low

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

Values and preferences

Literature review
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 face masks, 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.

Resources

Respirators, half-sphere, duckbill or folded (N95/FFP2), US$ 1.53
Mask, surgical with splash resistance, flat, rectangular with folds, US$ 0.01

Acceptability

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.

Feasibility

Feasibility, both in terms of availability and acceptability to users, needs to be considered.

Justification

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 or humid conditions, masks may become wet through respiration. 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.

Research Needs

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 *Ebolavirus*; can *Ebolavirus* be transmitted via airborne particles?

Strong recommendation for , Moderate certainty evidence

Use a fluid-resistant particulate respirator during procedures that generate aerosols of body fluids.

Note: This recommendation is extracted verbatim from the 2016 Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline [17].

Evidence To Decision

Certainty of the Evidence

Moderate

Justification

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*[122][123]*.

Conditional recommendation for , Very low certainty evidence

WHO **suggests** that health and care workers with contact with patients who have Ebola disease or Marburg disease wear:

- A medical mask in combination with eye protection[1] (versus wearing eye protection[1] alone)
- A fluid-resistant coverall (versus a fluid-resistant gown)
    - Head-and-neck covering (as part of their PPE in addition to covering their mucous membranes) if a gown is being used instead of a coverall
- Two pairs of gloves
- Either a disposable or reusable apron to cover the coverall (or gown, if used)

[1] Eye protection means the use of a face shield or goggles.

Remarks:

Coverall

- *Use of a coverall versus a gown may be dependent upon the type and specifications of PPE available.*

Head-and-neck covering

- *Groups more likely to benefit from covering head-and-neck skin in addition to covering mucous membranes include:*
    - *Those who do not have intact skin. Though Ebola is not transmitted via intact skin, the risk of transmission would increase with the presence of broken skin (which might not be obvious at the time) and may be climate-dependent (e.g. more common in areas of high humidity).*
    - *Individuals working in certain settings such as "wet areas" might have more of a need to cover head-and-neck skin in addition to mucous membranes if there is a risk of splashes/sprays.*
    - *Individuals who are not vaccinated against the circulating species (if a vaccine is available) may benefit from use, though data gaps exist on duration of protection from vaccine as well as from prior natural infection.*

Two pairs versus one pair of gloves

- *Although this is a conditional recommendation and the certainty of the evidence is very low, the GDG members did not cite any specific conditions where they would recommend one pair of gloves over two pairs of gloves.*
- *WHO guidance from 2016 included a strong recommendation in favor of the use of two pairs of gloves based on moderate-certainty evidence. A reassessment of the evidence resulted in a lower rating of the certainty, warranting a conditional recommendation.*

Disposable versus reusable apron

- *Choice of disposable or reusable apron depends on the ability to safely dispose of (disposable) or safely decontaminate (reusable) the used PPE.*

Practical Info

Implementation considerations:

Health and care workers should be trained on the use of PPE, including procedures for putting on and taking off PPE.

Health and care workers should conduct a risk assessment prior to conducting activities to determine PPE requirements; depending on symptoms and contact with the patient or the patient environment.

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

- Masks should be changed when wet. If an off-the-face design is not available, use of a respirator may be considered.
- Details on specifications of goggles or face shield can be found in the recommendation above on goggles and face shields.
- Anti-fog solution or alternatives to prevent fogging of goggles (e.g. soapy water) should be available for use.

Coverall versus gown.

- Use of a coverall versus a gown might be dependent upon PPE availability, including specifications of the available PPE (for example fluid resistance of the available gown or coverall).

Two pairs versus one pair of gloves

- Given that quality of gloves may vary in the field, ensuring correct glove selection (following standards and quality control) is important.
- Given that fatigue often results in an increased risk of making doffing errors, it is important that HWs be trained well and that they follow glove-use protocols consistently.
- Well-fitting gloves are important for comfort and ease of use; therefore, multiple glove sizes need to be available for different hand sizes. Loose, ill-fitting gloves are not optimal for inserting lines, etc.
- Glove length is also an important consideration and should follow PPE standards. In some situations, (e.g obstetrical), longer cuff lengths are required.
- The preferred glove type, based on previous guidance, is nitrile gloves as per the recommendation below.

Head-and-neck covering

- The decision to cover the head-and-neck skin in addition to covering mucous membranes should be based on a risk assessment.
  - Head-and-neck covering should be used if a gown is being worn (versus a coverall, which already includes a head-and-neck covering).
- When a coverall is used that covers the head and neck (most common type available), there is no need for an additional head-and-neck covering
- Ensure common practices are in place, including steps for putting on and taking off PPE, as well as PPE selection across team members, that allows for a contextual point-of-care risk assessment, but not an individual risk assessment.
- Training on how to use PPE appropriately, including choice of PPE and procedures for putting on and taking off PPE, should be provided to ensure that there is no variation in practice within the ETC.
- PPE should be available that is appropriate for people with certain hairstyles or beards or who wear headscarves.
- Different PPE exists in field settings; while most coveralls include head covering, some types of coveralls do not.
- In the field, some organizations have utilized two head coverings, i.e. a coverall hood in addition to an additional separate hood. This practice should be discouraged as it is unnecessary, provided the head covering is well fitted.
- Standard infection and prevention principles should always be followed.
- Educate health and care workers about when to cover the head-and-neck skin, as well as about the potential unintended effects of covering head-and-neck skin and ways to prevent and reduce these effects.

Disposable versus reusable apron

- It should be made clear that disposable aprons should be single-use only in order to keep these items from being reused.
- A disposable gown might be preferred for some patient-care activities whereas a reusable apron might be preferred when there is more heavy-duty contact or increased risk of exposure to splashes/sprays of body fluids (e.g. environmental cleaning, burials).
- Aprons should be changed between patients whenever possible or, at a minimum, when they are visibly soiled.

Evidence To Decision

Benefits and harms

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence for the effects of wearing eye protection in combination with a medical mask (compared to wearing eye protection alone) on infection with Ebola virus or Marburg virus. Despite the lack of

evidence, the GDG members judged that the desirable effects of wearing eye protection in combination with a medical mask would be moderate (compared to wearing eye protection alone).

There was also no evidence for the effects of wearing eye protection in combination with a medical mask (compared to wearing eye protection alone) on the outcomes of PPE breaches and compliance and/or breaches (touching face) related to heat/humidity and comfort, human factors, health worker confidence. GDG judgement was that the undesirable effects of wearing eye protection in combination with a medical mask were small (compared to wearing eye protection alone) despite the lack of evidence.

On the balance of effects of benefits and harm, the GDG judged that it probably favors wearing a medical mask in combination with eye protection rather than wearing eye protection alone during triage.

Coverall versus gown.
The systematic review of evidence did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the outcome of infection with Ebola or Marburg. The desirable effects of wearing a coverall (compared to wearing a gown) were judged by the GDG to be moderate despite the lack of evidence.
There was no evidence for the undesirable effects of wearing a coverall (compared to wearing a gown) for the outcomes of PPE breaches and compliance related to heat and comfort, human factors, health and care worker confidence. The undesirable effects of wearing a coverall (compared to wearing a gown) were judged by the GDG to be moderate, despite the lack of evidence.

On balance of effects, GDG members judged that it probably favoured wearing coveralls.

Two pair of gloves versus one pair
The systematic review did not identify any evidence on the desirable effects of wearing two pairs of gloves compared to one pair of gloves for the outcome of infection with Ebola or Marburg virus.
None of these studies looked directly at transmission but looked instead at non-compliance and contamination as surrogate measures.
The GDG judged that the desirable effects were large for wearing two gloves versus one pair of gloves.
The systematic review of the literature did not identify any adverse effects from PPE use for wearing two pairs of gloves versus one pair of gloves. A narrative study did identify some factors such as reduced dexterity and a cumbersome removal process of the PPE as disadvantages. Therefore, the GDG judged the undesirable effects of wearing two gloves versus one pair of gloves to be small.

GDG members judged that the balance of effects favours the use of two pairs of gloves.

Head-and-neck covering

Four comparative studies were included in the analysis that looked at heat stress, simulation contamination and deviations (human factors) *[124][125][126][127]*. No comparative studies provided direct information on the transmission or incidence of Ebola or Marburg virus disease related to the use of personal protective equipment (PPE) for head-and-neck skin protection.

Two non-randomized simulation studies addressed outcomes related to heat stress for health workers by comparing additional head/neck covering PPE (hoods) versus PPE ensembles with mucous-membrane covers alone and simulated various ambient conditions for West African countries *[124][125]*. Several heat-related outcomes were assessed and included time to reach critical core temperature, body surface skin temperature, heat sensation, discomfort, core temperature, skin temperature, heart rate, average sweat weight loss per hour, perceived exertion, breathing comfort, wetness with most heat-related outcomes being significantly worse in groups with the additional head-and-neck covering versus mucous-membrane covering alone.

Two crossover RCTs simulated contamination events (fluorescent solution applied to participants to simulate contamination of PPE during clinical activities) for HWs while removing PPE ensembles with and without additional neck covering *[126][127]*. These studies found that higher levels of contamination were generally observed in groups without head-and-neck coverage (i.e those using mucous-membrane protection alone in the absence of head-and-neck coverage). These RCTs also found that errors in PPE removal appear to be higher in the groups with more PPE equipment (covering of head and neck as well as mucous-membrane coverage), but this was inconsistent across the above-mentioned outcomes.

Based on review of the evidence, the GDG judged that desirable effects of covering the head-and-neck skin in addition to covering the mucous membranes were small, and that the corresponding undesirable effects were moderate.

On the balance of effects, the GDG judged that it probably favours covering the mucous membrane only (compared to also covering the head-and-neck skin). However, status quo in terms of current practice includes the head-and-neck skin coverage and stronger evidence is needed to change these practices.

Disposable versus reusable apron

No studies met the eligibility criteria to provide comparative data on disposable (e.g. biodegradeable) versus reusable types of aprons.

Contextual data were reviewed from several studies. In some settings, aprons were included with PPE to increase protection to the front of the wearer, as this was considered a high-risk area for exposure to splashes or spills and the zipper of a coverall may not be impermeable *[128]*.

Another study noted that plastic aprons had a higher chance of contaminating the environment than personal protective equipment such as a gown composed of water-resistant, non-woven material or a reusable cotton gown. Because plastic had the lowest water-absorbing properties, the droplets that cannot be absorbed by the surface of the plastic might then drop to the floor or spread to the surrounding area, which especially increased contamination *[129]*.

In a study in 2015, 22 commercial, single-use isolation gowns were tested for barrier and strength properties using American Society of Testing and Materials International ASTM (D5034, D5733, D1683, F1671) and American Association of Textile Chemists and Colorists (AATCC 42 and 127) test methods and the Association for the Advancement of Medical Instrumentation (AAMI) PB70 liquid barrier classification standard requirements [132]. Testing results demonstrated that there is a large variation in the barrier and strength properties of existing isolation gowns in the marketplace. It was also found that nine (41%) of the 22 tested isolation gowns failed to meet the AAMI PB70 requirements for the liquid barrier performance at the level specified by the manufacturer. The results support the use of aprons for additional protection.

A study of a convenience sample of 200 HWs in the United States of America found that HWs dispose of their PPE in a trash can in a health-care unit, and non-disposed PPE is laundered at home, which may expose family members to a health risk if proper precautions are not followed *[123]*.

The desirable effects of disposable over reusable aprons were judged to be small by the GDG members. The undesirable effects of disposable over reusable aprons were judged to be small by the majority of the GDG members. The GDG members judged that the balance of effects does not favour either disposable or reusable aprons.

Certainty of the Evidence

Very low

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any primary studies comparing the effects of wearing eye protection in combination with a medical mask to wearing eye protection alone. Although two systematic reviews of potential interest were identified, they provided only contextual information, and none of their included studies met the eligibility criteria. Therefore, the certainty of evidence was judged to be very low.

Coverall versus gown

The systematic review did not identify any primary studies comparing the effects of wearing a coverall versus a gown. Two systematic reviews of potential interest were identified. While the reviews provided some contextual information, none of the included studies met the eligibility criteria. Therefore, the certainty of evidence was judged to be very low.

Two pairs versus one pair of gloves

No evidence was identified for direct outcomes. Evidence is based on surrogate outcomes from simulation studies and therefore is deemed very low-certainty evidence.

Head-and-neck covering

No studies provided direct information on the transmission or incidence of Ebola disease or Marburg disease related to the use of personal protective equipment (PPE) for head-and-neck skin protection. Two simulation studies that addressed outcomes related to heat stress for health-care workers (HCW) putting on extra head/neck covering PPE (hoods were included) and two crossover, randomized, controlled trials that simulated contamination events for HCWs while taking off

PPE ensembles with and without neck covering.

Overall, the evidence for outcomes of those studies (heat tolerance, human factors and contamination during procedure to take off PPE), when evaluated using the GRADE process was judged to be very low.

Disposable versus reusable apron

There were no eligible studies. There are very limited data to support the choice between disposable andreusable types of aprons. The certainty of the evidence was judged to be very low.

Values and preferences

No substantial variability expected

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone

Although the systematic review did not identify any evidence, the GDG judged that there was probably no important uncertainty or variability in how much people value the main outcomes.

Coverall versus gown.
Although the systematic review did not identify any evidence, the GDG members judged that there was possibly important uncertainty or variability in how much people value the main outcome.

Two pairs versus one pair of gloves
For the main outcomes are transmission of Ebola or Marburg virus and adverse effects. GDG members judged that there is probably no important uncertainty or variability in how much people value the main outcomes. Glove type was not considered during GDG judgement.

Head-and-neck covering

Data from the mixed-methods study indicated that 90% of respondents highly valued the importance of reducing EVD transmission. Justification for the high value of this outcome included concerns related to the Ebola virus: highly infectious, high morbidity rate, high mortality rate; impact on health workers; protecting the community including family members and saving on countries' economies. Those respondents that felt that this outcome was less important (three respondents) indicated so because proper IPC measures can control the risk of transmission and vaccination was linked to decreased risk.

HW participants rated the importance of adverse events from PPE as follows: 38% thought it was critical; 28% thought it was important,;and 34% thought it was not important.

When assessing valuation of the outcomes of interest, 53% were more concerned about Ebola transmission than they were about adverse effects from PPE use and 47% were equally concerned. None of the participants was more concerned about adverse effects from PPE use than about Ebola transmission. The reason for being more concerned about Ebola transmission was the fact that infection with Ebola can be fatal and the adverse effects are less serious, preventable and can be managed.

The GDG judged that there were no important uncertainty or variability in how much people value the main outcomes.

Disposable versus reusable apron

The systematic review did not identify any evidence. It was judged by the majority of GDG members that there was probably no important uncertainty or variability in how much people value the main outcomes. As described above for the PPE elements, HW participants in the mixed-methods study were generally more concerned about Ebola transmission than adverse effects of PPE.

Resources

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

Although the systematic review did not identify any evidence, the GDG judged that the utilization of a medical mask as well as eye protection involved moderate costs.

There were no included studies on cost effectiveness and therefore no GDG judgement was made.

Coverall versus gown.

The GDG judged that there were moderate costs associated with wearing a coverall (compared to wearing a gown). Although no studies were presented on cost-effectiveness, GDG members judged that it probably favours coverall use.

Two pairs of gloves versus one pair
The systematic review found no relevant contextual data related to resource use.
The GDG discussed that the cost and resources depend on the type of gloves being used/recommended. The GDG judged that the use of two pairs of gloves was associated with moderate costs (compared with one pair).
There were no included studies for the cost effectiveness of two pairs of gloves versus one pair. Nonetheless, the GDG judged that the cost effectiveness probably favours the use of two pairs of gloves given the high cost/impact of a possibly resulting Ebola or Marburg virus infection if no appropriate measure were used.

Head-and-neck covering

Data from the mixed-methods study showed that, in terms of resources used, 49% of participants indicated that there was a larger cost or moderately larger cost when covering the head and neck as well as the mucous membranes versus mucous membranes alone. Cost implications will likely be more if the HWs use have a separate hood rather than a coverall, where the latter would cost less. Waste management costs might be increased with additional pieces of PPE (i.e. a hood).

The GDG judged that there were moderate costs associated with the use of head-and-neck coverings in addition to covering the mucous membranes (compared with covering only the mucous membranes).

Disposable versus reusable apron

Data from the mixed methods study indicated that 34% of participants felt that there were higher costs associated with using disposable/biodegradable aprons versus reusable aprons; 14% felt there were moderately larger costs; 14% stated there was negligible costs and savings; 5% stated there were moderately larger costs; and 12% stated there were larger savings. Six percent said it varied and 15% did not know. Reasons for larger/moderately larger costs included the facts that replenishing supplies is costly and requires logistics (such as finding a supplier); it generates more waste; and high-quality, disposable aprons are costly. Those who indicated there was a negligible difference in costs and savings stated so because the cost of disposable aprons is higher and larger quantities need to be purchased, but decontamination and drying of the reusable aprons is as costly and needs manpower to do so. HWs who indicated that there were larger savings/moderately larger savings viewed the cost per unit of re-usable aprons to be higher, and that disinfecting is costly. Some proposed that resource use would vary depending upon on the setting and the facility.

The GDG judged that disposable aprons required moderate costs as compared to reusable aprons.

Equity

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence and GDG members judged that they did not know the impact on equity.

Coverall versus gown.
The systematic review did not identify any evidence. However, the GDG members judged that there was probably an increased impact on health equity with the use of a coverall compared to use of gowns.

Two pairs of gloves versus one pair.
The systematic review found no relevant contextual data related to equity. The GDG discussed that equity considerations include the size and fit of the gloves with two pairs of gloves versus one pair of gloves, as well as availability in remote areas and urban centres.
The GDG judged that health equity would probably be increased when using two pairs of gloves rather than one pair of gloves.

Head-and-neck covering

Data from the mixed-methods study indicated that 25% of respondents were concerned about equity issues. Groups that might be affected include low-resource countries, rural areas, different types of health care providers, certain religious groups (who may have head coverings) and individuals with certain hairstyles (e.g. long hair, dreadlocks, etc.). Concerns were raised around low-resource countries, which might not have enough PPE.

The GDG judged that equity would be probably reduced for some groups when covering the head and neck in combination with covering mucous membranes (compared with covering only mucous membranes).

Disposable versus reusable apron

Data from the mixed-methods study showed that 16% of HWs felt that there were equity considerations with using disposable/biodegradable versus reusable aprons, while 64% felt there were none. An additional 20% did not know. Causes of inequity and groups identified to have reduced access included those in low-resource settings where supply can be a problem and where elimination methods such as incineration might not be available. It was also identified that the type of task (e.g. cleaning) might affect the type of disposable gown needed. Equity considerations might also include poor fit of existing PPE, and the fact that disposable PPE could be tripping hazards for some body types. Judgement by the GDG members on whether disposable aprons affected equity was that it varies, as there was a large distribution of votes.

Acceptability

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

Although the systematic review did not identify any evidence, the GDG judged that wearing a medical mask as well as eye protection during the triage process was probably acceptable to the key stakeholders.

Coverall versus gown.
Although the systematic review did not identify any evidence, coverall use was judged by the GDG to probably be acceptable to key stakeholders.

Two pairs of gloves versus one pair
The systematic review found no relevant contextual data related to acceptability.
The GDG judged that the use of two pairs of gloves was acceptable compared to one pair of gloves despite the lack of evidence.

Head-and-neck covering

Several studies *[36][124][130][131]* were reviewed that evaluated health and care workers' tolerance, comfort and preference while wearing head-and-neck coverings. In one study *[36]*, 64% of those surveyed found heat and dehydration to be a major issue when using a hood. Simulation studies conducted by Coca et al 2015 suggested that encapsulation of the head-and-neck region resulted in higher model-predicted, subjective impressions of heat sensation. Additional simulation studies conducted by Coca et al in 2017 *[124]* showed that heart rate and core temperature at the end of the exercise and perceptions of heat and exertion were significantly higher in individuals wearing goggles, coverall and separate hood or a highly impermeable coverall, separate hood and surgical mask cover over the N95 respirator compared to those wearing a face shield, no hood, and fluid-resistant surgical gown.

The data from the mixed-methods study showed that 72% of respondents said that it was more acceptable or probably more acceptable to cover the head and neck as well as the mucous membranes for reasons that included: increased sense of safety when protecting the mucous membrane; reduced risk of transmission through splashes into the mucous membrane; and reduced risk of transmission from other diseases. Individuals (8%) who found covering the head-and-neck skin was less acceptable or probably less acceptable cited reasons such as covering head and neck is not needed if the skin is intact, as the virus does not penetrate through intact skin and that covering the head and neck might scare the patient. Furthermore, covering the head and neck can interfere with patient communication and eventually impede the care. Seventeen percent responded that acceptability varied and risks should be evaluated based on the risk of transmission. If the HW is not performing an invasive procedure, head covers are unlikely to offer additional protection.

The GDG judged that covering the skin on the head and neck in addition to covering the mucous membranes was acceptable.

Disposable versus reusable apron

Contextual data on feasibility/acceptability included a simulation study of 50 participants that examined body and environmental contamination rates during the removal of cotton gowns, water-resistant gowns, or plastic aprons, based on the individuals' typical PPE-removal methods and gown-removal methods recommended by the CDC [References need to be added here]. Plastic aprons had a higher chance of contaminating the environment than did the cotton or water-resistant gowns and was thought to be due to the fact that plastic had the lowest water-absorbing properties and droplets were not absorbed by the surface and therefore might drop to the floor and spread to surrounding areas. The plastic apron resulted in a smaller protected area, which caused heavier contamination of the clothing under the apron. The conclusion of this study was that double gowns with an outer layer of absorbent cotton (to reduce spread of contaminants to the environment) and an inner water-repellent gown (which can resist contaminants and prevent penetration into the cloth underneath as well as skin), provided better protection than a single gown did in preventing contact with the patient's blood and body fluids during surgery and other splashing procedures. When using a Likert scale to look at PPE design in terms of body protection, such as fit, mobility, comfort, putting on and taking off PPE and aesthetics, HWs felt that the current PPE recommendations in the hospital (in the convenience sample of 200 HWs in the USA), which included scrubs, gowns, coveralls and apron met their needs for fit, comfort, mobility, putting on and taking off PPE.

Based on the data from the mixed-methods study, use of a disposable/biodegradable apron was considered less acceptable compared to use of a reusable apron by 7% of participants; probably less acceptable by 10%; probably more acceptable by 24%; and more acceptable by 44%. Thirteen percent felt that it varied and 3% did not know.

Reasons for the disposable/biodegradable apron being more acceptable/probably more acceptable included that it was safer, lighter and easier to manage. There were also concerns that reusable aprons increased the risk of exposure during cleaning; might not always be accessible; and could increase the risk of transmission if not handled or disinfected appropriately. Those who found it less acceptable/probably less acceptable indicated that the disposable/biodegradable aprons could tear and result in exposure of the HW to the virus. It was also indicated that it involved more resources and was not environmentally friendly or sustainable. Those who indicated it varied sald that the use might depend on the type of care the health worker was providing, direct versus indirect care, etc. For example, disposable aprons are more acceptable during clinical procedures without large bodily fluids; heavy-duty aprons would be more acceptable when handling large amounts of potentially infectious fluids, as commonly generated during environmental cleaning procedures. Another example included the assertion that a disposable apron would be more acceptable for indirect care, whereas heavy-duty aprons would be more acceptable for direct care.

GDG judgement indicated that the use of disposable aprons was probably acceptable.

Feasibility

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

Although the systematic review did not identify any evidence, the GDG judged that it was probably feasible to implement wearing a medical mask and eye protection during the triage process.

Coverall versus gown.
The systematic review did not identify any evidence. Coverall use was judged to be probably feasible by GDG members.

Two pairs versus one pair of gloves.
One narrative review looked at the advantages and disadvantages of PPE used by health and care workers in high-risk settings, including Ebola disease outbreaks. Stated advantages of double gloves included: 1) decreases in the potential risk of transmission of highly virulent pathogens through glove holes or gloves damaged by disinfectants; 2) reduction in the risk of contamination of hands when removing gloves; 3) reduction in the risk of needlestick injury.
Disadvantages described in this review were: 1) decreased tactile sensation and dexterity; and 2) a cumbersome removal process.
The GDG judged that it was probably feasible to wear two pairs of gloves versus wearing one pair of gloves.

Head-and-neck covering.

Zamora et al. 2006 *[127]* conducted a prospective, randomized, controlled crossover study to compare two PPE ensembles. The PPE ensemble E-RCP (enhance respiratory and contact precautions) included a head covering (without covering the

neck skin), goggles and a face shield. The PAPR system in use had outer and inner protective layers that included head-and-neck coverings. Participants wearing the E-RCP were more likely to have some contamination sites on the neck and hands. However, putting on and taking off the PAPR system took longer than putting on and removing E-RCP garments ($p < 0.0001$) and participants experienced more errors in the removal process. In a study done in an IPC unit in a tertiary-care hospital in Malta, the preferred option by participants was the use of a PAPR rather than goggles and an N95 due to the sense of protection and comfort it conferred. A review done at the Jewish General Hospital in Canada discussed the advantages and disadvantages of using a PAPR versus an N95. Advantages to the PAPR included providing head-and-neck protection that did not require fit testing and could be used by individuals with facial hair. They also allowed for continuous beside care of the patient. Disadvantages included difficulty in communicating while putting on the PAPR; the inability to use a stethoscope; and the requirement for batteries to ensure proper airflow rates in the hood*[132]*.

The data from the mixed-methods study indicated that 61% of participants found covering the head and neck to be more feasible/probably more feasible given that covering the head and neck is not perceived as a complicated process and can be done easily to give a sense of safety. Nineteen percent of participants found it to be less feasible/probably less feasible since donning and doffing takes more time, is more complicated and is costly. Seventeen percent responded that feasibility of covering the head and neck varied and noted that PPE choice might be different in HICs than in LMICs (e.g. PAPR is more commonly utilized in HICs).

The GDG judged that covering the skin on the head and neck in addition to covering the mucous membranes is probably feasible.

Disposable versus reusable apron.

Regarding feasibility, 10% of the mixed-methods survey respondents felt that it was less feasible to use disposable/biodegradable aprons, and 8% felt it was probably less feasible. Eighteen percent thought it was probably more feasible and 49% thought it was more feasible. Ten percent felt it varied, and 4% did not know. Reasons for it being probably more feasible/more feasible included that it was more practical than reuse because no cleaning and disinfection was used, and they are comfortable. There was also a consideration for weighing the risk of reusable versus disposable aprons in that reusable of aprons would result in more chlorine exposure and concern was noted that individuals (such as cleaners) may not be disinfecting the PPE properly. Respondents felt that the disposable/biodegradable aprons were more available and that the risk of Ebola transmission was reduced, given the concern for risk of contamination if reusable aprons are used.

Reasons for disposable/biodegradable aprons being less feasible/probably less feasible included that good-quality, disposable/biodegradable aprons cost more, which would make their use less feasible in aresource-limited setting. Those who stated that it varied indicated that this depended on the availability of waste management (which is costly and requires equipment) and is also related to HW risk, given that the disposable gowns could rip, are a source of waste, and pose a risk to waste collectors.

GDG judgement was that disposable aprons were probably feasible.

Justification

Eye protection alone (face shield or goggles) versus wearing a medical mask in combination with eye protection (face shield or goggles) alone.

The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: infection with Ebola or Marburg virus, PPE breaches, compliance and/or breaches (touching face) related to heat/humidity and comfort, human factors, health worker confidence.

Some GDG members noted that no studies have demonstrated that the face- shield designs conferred protection from droplets. Thus, extrapolation of an analysis of dispersion of simulated spray from a cough (droplets) in SARS- CoV-2 and subsequent contamination indicated that no face shield provided adequate protection from droplets *[133]*. Protection of the health workers' nose and mouth (mucous membranes) may be insufficient with goggles/face shield alone.

As the risk of health- worker exposure to splashes or sprays (e.g., vomit, blood) is likely higher during activities where there is contact with patients, the GDG judged that use of a medical mask in combination with eye protection was warranted.

Coverall versus gown.

The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: infection with Ebola or Marburg virus, PPE breaches, compliance related to heat and comfort, human factors, health- worker confidence.

However, the GDG felt that, during triage, it would be difficult to maintain a 1-metre distance and the risk of exposure of health workers to blood or body fluids may be higher than during screening activities. For this reason, it was felt that the use of a coverall may be preferred over the use of a gown. However, this may be dependent upon the technical specifications and availability of the PPE.

Two pairs versus one pair of gloves.

This PICO question was developed late in the GDG process, when many of the other PICO systematic reviews were already done. Therefore, this review was done as part of a secondary analysis of articles already identified from searches for other key questions.

The majority of the evidence and contextual data that were presented were simulation studies and are not likely to directly reflect real-world situations nor were they linked to any specific outbreak. Simulation studies do not assess such factors as stress, fear, heat and humidity. In discussing the simulation scenarios, the GDG noted that they may underestimate the risk of self-contamination (given that psychological and environmental factors might alter the results) and overestimate risk of self-contamination (given that some studies have very high levels of "inoculum" of the simulated materials, which are unlikely to be encountered in clinical practice).

The GDG discussed the type of gloves used and the difference in quality based on the type of gloves selected, e.g. latex versus nitrile. It was also clarified that double gloves do not prevent needlestick injuries, but rather decrease the inoculum in cases where a needlestick occurs. It was also highlighted that microbiological understanding of the amount of inoculum needed for Ebola virus transmission to occur is lacking. Other key reasons for the selection of double gloves included the fact that gloves are not 100% impermeable, and the double-glove recommendation that currently exists is based on minimizing potential contamination during the PPE removal process.

The GDG noted that HWs may be uncomfortable with only one pair of gloves for a number of reasons: 1) if they must remove a pair of gloves while in an ETC due to contamination, they may not have not have another pair available; 2) given that the principles of IPC call for removing the dirtiest piece of PPE first, (and that would typically be the gloves), HWs who were wearing only one pair of gloves would find that they were wearing no gloves at all when removing the rest of their PPE, and would therefore risk contamination.

Use of two pairs of gloves is important to the current IPC recommendations in ETCs. It was discussed that glove use has two purposes, the first for the protection of the HW and the second for the protection of patients.
The fit and comfort of gloves was discussed, and it was noted that it takes about a day for a clinician to become accustomed to wearing two pairs of gloves. An important consideration is having gloves that are well-fitting and available in different sizes.

The GDG therefore judged in favour of a conditional recommendation for the use of two pairs of gloves when caring for suspect/confirmed cases of EBOD or MARD.

Head-and-neck covering.

No studies provided direct information on the transmission or incidence of Ebola virus disease or Marburg virus disease related to the use of personal protective equipment (PPE) for head-and-neck skin protection. A review of existing WHO, US CDC, ECDC,*[17][134]* and US OSHA recommendations*[135]* on head-and-neck coverings helped provide contextual data to the GDG. The modes of transmission of Ebola virus and Marburg virus were discussed, with the GDG noting that transmission is primarily through contact with blood/body fluids. The skin provides a protective barrier from blood and other body fluids. However, HWs may have broken skin they may be unaware of.

The GDG also discussed the values and preferences of health workers, noting that 90% of respondents valued the importance of reducing EVD transmission. Justification for the high value of this outcome included concerns related to the Ebola virus: highly infectious, high morbidity rate, high mortality rate; impact on health workers; protecting the community, including family members, and saving countries' economies. The GDG judged that the use of a head covering was acceptable and probably feasible.

Considering the lack of direct evidence and the health worker perceptions, the GDG judged in favor of a conditional recommendation for the use of head-and-neck coverings, emphasizing the importance of health worker risk assessment, presence of intact skin and HW vaccination status. The status quo in terms of current practice includes the head-and-neck skin coverage and the GDG judged that stronger evidence is needed to change these practices.

Disposable versus reusable apron.

The systematic review did not identify any evidence for the effects of wearing a disposable/biodegradable apron (compared to wearing reusable apron) on the following outcomes: Infection with Ebola or Marburg, Environmental impact of single-use disposable PPE, Exposure while cleaning and disinfecting aprons, Breaches in cleaning and disinfection practice, PPE breaches.

Contextual data included the review of current WHO guidance, which indicates that a disposable, waterproof apron worn over the gown or coverall should be used. If disposable aprons are not available, heavy- duty, reusable waterproof aprons can be used if appropriate cleaning and disinfection between patients is performed. When removing reusable aprons over the head, care must be taken to not disrupt face shield/goggles/mask. The *WHO **Personal protective equipment for use in a filovirus disease outbreak** Rapid advice guidance* from 2016 *[17]* indicates that the choice of apron should be, in order of preference: 1) a disposable, waterproof apron; 2) if a disposable apron is not available, a heavy-duty, reusable waterproof apron, provided that it is appropriately cleaned and disinfected between patients.

The GDG reviewed a presentation by the WHO Supply Chain Technical Lead for Operations Support and Logistics that outlined the technical specifications of reusable versus disposable aprons. Aprons are not medical devices, and are not standardized. They maybe be considered PPE in some instances but generally are not seen as true PPE. Disposable versus reusable aprons are distinguished based on thickness. The minimum thickness for reusable aprons is 300 micrometers, and covering size is approximately 70-90cm width x 120-150cm length. The following document provides details on ***Preferred Product Characteristics for Personal Protective Equipment for the Health Worker on the Frontline Responding to Viral Hemorrhagic Fevers*in Tropical Climates*** *[114]*

GDG members noted that the rationale for wearing an apron over the gown or coverall is that the risk of splashes from the patients' vomiting, diarrhea or bleeding is high, and that it is easier to remove and replace a soiled apron than a gown or a coverall. There were some concerns noted that disposable aprons are "light" and health workers may not feel safe, in particular those, like burial teams, responsible for performing tasks that Involve heavy lifting. It was also noted that disposable aprons may cause an increase in waste disposal, which may have and an environmental impact .

The GDG judged that a conditional recommendation should be made and that the choice of the type of apron should be based upon the ability to safely dispose of the item; safely decontaminate the item;and carry out a risk assessment for the task to be performed.

The GDG noted that overall compatibility of different pieces of PPE used together should be considered, as there is a lack of safety data on combination PPE and effectiveness might decrease with non-compatible pieces of PPE.

Research Needs

- More evidence is needed about combined effect of PPE and evidence indicates that there might be harm with multiple pieces of PPE (heat, errors with doffing).
- There is a need for better standards and evidence on effectiveness and safety of different combinations of PPE.
- More research is needed on effectiveness and need for head-and-neck coverings.

Good practice statement

Cleaners/hygienists[1] and mortuary/burial workers[2] should wear the same PPE recommended for other health and care workers, with the exception that 1) the outer pair of gloves should be heavy-duty (utility) gloves; 2) aprons should be heavy duty; and 3) their shoes should be waterproof boots.

[1]Cleaners/hygienists includes health and care workers handling linens or waste, cleaning the environment.

[2] Mortuary/burial workers include health and care workers involved in handling dead bodies.

Practical Info

Implementation considerations:

Health and care workers should be trained on use of PPE, including procedures for putting on and taking off PPE.

For detailed implementation considerations refer to the conditional recommendation above on PPE for contact with patients with suspect or confirmed Ebola or Marburg disease.

Heavy-duty (utility) gloves

- The inner glove should be a nitrile glove and the outer glove a utility or heavy-duty glove
- If the outer utility glove is to be reused, then a process for decontamination must be put in place.
- The outer glove should be disinfected(using either soap and water, alcohol-based hand rub or a 0.05% chlorine solution) in

between environments and tasks. For example, outer glove disinfection should take place when moving from one patient environment to another.

Waterproof boots

For details on implementing the use of water proof boots please refer to the statement on footwear above.

Justification

The 2016 personal protective guideline specifically excluded health and care workers from roles such as hygienists, burial teams, waste management from the recommendations on PPE.

The GDG desire this to be a comprehensive document and therefore feel it is important to include all health and care workers in all roles. The GDG discussed the risk of exposure for health and care workers performing activities where they may have indirect contact with patients with Ebola disease or Marburg disease, or the contaminated environment, such as through collection of contaminated waste; handling of soiled linens; cleaning and disinfection of the environment; and assisting with the handling or burials of the deceased. It was agreed that health and care workers performing these activities are at equal risk to clinicians providing direct care.

The GDG agreed that the same level of protection should be required for health and care workers performing these activities. In addition, due to the nature and physical stresses of these activities, the GDG emphasized that the outer pair of gloves should be a heavy-duty, utility glove. In addition to a coverall (or gown), health and care workers should consider an apron and wear waterproof boots. The GDG agreed that a good practice statement was warranted.

Conditional recommendation for , Very low certainty evidence

WHO **suggests** that health and care workers with direct contact and/or indirect contact with patients with Ebola disease or Marburg disease wear eye protection (goggles or a face shield) **under** the head-and-neck covering versus over the head-and-neck covering.

Remarks:

- *As part of general IPC principles, removing the mucous-membrane protection last remains a key principle balanced against the risk of fogging and touching the eye protection unnecessarily as well as comfort and tolerance considerations.*
- *Certain types of eye protection may be better suited to be worn over the head-and-neck covering. Examples may include a face shield that, if worn under a coverall hood, may increase a person's risk of touching the face to adjust the PPE.*

Practical Info

Implementation considerations:

- Eye protection should remain in place as long as possible and be removed as late as possible, regardless of type of eye protection used (goggles or face shield).
- Staff should be trained in one system and stay consistent with those procedures as there would be an increased risk with variation in practice rather than consistency of practice. Posters and educational materials also need to be consistent.
- Aligning practices according to country MOH and what other partners are doing in the field is important to reduce confusion and variations in practices.
- PPE should to be put on and taken off properly and worn within time limits proposed for the PPE.
- Anti-fog solution or alternatives to prevent fogging of goggles (e.g. soapy water) should be available for use.
- When hood-and-neck covers are used, depending on the type used (e.g. hoods of different sizes/shapes), it might not be possible for the protection to be placed under the head-and-neck covering, and this should be taken into consideration when implementing recommendations for putting on and taking off PPE.
- There are other mitigation strategies that can be used if the eye protection is taken off earlier in the removal sequence.

Evidence To Decision

Benefits and harms

No studies found during the literature search described above provided direct information on transmission or incidence of Ebola disease or Marburg disease. Two crossover, randomized, controlled trials (RCTs) were included in the analysis and looked at outcomes related to contamination and deviation rates during the process for putting on and taking off PPE, based on the eye protection worn under the head-and-neck covering compared to eye protection worn over the head-and-neck covering *[136][126]*. In both studies, fluorescent solutions were applied to participants to simulate contamination of PPE during clinical activities. Outcomes assessed included levels of contamination following removal of PPE (small- and large-sized patches) on various areas (overall, hair and head, anterior/posterior neck) and the number of participants with patches. No clear pattern emerged for whether the head cover worn under or over the coverall resulted in greater contamination during the process of putting on or taking off PPE.

Data from two studies found that there was no clear pattern for whether the head cover worn under or over the coverall resulted in greater contamination during the process of putting on or taking off PPE *[126] [136]*.

One RCT looked at human factors by assessing deviation rates during the process of putting on or taking off PPE, depending on whether the eye protection was worn under or over the head-and-neck covering, and found that errors appeared to be higher among those wearing the eye protection (face shields) under the hood than over the hood. However, they were also wearing more PPE *[126]*.

The GDG judged that the desirable effects of goggles being worn under compared to over the head-and-neck skin covering were small and the undesirable effects of goggles being worn under compared to over the head-and-neck skin covering were also deemed to be small. On the balance of effects, the GDG judged that it probably favoured wearing the goggles **under** the head-and-neck skin covering rather than over the head-and-neck skin covering.

Certainty of the Evidence

Very low

No studies provided direct information on the transmission or incidence of Ebola disease (EBOD) or Marburg disease (MARD) related to the order in which eye protection and head-and-neck covering were worn. Two crossover, randomized, controlled trials simulated contamination events for health and care workers (HCWs); contamination was recorded during the process of putting on or taking off of Ebola personal protective equipment (PPE) ensembles with differing equipment and orders in which the eye protection (face shields) and head-and-neck coverings (hoods) were worn. Deviation rates from the protocols for putting on or taking off PPE were also noted. However, the studies were downrated following GRADE assessments due to study design (simulation studies), high risk of bias, limited participant size, and optimal information size threshold not met.

The evidence was judged to be of very low certainty.

Values and preferences

The GDG judged that there was probably no important uncertainty or variability in how much people value the main outcomes.

Resources

None of the participants of the online survey from the mixed-methods study indicated larger cost or moderate cost for wearing the eye protection under the head-and-neck skin covering. In all, 50% indicated a negligible difference in costs and savings, while 10% indicated there was a moderate or larger cost savings, and 20% did not know. All of the interview participants indicated that there was no difference. The reason for no difference mentioned by both survey and interview participants was that the same protection equipment is being used under and over. Survey participants who opted for more saving did so due to the fact that wearing eye protection under the head-and-neck skin covering may reduce the risk of transmission. The reason participants indicated that it varies was dependent on whether the eye protection could be reused.

The GDG judged that there were likely negligible costs and negligible savings regardless of if the goggles are worn under

versus over the head-and-neck skin covering.

There were no studies on cost effectiveness. However, the GDG judged that the cost effectiveness for goggles worn under versus over the head-and-neck skin covering does not favor either option.

Equity

Data from the mixed-methods study indicated that 12% of participants had some equity concerns; 52% had no equity concerns; and 36% did not know. Groups with reduced access identified during the survey included people who wear glasses or hearing aids, certain ethnicities (reverend sisters, Muslim women), women with long hair.

The GDG judged that wearing the goggles under the head-and-neck skin covering compared to over the head-and-neck skin covering had probably no impact on health equity.

Acceptability

Data from the mixed-methods study indicated that 12% of participants responded that wearing eye protection under head-and-neck skin covering was less acceptable and another 12% stated that it was probably less acceptable. Fourteen percent stated it was probably more acceptable; 35% stated that it was more acceptable; 14% indicated that it varied; and 14% did not know. Those 49% who stated that wearing eye protection under versus over the head-and-neck skin covering was more acceptable/probably more acceptable indicated so because it allowed for better protection to the mucous membranes and allowed for the eye protection to be removed last. Interview participants who viewed wearing eye protection under head-and-neck skin covering as less or probably less acceptable indicated that it might be uncomfortable, and that eye protection worn over head-and-neck skin covering was easy to remove. Those who indicated it varies believed that the acceptability might depend on what type of eye protection was used (face shield versus goggles) and availability of resources, such as anti-fog formulations. They also felt that either would be acceptable if there was consistency.

The GDG judged that there was equal acceptability between wearing the eye protection over or under the head-and-neck skin covering.

Feasibility

A non-comparative simulation study and consensus panel one in the UK provided contextual data on feasibility and reported no contamination event on a video exercise of wearing a unified PPE ensemble where a disposable full-face visor was worn over the hood *[137]*.

Forty-five percent of online survey participants from the mixed-methods study thought it was more feasible or probably more feasible to wear eye protection under versus over the head-and-neck covering; 35% thought it was less/probably less feasible; and 9% said it varied. Cited reasons for more feasible/probably more feasible by participants were because this is how they have been trained/is current practice for most and that it is easier. Reasons for being less feasible were adjustments to the face shield/goggles when they are under the hood can be challenging; distortion of shield when under the head covering, and unclear vision. For those who indicated varied, it was because feasibility depended on the type of eye protection used. They stated that the wearing of eye protection under the head-and-neck covering was more feasible for goggles and less feasible for the face shields.

The GDG judged that there was equal feasibility between wearing eye protection under or over the skin-and-neck covering.

Justification

Contextual data were considered by reviewing current WHO, US CDC and ECDC recommendations *[17][134][138]* Current WHO guidance to date has recommended that PPE that covers mucosa be removed as late as possible in the PPE removal process and that the eye protection should be used under the head-and-neck skin covering. In contrast, the US CDC and ECDC recommend that eye protection be put over the head-and-neck skin protection.

The initial PICO question discussed eye protection as a whole, which included goggles as well as face shields. There was a discussion on whether goggles and face shields are the same based on the data that came up during the qualitative study. It was

agreed to start recommendation development with the goggles and then discuss face shields separately and to then see if there are any other considerations that might make the type of eye protection different. GDG polling was done initially for goggles and then was repeated for face shields.

There was a prolonged discussion about whether a recommendation should indeed be made to wear the eye protection below or over the head-and-neck covering, including many of the implementation considerations. The recommendations made in 2014 were made without a systematic review of data. However, after the 2022 systematic review was done, the data provided **no evidence** to assist with response to this question. While there was a consideration and discussion to abstain from making a clear recommendation, this was balanced with the fact that recommendations are important for training, posters and other educational materials. There has also been a lot of experience with Ebola since the 2014 guidance was released.

A discussion of field experience, which included a variation of practice of either wearing eye protection under the head-and-neck skin protection (according to WHO guidelines) and other key field partners who use eye protection over the head-and-neck skin protection was undertaken during the GDG meeting.

Discussions about face shield were held separately, as it was felt that there were different considerations in using the face shield. These included the fact that, depending on the type of head-and-neck skin covering (e.g. hood), it might be difficult to put a face shield on underneath and that distortion of the face shield, which might affect vision and protection, could occur. The concept of having the eyes, nose and mouth covered until the end of the PPE removal process was agreed to apply regardless of the type of eye protection.

The GDG determined that the principle of protecting the mucous membranes of the eyes as long as possible was important and, as such, issued a conditional recommendation in favour of wearing eye protection under the head-and-neck covering, provided this was feasible with the PPE equipment available.

Research Needs

For all elements of PPE individually and as an ensemble, simulation studies are needed to test different choices of PPE.

Research is needed on PPE designs that are suitable to women and men, according to their size, anatomy and hygiene needs (including menstrual hygiene management for women health and care workers).

Standardization of products is important to ensure that they will fit under the head and neck skin covering safely.

Strong recommendation for , Moderate certainty evidence

Nitrile gloves are preferred over latex gloves.

***Note: This recommendation is extracted verbatim from the 2016 Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline** [17].*

Practical Info

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.

Evidence To Decision

Certainty of the Evidence

Moderate

Strong recommendation; moderate quality evidence on health worker tolerance of nitrile gloves compared with latex gloves.

Values and preferences

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.

Justification

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*[139][140]*. If nitrile gloves are not available, latex gloves may be used. Non-powdered gloves are preferred to powdered gloves.

Conditional recommendation for , Very low certainty evidence

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.

***Note: This recommendation is extracted verbatim from the 2016 Personal protective equipment for use in a filovirus disease outbreak - Rapid advice guideline** [17].*

Remarks

For details on the type of apron suggested, please see the recommendation for health and care workers with contact with patients who have Ebola or Marburg disease.

Practical Info

Applicability

This recommendation is applicable to health workers involved in caring for patients suffering from filovirus disease.

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: EN13795 high performance level, or AAMI level 3 performance, or equivalent; or • option 2: tested for resistance to bloodborne pathogen penetration: AAMIPB70 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 class3 exposure pressure, or equivalent; or • option 2: tested for resistance to bloodborne pathogen penetration: meets or exceeds ISO16604 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.

Evidence To Decision

Benefits and harms

There was no comparative evidence found or estimate of effectiveness for benefits and harms for use of disposable gown and apron versus disposable coverall and apron.

Certainty of the Evidence

Very low

Conditional recommendation; very low-quality evidence comparing gowns and coveralls.

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 combatting 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 gowns, including aprons, disposable aprons, and yellow hazardous material suits with thick aprons.
- 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.

Resources

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.

Justification

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 by the health worker. 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.

Implementation

- 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

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.

Research Needs

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.

Strong recommendation against , Very low certainty evidence

WHO recommends **against** the spraying of health and care workers who have direct or indirect contact with patients who have Ebola virus disease or Marburg virus disease during the process of taking off personal protective equipment.

Remarks:

- *Spraying refers to the use of disinfectants, such as chlorine products, throughout the PPE removal process.*

Practical Info

Implementation considerations:

- Ensure training and education is in place to ensure best practice and maintaining IPC principles, including hand hygiene and procedures for putting on and taking off PPE.
- Ensure that messaging around “no-spraying” of humans continues to be emphasized.
- The use of an apron over a gown or coverall may reduce contamination of PPE.
- HWs should leave the area if PPE is soiled or contaminated. PPE should be safely taken off following procedures and new PPE put on to re-enter the area.

Evidence To Decision

Benefits and harms

Two studies addressed the question: one non-randomized simulation study *[141]* and one retrospective cohort study of HWs *[142]*.

In the non-randomized, parallel group simulation study, which looked at extra glove sanitization with hypochlorite spray (n=5) versus ABHR (n=10) during a 16-step Ebola virus PPE-removal protocol, self-contamination with Phi6 and MS2 of inner gloves, hands, face or scrubs following the PPE-removal protocol was assessed as the main outcome of the study *[141]*. Results showed that there was no detectable transfer of Phi6 for any of the participants in either group (hypochlorite or ABHR). MS2 was detected on the inner gloves in 8/10 participants who used ABHR and in 0/5 of the inner gloves of participants who used hypochlorite spray. MS2 was not detected on any of the hands of participants who used ABHR, and was detected in 1/5 of the hands of participants who used the hypochlorite spray.

A retrospective cohort study of 268 participants who had responded to the 2014-2016 West Africa Ebola outbreak assessed Ebola virus IgG antibody levels and prior-exposure events *[142]*. This study collected information on PPE used, including if removal of PPE was performed with or without chlorine spray. While the study did report on outcomes, the data from this study were unreliable due to collinearity between use of spray and HW role. Almost all participants who reported performing clinical work used spray and almost all participants who did not use spray worked in the laboratory. The authors themselves indicated that the difference in the likelihood of exposure between these two occupational groups made it impossible to ascertain the independent effect of spraying PPE with chlorine.

Contextual data relevant for implementation did not evaluate spraying versus not-spraying. Instead, the researchers noted how PPE was removed *[143][144][145]*. One study looked at a PPE-removal protocol, the last step of which involved the HW stepping on a rubber disinfection mat and scraping the soles of the boots on the mat, as well as repeated washing of gloved hands in 0.5% chlorine, followed by rinsing the tap with the chlorinated water before turning off the tap *[143]*. HWs then stepped out of the chlorine bath/boot-spraying area and exited. The study found that the PPE worn maximized

dexterity and enabled personnel to work in hot temperatures (up to two hours), protected the mucosal membranes when removing the outer layers and, most relevant to the PICO question, minimized potential contamination of the PPE-removal area with infectious materials by reducing the requirement to spray PPE with hypochlorite.

A 2016 cross-sectional survey of 1550 volunteers (500 HWs, 550 Ebola survivors, 500 quarantined and asymptomatic Ebola contacts) who had been sprayed directly with chlorine *[145]* looked at both implementation and acceptability. Those without a history of direct chlorine spray exposure were excluded. Some participants (HWs and quarantined individuals) were present when the surrounding environment was sprayed because it was impossible for them to get away from a chlorine-free environment. This study found that 92% of HWs were sprayed when leaving the ETU, but 23.5% were also exposed when they were spraying others and 23.6% were present when others were being sprayed. Some participants described being sprayed in their own homes or when visiting community dwellings. Strength of the chlorine solution and volume (quantity) of the spray were not clear. Although the recommended chlorine strength was 0.5%, there was no way to establish the exact concentration of the mixture. Spraying continued until the persons were totally soaked and all visible organic material was washed away for each Ebola exposure. Adverse events in HWs were common, including 64% reporting chest conditions (cough, difficulty breathing, chest tightness, burning throat) and 48% reporting eye problems, including after a single chlorine exposure. Skin irritation was also common (33.6% of HWs) in those who were using chlorine for hand hygiene. Odds of chest symptoms, deterioration of eye and skin conditions increased in those who had multiple exposures to chlorine. Although PPE was worn in most instances of chlorine spraying, this was not always the case. While eye protection was reportedly “always” worn by most (82%), 14% had eye protection only sometimes, and 3% reported “never”. Skin protection consisting of gloves and coverall were “always” worn by >90% of HWs. Despite the use of PPE, some HWs experienced respiratory symptoms, suggesting that wearing PPE did not protect the HW from the adverse effects of chlorine.

The GDG judged that the desirable effects of not spraying (versus spraying) were trivial and the undesirable effects of spraying versus not-spraying were moderate. Overall, GDG judgement was to **not spray** health workers.

Certainty of the Evidence

Very low

Based on the Casanova 2016*[141]* study, the certainty of evidence comparing effects of hypochlorite spray and ABHR for prevention of Phi6 transfer due to indirectness and imprecision was very low. There was also low certainty of evidence that glove sanitization with hypochlorite prevented transfer of MS2 compared with ABHR due to indirectness and imprecision.

The Houlihan 2017 study*[142]* was also reviewed using GRADE and the certainty of evidence for the effectiveness of spraying PPE with chlorine prior to PPE- removal to risk of Ebola virus transmission was very low.

Values and preferences

No substantial variability expected

The mixed-methods study looked at the valuation of two main outcomes: *Ebolavirus* transmission and adverse effects of chlorine exposure. The large majority (90%) of respondents thought the *Ebolavirus* transmission outcome was critical. Adverse effects from chlorine exposure were deemed critical by 49% of respondents, important by 33% and less important by 18%. Those who felt it was critical/important cited reasons including the impact on HW and patient health; risk of misuse; contribution to environmental pollution; and increased risk of *Ebolavirus* transmission.

Independent of the intervention, looking at outcomes (transmission and adverse events), GDG members judged that there was probably no important uncertainty or variability with spraying versus not spraying of HWs during the PPE-removal process.

Resources

Data from the mixed-methods study regarding resource use for spraying versus not spraying of HWs during the PPE-removal process indicated that 26% stated that there was a larger cost (with spraying); 30% stated that there were moderately larger costs; 18% felt any costs or savings were negligible; 3% felt there was a moderately larger savings; and 6% thought there was a larger savings. Three percent (3%) felt it varied and 14% did not know.

Reasons for the larger/moderately larger costs for spraying versus non-spraying included the need for costly equipment and

higher cost (since more chlorine is needed for spraying, the human resource cost was higher and it was time-consuming). It was also mentioned that the costs to HWs of dealing with possible infections and adverse events were higher with spraying. Those who felt that there was negligible difference in costs and savings stated that not much disinfectant is needed to spray during the PPE removal process. Those who felt that there were larger or moderately larger savings with spraying stated that this was because spraying is less costly due to the benefits of avoiding infection.

The GDG judged that resource requirements for spraying versus not spraying were moderate. Although no cost-effectiveness studies were available, the GDG judged that it it was probably more cost effective to not spray.

Equity

The mixed-methods study revealed that 21% of participants felt there were equity concerns with spraying versus not spraying HWs, while 49% felt there were no equity concerns. Thirty percent did not know. Equity concerns for those with health challenges, certain job types (e.g. cleaners) and those with allergies were raised during this study.

GDG members judged that there was probably reduced equity for spraying. Groups identified for whom there could be reduced equity included cleaners and those with limited access to equipment needed for spraying.

Acceptability

No important issues with the recommended alternative

Data from the mixed-methods study showed that most respondents felt that chlorine spraying was less acceptable or probably less acceptable (43%), and 39% felt it was probably more acceptable/more acceptable to spray the HWs. Three percent felt it varied and 4% did not know. Reasons for spraying being less acceptable/probably less acceptable included the opinion that spraying could increase risk of transmission of *Ebolavirus* and harm the HCWs if mucous membranes were not properly protected; that it required more time and effort; and that, if removal of PPE is done correctly, there is no need to spray nor does this practice confer any additional benefit. The respondents who felt that spraying was more acceptable/ probably more acceptable felt that this practice gives a sense of safety and reduces the risk of transmission.

While the majority of GDG members voted that there was probably no acceptability for the intervention of spraying, some GDG members said that acceptability could vary in different locations. They noted that, in the DRC, where there had been prior training and where health and care workers and residents had been very accustomed to spraying, there might be decreased acceptability of not spraying. Further conversation indicated that revised training done more recently in DRC, where thousands of people underwent ministry-approved training, clearly supported not spraying in their protocols.

The GDG judged that it was probably not acceptable to spray HWs with chlorine.

Feasibility

The mixed-methods study showed that 39% of HWs felt spraying was less feasible; 17% felt spraying was probably less feasible; 11% felt spraying was probably more feasible; 27% felt it was more feasible; 3% said it varied, and 3% did not know.

Reasons that spraying was felt to be less feasible/probably less feasible were that it required more manpower, more technology, additional effort, more time, a dedicated area and that it had infrastructure challenges. The fact that spraying was easy to perform was the reason respondents felt spraying more feasible/probably more feasible. Those who felt the feasibility was varied said it depended on training.

Spraying HWs versus not spraying HWs was judged by the GDG to probably not be feasible.

Justification

Two studies met eligibility criteria and were included. One study only considered spraying of gloves with hypochlorite versus use of ABHR during the doffing process *[141]*. The second study did not include PPE removal methods in the analysis, as it was collinear with the health worker role. For example, almost all HWs in clinical roles were sprayed with chlorine and had assistance during the PPE-removal process whereas, almost all laboratory staff were not sprayed with chlorine and were not assisted during removal of PPE *[142]*. However, due to moderate - high risk of bias and due to indirectness, these studies were judged to

be very low certainty evidence. The GDG noted that the difference in the likelihood of exposure between these two occupational groups makes it impossible to analyze the independent effect of spraying the PPE with chlorine.

Contextual data were presented during the GDG meeting for review. The 2014 WHO guidance stated that ,considering its limitations, spraying should be used with caution, and spraying of people wearing PPE or street clothes and for the routine disinfection of rooms is not recommended. It also states that, if spraying chlorine solutions is utilized, staff should still maintain maximum attention while manipulating organic material, touching contaminated surfaces, and removing PPE, because these may still be contaminated by Ebola virus even after spraying. Other organizations such as the US CDC and the European CDC do not recommend spraying of the HW during PPE removal. MSF guidelines do still include spraying of HWs during the PPE-removal process. The chlorine spraying is done once at the beginning, immediately prior to PPE removal, and hand hygiene is performed during the remaining PPE-removal process.

The GDG discussed issues related to spraying of a human with chlorine and no clear rationale for doing so could be identified. Spraying with chlorine for PPE removal does not replace the need for hand hygiene at identified points during the PPE-removal procedure. The absence of meeting a contact time (as discussed in disinfection of surfaces recommendation) when spraying individuals with chlorine for removal of PPE was also discussed and, theoretically, would make the practice of spraying for PPE removal irrelevant. This may lead to a false sense of protection by the HW performing the PPE removal. It was noted by the GDG that adherence to PPE-removal protocols is of utmost importance.

Based on the very low certainty evidence for spraying of humans during PPE removal to reduce infection with *Ebolavirus* or *Marburgvirus*, and concerns regarding reported adverse events as a result of exposure to chlorine from spraying, the GDG felt that a strong recommendation was warranted against spraying of humans with chlorine *[145]*.

Research Needs

- Further study on other disinfectants that might be alternatives to using chlorine is needed
- Further study on effectiveness of spraying and consideration of other products, such as soap and water for spraying, may be useful
- More field studies on risks of self-contamination and subsequent exposure and infection risks during PPE-removal procedures is needed

13. Hand hygiene and glove disinfection recommendations

This section provides recommendations from existing guidance for hand hygiene practices to be performed by health and care workers providing care to or interacting with patients or their environment who are suspected/confirmed cases of filovirus infection: namely *Ebolavirus* or *Marburgvirus*. These recommendations are based upon the *Guideline on hand hygiene in health care in the context of filovirus disease outbreak response: rapid advice guideline [18]* and the *WHO guidelines on hand hygiene in health care [35]*. Additional literature reviews were conducted to address the issue of disinfection of gloves between patients when caring for suspected/probable/confirmed cases of Ebola disease or Marburg disease.

13.1 Hand hygiene

Strong recommendation for , High certainty evidence

WHO **recommends** performing hand hygiene by using either an alcohol-based hand rub or soap and running water, applying the correct technique recommended by WHO. Alcohol-based hand rubs should be made available at every point of care (at the entrance and within the isolation rooms/areas) and are the standard of care. If alcohol-based hand rubs are unavailable, hand hygiene should be performed with soap and running water whenever necessary. When hands are visibly soiled, hand hygiene should always be performed with soap and running water.

Note: This recommendation is extracted verbatim from the "Guideline on hand hygiene in health care in the context of filovirus disease outbreak response: rapid advice guideline, November 2014".

Practical Info

Implementation considerations

- Ensure staff are trained on appropriate techniques for hand rubbing and handwashing
- Resources should be available for staff/patients and visitors at designated areas and points of care (e.g., alcohol-based hand rub, stations/sinks with soap and water) to perform hand hygiene.
- Posters depicting proper technique for hand rubbing and handwashing should be available in identified areas such as screening and triage and patient-care areas.

Evidence To Decision

Certainty of the Evidence High

Justification

This first recommendation is based on the *WHO Guidelines on Hand Hygiene in Health Care [146]*. The preferred use of alcohol-based handrub for hand hygiene in health care is based on the following criteria for which evidence is provided in the WHO Guidelines and its related Summary *[35]*, namely:

- elimination of the majority of microorganisms (including viruses);
- the short time required for microbicidal activity (20 to 30 seconds) for ABHR versus soap and water (40 to 60 seconds);
- availability of the product at the point of care;
- better skin tolerability;
- there is no need for any particular infrastructure (clean water supply, washbasins, soap and hand towels).

Handwashing with soap and water is also considered highly effective at removing microbial contamination, although no specific data are available for filovirus. According to experts' consensus, handwashing with soap and water can be considered highly effective against enveloped viruses. The correct application technique and duration of the procedure are considered crucial to achieving the desired effect for both hand rubbing with an alcohol-based hand rub and handwashing with soap and water.

Strong recommendation for , High certainty evidence

In settings where bleach/chlorine solutions are currently used for hand hygiene, WHO **recommends** implementing a strategy to change to alcohol-based hand rub or soap and water.

Note: This recommendation is extracted verbatim from the "Guideline on hand hygiene in health care in the context of filovirus disease outbreak response: rapid advice guideline, November 2014".

Evidence To Decision

Certainty of the Evidence

High

Justification

This recommendation is based on the *WHO Guidelines on Hand Hygiene in Health Care*, which urge health-care administrators to provide access to a safe, continuous water supply to facilities to perform handwashing, and a readily accessible alcohol-based hand rub at the point of patient care *[35]*. The guidelines also urge national governments to make improved hand hygiene adherence a national priority and to consider providing a funded, coordinated implementation programme, while ensuring monitoring and long-term sustainability.

Conditional recommendation for , Very low certainty evidence

Bleach/chlorine solutions currently in use for hand hygiene and glove disinfection may be used in the interim period in emergency situations until alcohol-based hand rubs or soap and water become available.

Note: This recommendation is extracted from the "Guideline on hand hygiene in health care in the context of filovirus disease outbreak response: rapid advice guideline, November 2014".

Evidence To Decision

Benefits and harms

In terms of balancing benefits and harms, the conclusion is that the benefits outweigh the harms for the proposed recommendation.

Certainty of the Evidence

Very low

Very low-certainty evidence for the comparative efficacy of bleach/chlorine solutions compared with alcohol-based hand rub or soap and water, and very low-certainty evidence about tolerance to bleach or chlorine solutions for hand hygiene and glove disinfection.

Values and preferences

No substantial variability expected

No major variability is expected with respect to the values and preferences of health and care workers and the use of chlorine solutions for hand hygiene. It was highlighted, however, that alcohol-based hand rubs are generally preferred because they are better tolerated and produce much less skin barrier impairment than do any other means of hand antisepsis mentioned in the present guideline.

Justification

In 2014, when this recommendation was written, there was very limited evidence found to evaluate the efficacy of sodium hypochlorite (bleach/chlorine solutions) compared with other agents when used for hand hygiene or glove disinfection. No comparative study is available to show the efficacy of bleach/chlorine solutions in preventing the transmission of filovirus or other enveloped viruses to patients and health and care workers or in reducing the viral load on hands.

However, according to expert consensus, bleach/chlorine solutions with a concentration of 500 ppm sodium hypochlorite (0.05% chlorine solution) can be considered efficacious against filovirus, including when used for hand hygiene. Furthermore, available data indicate that, for hand hygiene efficacy, there is a link between bleach/chlorine solutions' concentration and contact time. A concentration of 0.05% chlorine solution applied for a minimum time of 40 seconds to 60 seconds until hands are dried is considered appropriate for hand-hygiene practices. To perform the correct technique, the same steps as for hand rubbing should be followed.

There is extremely limited evidence showing that bleach/chlorine solutions used for hand-hygiene purposes can cause skin irritation or lesions. There is no evidence that low concentrations of bleach/chlorine solutions used for hand hygiene cause respiratory irritation, other respiratory symptoms or asthma. However, respiratory symptoms are clearly reported and described in patients, health and care workers and other users as a consequence of exposure to bleach/chlorine solutions used for environmental decontamination. Finally, there is evidence for risk of irritative conjunctivitis as a result of exposure to bleach/chlorine solutions. Therefore, the experts concluded that the use of bleach/chlorine solutions at the concentrations currently used for hand hygiene (500 ppm sodium hypochlorite or a 0.05% chlorine solution) can be acceptable from a tolerability point of view, when other hand-hygiene agents are unavailable. However, in terms of adverse effects on the skin, alcohol-based hand rubs are considered the best option for hand hygiene. In addition, using chlorine is not advised for people with pre-existing skin conditions (e.g., contact dermatitis).

Although best IPC practices dictate that gloves should be changed between patients, in the specific context of EBOD outbreaks, the decontamination of gloves has been considered for the purpose of avoiding changing both pairs of gloves between patients within the isolation area, given the high risk of health and care workers' hand contamination with a patient's blood and/or other body fluids. Experts convened by WHO to develop recommendations on PPE to be used for the care of EBOD patients agreed that glove disinfection could help facilitate changing gloves safely while providing clinical care for patients with filovirus disease and/or when gloves become compromised. In these cases, a two-step procedure should be followed: 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 handrubs are preferred when disinfecting gloved hands. However, if these are unavailable, bleach/chlorine solutions are acceptable in the interim.

13.2 Glove disinfection

Conditional recommendation for , Very low certainty evidence

WHO **suggests** that health and care workers providing direct or indirect care to patients with Ebola disease or Marburg disease in health-care facilities, including Treatment Centres (TCs), **wash/disinfect the outer pair of gloves; remove the outer pair of gloves; wash/disinfect the inner pair of gloves; and then put on a new outer pair of gloves between patients** instead of:

- Washing and disinfecting the outer glove only or
- Washing and disinfecting the outer glove only, removing it and putting on a new outer glove.

Remarks

- *The decision on glove disinfection may be dependent upon availability of gloves.*

Practical Info

Implementation Considerations

- These recommendations apply to actions taken by the health and care worker between patients.
- Alcohol-based hand rub or soap and water are the recommended methods for hand hygiene and are the preferred methods for glove disinfection between patients.
- If chlorine solutions are used, regular testing of chlorine solutions should be in place to ensure they contain adequate chlorine concentration.
- Staff should be trained on the WHO *5 Moments for Hand Hygiene* and the recommended technique for hand cleaning (hand rubbing and hand washing).
- Hand-hygiene stations should be available in the screening and triage areas, areas for putting on and taking off PPE areas as well at points of care throughout health facilities and TCs.
- Posters for hand-hygiene moments and technique should be made available.

- When washing/disinfecting gloves, it is important to note that pathogens other than *Ebolavirus/Marburgvirus* can be transmitted, (e.g. HIV, HBV, HCV, etc.), and therefore glove reuse may still carry some risk.
- The setting (e.g. health-care facility versus TC) may affect the process for glove disinfection. In some settings (e.g. TCs), health and care workers may be reluctant to remove gloves or may have difficulty putting new outer gloves over inner gloves that may have become wet during decontamination with soap and water or chlorine solutions (0.05%) and may choose one of the alternate methods.

Evidence To Decision

Benefits and harms

Small net benefit, or little difference between alternatives

The systematic review did not identify any evidence that met the inclusion criteria. A simulation study looking at PPE-removal practices by Casanova et al 2018 *[147]* noted that, because gloves are repeatedly touching PPE during the removal process, even the use of ABHR on the outside of the gloves between removal steps may not completely prevent inner-glove contamination.

Three options were discussed:

Option A: Wash/disinfect the outer glove between patients.

Option B: Wash/disinfect the outer glove, remove it, and put on a new outer glove between patients.

Option C: Wash/disinfect the outer glove, remove it, wash/disinfect the inner glove and put on a new outer glove between patients. (From 2014 guidance and current standard of practice).

Two comparisons were discussed (Option A versus C, Option B versus C) with Option C being accepted as the current standard of practice. In terms of transmission, Option C focuses on the protection for the health and care worker and the patient, whereas Option A tends to favour only health and care worker protection rather than the protection of the patient.

The GDG judged that the desirable effects were small for Option A compared to Option C and trivial for Option B compared to Option C and that the undesirable effects were moderate for Option A and Option B when compared to Option C.

Overall, the GDG judged that the balance of effects favoured option C (wash/disinfect the outer glove, remove it, wash/disinfect the inner glove and put on a new outer glove between patients) over option A (wash/disinfect the outer glove between patients), and favoured Option C over Option B (wash/disinfect the outer glove, remove it, put on a new outer glove between patients). This was also in line with the 2014 WHO guidance and current practice.

Certainty of the Evidence

Very low

The certainty of evidence was deemed to be very low as the systematic review did not identify any evidence for the effects of the options on the following outcomes:

- Infection with *Ebolavirus* or *Marburgvirus*
- Adverse effects (e.g. dermatitis)
- PPE breaches
- Compliance

Values and preferences

No substantial variability expected

The data from the mixed-methods study indicated that 53% of participants were more concerned about Ebola or Marburg virus transmission than about adverse effects from PPE use, whereas 47% were equally concerned about Ebola or Marburg virus transmission and adverse effects from PPE use. HWs indicated that reducing the risk of transmission of the virus was a critical outcome, one that can be achieved only with proper implementation of IPC measures.

GDG members judged that there was probably no important variability or uncertainty in how much people value the main outcomes.

Resources

Most participants in the mixed-methods study indicated that Option C requires more resources.

The GDG judged that Option A (wash/disinfect the outer glove between patients) would result in moderate savings when compared to Option C (wash/disinfect the outer glove, remove it and wash/disinfect the inner glove and put on a new outer glove between patients), and that Option B (wash/disinfect the outer glove, remove it, put on a new outer glove between patients) would result in negligible cost or savings when compared to Option C.

There are no studies on cost effectiveness, but the GDG judged that cost effectiveness probably favours Option C (wash/disinfect the outer glove, remove it and wash/disinfect the inner glove and put on a new outer glove between patients) over Option A and Option B.

Equity

Intervention likely increases inequity

The qualitative data from the mixed-methods study showed that Option A and Option B have fewer equity concerns over Option C. Health and care workers in some LMICs may have insufficient access to hand hygiene facilities, including consistent water supply; in some areas, the supply and quality of gloves can be sources of inequities. In addition, those with sensitivities to ABHR or chlorine solution may be at a disadvantage using Option C.

The GDG also noted that that, with Option A, health and care workers might transmit infections to vulnerable groups (i.e. those who are sick).

The GDG judged that health equity would probably be reduced with Option A (wash/disinfect the outer glove between patients) compared to Option C (wash/disinfect the outer glove, remove it and wash/disinfect the inner glove and put on a new outer glove between patients), and that Option B (wash/disinfect the outer glove, remove it, put on a new outer glove between patients) would have probably no impact on health equity.

Acceptability

It was highlighted that Options A and B were not consistent with WHO's *My 5 Moments for Hand Hygiene [115]*. Option A would not be considered ideal when considering the risk of transmission of other pathogens (such as HIV).

The data from the mixed-methods study showed that 17% of participants found Option C acceptable while 44% indicated that removing both pairs of gloves, cleaning hands and putting on new gloves was acceptable. Those favouring this option indicated that this would be more acceptable as it reduces cross contamination among patients, conditional upon the inner glove not being contaminated. Some participants raised concerns over the time it takes to go through the process between patients. While 19% of participants responded that Option A was acceptable, the GDG noted this was not ideal and determined not to further consider this option, as it did not align with the WHO's *My 5 moments for hand hygiene.* Meanwhile, another 19% of participants indicated that Option B was acceptable.

Based on the mixed-methods study, HWs were in favour of removing outside gloves to protect patients and washing inner gloves to protect themselves from any potential risk of contamination due to poor integrity of the glove, However, they raised concerns over the feasibility of that option, since it can sometimes be a challenge to place a new outer glove over a wet inner glove and it can be time-consuming to do so in high-workload areas. The following points were raised during the GDG discussions about the different options and GDG members felt that not specifying a method of disinfection might affect the recommendations that have been made.

For Option C, the GDG noted that there was a risk of ripping the outer pair of gloves during removal; the group also discussed that there could be deleterious effects to the inner glove during the Option C disinfection process. The group noted further that, because this option is more time consuming, it might shorten the time available for patient care.

Although some of the participants indicated that washing the outer gloves alone would be acceptable, some suggested this would be acceptable as the default only for "low-soiling" events. Concerns were expressed over possible tears/rips of the inner glove when removing the outer glove and exposure of skin in an ETC setting if changing both gloves.

GDG members noted that patients are another key stakeholder to consider, as the different options have different impacts on them in terms of transmission risks. Hence, acceptability to patients might differ from acceptability to health and care workers.

Additionally, participants were asked about acceptability of different products for hand hygiene between patients who have Ebola disease or Marburg disease. In all, 45% of participants found ABHR to be acceptable; 34% found use of chlorine to be acceptable; and 21% found use of soap and water to be acceptable. Survey participants commented that ABHR is highly effective, less corrosive than chlorine, not as harsh on skin and very quick to use. Some indicated that use of soap and water should be the first choice if hands/gloves are visibly soiled, although, when using soap and water, splashing can occur and the method requires time for the hands to dry.

GDG members judged that Options A (wash/disinfect the outer glove between patients) and B (wash/disinfect the outer glove, remove it, put on a new outer glove between patients) are probably acceptable.

Feasibility

Intervention is likely difficult to implement

The qualitative data from the mixed-methods study showed that about half the study participants found Option A to be the most feasible of the choices presented.

Participants in the mixed-methods study indicated that keeping the inner glove is less wasteful, provided it is still intact; however, it is more time consuming, especially in high-workload areas. Participants also mentioned that this option would be the most feasible in settings where there is limited glove availability. Participants who rated Option B as the most feasible noted that, because the outer glove is often soiled, it will often need to be replaced.

In terms of feasibility of use of different products for glove disinfection/hand hygiene, 38% of survey participants found use of ABHR to be feasible; 37% found chlorine solutions to be feasible to implement; and 25% found soap and water to be feasible. Those who were in favour of soap and water indicated that it was their best option because it is typically readily available and the cheapest of the options, but there were concerns over possibly contaminating the water supply. Those in favour of ABHR indicated that it is easy to use, dries quickly, is portable, available, can be made locally, and does not require access to running water. Those in favour of chlorine stressed its effectiveness in killing the virus, however concerns were raised over chlorine's potentially adverse effects.

Some GDG members noted that, in large TCs with high volumes of patients, Options A or B would be more feasible than Option C.

Overall, the GDG judged that Option A (wash/disinfect the outer glove between patients) is feasible, and that option B (wash/disinfect the outer glove, remove it, put on a new outer glove between patients) is probably feasible.

Justification

Three key questions were examined in the systematic review done by the Knowledge Synthesis team:

1. Should health and care workers providing direct or indirect care to patients with Ebola or Marburg disease in ETCs or other health-care facilities wash their hands (soap and water) OR wash their gloves (soap and water) between patients?
2. Should health and care workers providing direct or indirect care to patients with Ebola or Marburg disease in ETCs or other health-care facilities disinfect their hands with ABHR OR disinfect their gloves with ABHR between patients?
3. Should health and care workers providing direct or indirect care to patients with Ebola or Marburg disease in ETCs or other health-care facilities disinfect their hands with chlorine OR disinfect their gloves with chlorine between patients?

These questions were then narrowed to the following options for discussion:

A. Wash and disinfect the outer glove between patients only
B. Wash and disinfect the outer glove, remove it, put on a new outer glove (between patients only)
C. Wash and disinfect the outer glove, remove it and wash/disinfect the inner glove, and put on a new outer glove between patients **(current guidance)**
D. Wash/disinfect the outer glove, remove both gloves, clean hands, put on new gloves, was removed from the options for consideration.

The GDG removed Option D from the discussion based on the mixed-methods study results and field experience, as they judged that HWs would not be comfortable having skin exposed while working with patients suspected of having or confirmed to have Ebola or Marburg disease in TCs and this option would not be considered acceptable.

The systematic review did not identify any evidence for the effects of any of the key questions or additional options on the following outcomes:

- Infection with *Ebolavirus* or *Marburgvirus*
- Adverse effects (e.g. dermatitis)
- PPE breaches
- Compliance

Given that Option C (wash/disinfect the outer glove, remove it and wash/disinfect the inner glove and put on a new outer glove between patients) is the current WHO recommendation, the GDG decided to retain this as an option to consider and noted that this would be used as the intervention arm during the process for evaluation of the EtD tables and development of the recommendation. The objectives of hand hygiene/glove disinfection between patients are twofold: to protect the health and care worker and to protect the patient.

The GDG extensively discussed the findings from the mixed-methods study. In light of the lack of evidence, these results and the experience of the GDG members weighed heavily in the decision-making. In particular, the GDG considered the values and preferences, for example, concerns regarding transmission of Ebola virus being higher than concerns about possible adverse events. The GDG also acknowledged that, while Option C may prove difficult to implement, it is acceptable to health and care workers.

A conditional recommendation was made, therefore, to uphold the existing 2014 guidance: wash/disinfect the outer pair of gloves; remove the outer pair of gloves and wash/disinfect the inner pair of gloves; and put on a new outer pair of gloves between patients.

Research Needs

- Testing of chlorine solution concentration in TCs as part of a research study
- Consideration of decontaminants/disinfectants like methylene blue that do not have the toxicity/corrosive effects that chlorine has
- Consideration of multiple different scenarios and disinfectant types on the different types of gloves that are aged and unaged, seeded with organisms Phi6 and MS2. Ultimate consideration to consider small-scale confirmation sampling with *Ebolavirus* rather than surrogates.
- Studies on different glove types (e.g. different biodegradable gloves, different thicknesses of gloves, etc.

14. Health and care worker exposures

Health and care worker exposure risks to *Ebolavirus* and *Marburgvirus*

Understanding health and care worker risk of exposure to *Ebolavirus* or *Marburgvirus* and the methods of classifying those occupational risks was identified as a key background question. The West African Ebola disease epidemic appears to have been the first outbreak during which researchers attempted to develop a risk-assessment algorithm for health workers.

During the West African outbreak, a substantial number of local health and care workers became infected with the EBV *[148][149]*, in contrast to international staff representing different organizations who were also potentially exposed but only a few of whom became infected. Studies of local health workers are difficult to interpret because community exposure cannot always be distinguished from workplace exposure in the absence of systematically gathered information that would enable stratification based on exposure risk. The disparities between expatriate health worker and national health worker infection rates may be due to inadequate personal protective equipment in impoverished health systems; inadequate infection prevention and control practices and protocols for routine health care in the context of an EBOD outbreak *[67]*; or community transmission of EBOD among national health and workers. Multiple studies have looked at rates of exposure among expatriate health workers in Ebola treatment units. While there were high rates of reported exposures (linked to breaches in protocols and inadequate or improper use of PPE), none of the participants in these studies developed evidence of Ebola virus infection (PCR or antibody), which further complicates efforts to make evidence-based algorithms for health worker exposure risks *[142][150]*.

In summary, there are no evidence-based risk assessment algorithms that can be used to classify levels of health worker exposure risk.

Good practice statement

Any health and care worker with an occupational exposure[1] to Ebola disease or Marburg disease should immediately be assessed for exposure risk, including other potential exposures (e.g. HIV, HBV, HCV), and managed accordingly.

[1]Occupational exposure: unprotected contact, including non-intact skin, percutaneous or muco-cutaneous exposure to blood, body fluids, secretions, or excretions, from a suspect or confirmed patient with Ebola disease or Marburg disease, or unprotected exposure to contaminated equipment or surfaces, that may result from or be related to the performance of an employee's duties*[151]*.

Practical Info

Implementation considerations:

- Facilities should undertake an assessment of health and care workers who have had an occupational exposure as a result of direct/indirect contact with a patient suspected of having or confirmed to have Ebola disease or Marburg disease.
- Instructions/SOPs for health workers who have an exposure, including those with percutaneous or muco-cutaneous exposure to blood, body fluids, secretions, or excretions from a patient with suspected or confirmed Ebola disease or Marburg disease should be available including:
  - immediately and safely stop any current tasks;
  - wash the affected skin surface immediately with soap and water (before leaving patient care area);
  - leave the patient care area, and safely remove PPE, then repeat washing the affected skin surface once doffing has been completed and occurs in a safer environment;
  - report the exposure to their immediate supervisor.
- All health workers should have an exposure assessment conducted by an occupational health or infection prevention and control focal point that that includes evaluation of the risk of level of exposure (non-exposure, low or high) and subsequent management.

Justification

The GDG considered WHO's existing guidance, ***Caring for those who care: guide for the development and implementation of occupational health and safety programmes for health workers***, noting the risks to health workers for several blood borne pathogens from workplace exposures (e.g. needle-sticks, blood splashes and cases of violence) *[152]*. The GDG determined that, while assessment of risks of an *Ebolavirus* or *Marburgvirus* exposure is essential to allow for possible vaccination of health workers (where applicable) or other treatments (where available), the ongoing risks associated with other bloodborne pathogens (e.g. HIV, HBV, HCV) should also be evaluated and managed according to established protocols.

Conditional recommendation for , Very low certainty evidence

WHO **suggests** health and care workers who have had an exposure to *Ebolavirus* or *Marburgvirus* be excluded from work for 21 days.

Remarks:

Exclusion is likely to be adopted when:

- *The health and care worker has not been previously vaccinated within the recommended time frame.*
- *The exposure is assessed to be a high risk for transmission.*
- *The health-care facility has adequate staffing available to provide health services if workers are excluded from work.*
- *There is a low risk of stigmatization for the health and care worker.*

Practical Info

Implementation considerations

- Health-care facilities that exclude health and care workers who have had an exposure at work should consider the following implementation measures:
  - conduct an assessment of the type of exposure
  - implement a process to monitor the health and care worker for symptom development
  - where resources (laboratory) exist, consider adding testing of exposed health and care workers to shorten the exclusion time frame
  - pay health and care workers who are excluded from work
  - offer community and health and care worker sensitization and engagement to reduce stigmatization
  - assess impact on equity
  - evaluate the situation - it may be dynamic and the number of workers might change throughout the outbreak
- The decision to exclude heath and care workers who have had an exposure to *Ebolavirus* or *Marburgvirus* needs to be flexible to adapt to the evolving situation of an outbreak and the operational considerations for health-service delivery.
- Date of exclusion of the HW should be 21 days from the last exposure to *Ebolavirus* or *Marburgvirus*.
  - For example, if the last date of exposure was January 1, then this would count as day = 0. Therefore, a full 21 days would be January 22 and the HW could return to work on January 23. If they were to develop symptoms during this period, they should be assessed fully by a medical provider (ideally at a TC) and their work exclusion would be extended if they were found to be infected with *Ebolavirus* or *Marburgvirus*.
- HWs who are excluded from work as a result of an exposure should self-quarantine and be followed daily.
- Exposed health workers should be provided instructions on self-monitoring for signs and symptoms of Ebola disease or Marburg disease infection for 21 days post exposure and instructed to seek immediate medical attention if symptoms develop.
- Vaccination should be offered where available (for health workers not already vaccinated) in accordance with current guidelines.

Evidence To Decision

Benefits and harms

The systematic review did not identify any evidence of the effects of exclusion from work (versus no exclusion) for the following outcomes: health-worker infections or health-care-associated transmission of the *Ebolavirus* or *Marburgvirus*.

Six studies provided information on occupational risks of Ebola virus acquisition and transmission*[153][154][155][156][157][158]* and two of these *[153][157]* provided additional information related to vaccination status of health and care workers (HWs).

GDG members noted that the desirable effect of excluding a health and care worker is to prevent onward transmission to other staff or patients. However, vaccination status of the health and care worker may have an impact in reducing this risk. In addition, risk of transmission may be less if the exposure was not high-risk.

Although the systematic review did not identify any evidence of harms for exclusion from work, GDG members noted that exclusion of health and care workers may lead to reduced staffing levels and difficulty for facilities to maintain health services to

the community. Depending upon the setting, some facilities may be able to mitigate staffing reductions, but others may not. Some health workers may face stigmatization within their communities if excluded from work. An additional undesirable effect may occur as health workers may not receive pay for their required time off, leaving a negative impact on the health and care worker.

Therefore, the GDG judged the benefits of exclusion to be small and harms to be variable, depending upon the context. On balance of effects, the GDG judged that it was probably in favor of not excluding HWs from work.

Certainty of the Evidence

Very low

Four studies *[154][155][156][158]*provided information on occupational risks of *Ebolavirus* acquisition and transmission and were included, as were two studies with information related to vaccination status. The certainty of evidence was judged to be very low.

Values and preferences

There was no evidence found through the systematic review. The GDG discussed how communities and health and care workers may experience the outcomes related to work exclusion (e.g. impact on care) versus avoiding onward transmission. However, the perception of the community also needs to be considered when making a decision to exclude health and care workers. The GDG judged that there is possibly important uncertainty or variability in this domain as it will be very dependent upon the context.

Resources

The systematic review did not identify any evidence on resources required. The GDG noted that costs of excluding health and care workers from work may include payment to the excluded staff member as well as to replacement staff. Health facilities may also have to take on the cost of monitoring the health worker. Support to health-care facilities through partners such as nongovernmental agencies may also have an impact on resources (e.g. availability of staff).

Resources required were judged by the GDG to be variable, depending upon the setting, while cost effectiveness would probably favor not excluding the health and care worker.

Equity

There was no evidence found through the systematic review. However, the GDG noted that issues of equity may be very subjective, depending upon the size of the outbreak, the health-care services available and the number of potentially excluded health and care workers. Equity may be different for the patient versus the health worker or health-care system. There was a concern that, with potentially reduced staffing, certain health services could be limited, leading to an equity issue. For example, health workers excluded may be those who work in high-risk areas such as labour and delivery services leading to limited access to health care for women who are pregnant.

The GDG judged that the impact on equity is variable.

Acceptability

The systematic review did not find any evidence on acceptability. The GDG discussed that health worker and community support for the decision is essential and will be context-specific and, therefore, their judgement was that it varies. Engagement with social mobilization and a strategy for community acceptance for either exclusion or no exclusion will be essential. The GDG judged that the acceptability of work exclusion is variable.

Feasibility

The systematic review did not find any evidence on feasibility. The GDG noted that the ability to exclude health workers will be dependent upon availability of replacement staff. The capacity to pay health workers excluded from work also needs to be considered. The GDG judged that work exclusion is probably feasible.

Justification

The systematic review did not find any evidence to support the practice of health-worker exclusion versus no exclusion from work after an exposure to *Ebolavirus* or *Marburgvirus*. There were also very limited data to support the practice of identifying health workers' risk of infection as a result of exposure based upon various patient-care activities. It is challenging to match risk-assessment data (e.g. odds-ratio estimates of seropositivity) with the prescribed care activities. It was noted in studies that vaccination of health workers may eliminate the risk of Ebola virus (EBOV) acquisition among health workers *[67][159]*.

The GDG judged that work exclusion (up to 21 days) of health and care workers exposed to *Ebolavirus* or *Marburgvirus* may protect staff and patients. However, vaccination status of the health and care worker should be evaluated. Resources and ability to continue to provide health services to the community were identified as important considerations.

Based on the very low certainty evidence and the variability of factors such as acceptability, feasibility, resources, health worker vaccination status, etc., the GDG determined a conditional recommendation to be appropriate.

Research Needs

- The GDG members noted that the issue of whether to exclude health and care workers from work after an exposure to *Ebolavirus* or *Marburgvirus*, and an evidence-based process to determine risk according to exposure have been identified as gaps for several years.
- There is a clear absence of data to stratify exposure risk (e.g. screening involves minimal contact versus a needlestick injury).
- The impact of vaccination as post-exposure prophylaxis needs further evaluation.
- Research protocols to address these gaps, including data collection tools, are needed.

15. Environmental cleaning and disinfection recommendations

Evidence was derived from experimental studies that have assessed the survivability of the viruses in a variety of controlled conditions as well as from real-world environmental audits. Fewer studies exist for *Marburgvirus* than for *Ebolavirus*. Many of the studies are descriptive and the experimental studies are subject to limitations of the control conditions in which the studies were carried out. Findings of the review are described below.

Survivability of *Ebolavirus* and *Marburgvirus* in the environment and on surfaces.

- *Ebolavirus* and *Marburgvirus* have similar survivability, thus recommendations for disinfection practices can be applied to both viruses *[79]*.
- Viruses on nonporous surfaces (e.g. steel, plastic, Tyvek[1]) have similar survivability times and longer survivability than on porous surfaces (e.g. cotton gowns). *Ebolavirus* has been shown to survive up to 365 hours (more than 15 days) on nonporous surfaces in a low-humidity, 22-degree Celsius setting. The decay rates of EBOV are dependent on the fluid matrix (e.g. vomit, faeces, blood) and the environment (e.g. temperature, humidity), not on the surface itself *[160][161][162]*.
- *Ebolavirus* survives longer in low-humidity, low-temperature settings (generally different from African settings) *[162]*.
- *Ebolavirus* has been shown to survive in wastewater; although viable virus concentrations rapidly diminish after 24 hours, the virus may be recovered for up to eight days. Standard levels of chlorine used for water disinfection inactivate *Ebolavirus* in wastewater *[163]*.
- *Ebolavirus* survival is significant in dried blood; the virus has been shown to survive for up to 16 days in a dried organic substance on a nonporous surface *[162]*.
- In real-world studies, Ebola virus RNA has been found only on visibly soiled surfaces and in the immediate vicinity of patients. Disinfection practices are generally effective in such cases *[68][69][164][165][166][167][168]*.

Six studies were found that report the results of environmental audits, during which high- and low-risk surfaces from Ebola treatment units were swabbed and tested for the presence of viral RNA and, in some cases, culturable virus *[68][69][164][165][166][167][168]*. Ebola virus was recovered only from areas in the immediate vicinity of patients or from visibly soiled surfaces. While Youkee et al. *[164]* suggested that some viral RNA may have been displaced in the process of cleaning (as the bedframe was found to harbour viral RNA only after a routine cleaning, not before), these studies suggest that, while EBOV may survive for an extended period of time on surfaces, current disinfection procedures are generally effective. All of these studies are descriptive, with limitations that have potential biases, and the experimental studies are subject to the limitations of the assays and the controlled conditions in which they are carried out. Discrepancies in the implications of the findings from the experimental studies (which suggest potentially weeks-long survivability of *Ebolavirus*) versus the real-world studies (which suggest that disinfection protocols are effective and that *Ebolavirus* is unlikely to be found outside of direct patient-care areas) suggest an urgent need for further high-quality research.

Effectiveness of hypochlorite and contact time

Evidence was sought to determine the chlorine concentration and contact time required to disinfect materials or surfaces contaminated with *Ebolavirus* or *Marburgvirus*. A number of experimental studies were reviewed, and all had limitations, such as low validity (e.g. limited applicability in real-world settings) and issues with the study methodology. Some real-world studies found a low risk of recoverable, infectious virus after routine disinfection protocols and several studies corroborated the efficacy of 0.5% chlorine disinfection. A summary of findings is below:

- 0.5% hypochlorite solutions (1000 ppm of available chlorine (avCL)) are effective for surface disinfection *[160][169][170][171]*.
- On nonporous, contaminated surfaces without visible spills, 10 minutes of contact time is consistently effective *[170][169][172]*.
- For surfaces with visible spills, complete disinfection can be achieved by covering the spill with a paper towel or cloth and pouring hypochlorite solution of 0.5% on it and then allowing 15 minutes of contact time *[160][169]*.
- The use of peracetic acid on dried spills should be considered but needs further investigation *[172]*.

No evidence was found for the required frequency of cleaning and disinfection of horizontal surfaces in facilities providing care to patients infected with *Ebolavirus* or *Marburgvirus*. However, indirect evidence suggests indications for cleaning and disinfection immediately after a patient discharge and whenever there is visible contamination of surfaces with blood or body fluids *[68]*.

1 Tyvek is a registered brand of synthetic, flashspun, high-density polyethylene fibers; **Tyvek**® is breathable, yet resistant to water, abrasion, bacterial penetration and aging*[173]*.

15.1 Environmental cleaning and disinfection

Conditional recommendation for , Very low certainty evidence

WHO **suggests** disinfecting **surfaces** in health-care facilities, TCs, isolation centers or community settings providing care to patients with Ebola disease or Marburg disease using the **wiping** method over the **spraying** method.

Remarks:

- *The surface type (porous versus non-porous) likely affects the ability to achieve appropriate contact time. For non-porous surfaces there might not be a difference in wiping versus spraying, whereas in porous areas spraying might be more effective, though data for Ebolavirus are lacking (see research gap).*
- *Although the most common product used for environmental cleaning in the field is chlorine, a variety of other products can be used for disinfection that are considered efficacious and less corrosive.*
- *The quality of wiping and the capacity to do this properly and with adequate contact time is important to ensure appropriate film is created over the surface of whatever is being wiped. This concept is also applicable to spraying.*

Practical Info

Implementation considerations:

- An example of a list of products approved as disinfectants for Ebola virus and viruses that cause other emerging infectious diseases can be found on the U.S. Environmental Protection Agency website *[175]*.
- IPC principles of cleaning (to remove the organic load) prior to disinfection is a core principle in order to reduce the organic load before disinfection.
- Dead-body management is not covered in this recommendation but is covered the section on Safe management of dead bodies.
- A key IPC principle is that, in health-facility settings, non-porous surfaces are recommended. But community settings are less likely to be able to control for non-porous surfaces and, therefore, porous surfaces could be more common (e.g. dirt or wood surfaces, cloths and uncovered mattresses, etc.).
- In areas that need disinfection, cleaners should focus on high-priority/high-touch surfaces (e.g. door knobs, beds, chairs) and patient-contact areas. For example, if there are areas such as a surface of an ambulance where no person or body fluid contact may occur, disinfection of this area would be a lower priority or not required.
- Visibly soiled surfaces require cleaning followed by disinfection as part of general IPC principles.
- Spraying when there are people (patients) in the area was not advised, since it may not always be feasible to remove all patients from a location where spraying is occurring.
- Contact time (the time that the surface is wet with the product e.g. chlorine) is a key concept regardless of what method is being used (spraying versus wiping). Enough product must be applied to create a “film” of disinfectant on the surface.
- If using chlorine for a disinfectant, consider the following concentrations:
  - 0.5% chlorine solution for a contact time of 10 min for general, non-porous surfaces;
  - 0.5% chlorine solution for 15-minute contact time for blood/body fluid spills.
- Training is encouraged on how to achieve adequate chlorine concentrations as well as education on the fact that higher chlorine concentrations than required can actually cause harm.
- Spraying of chlorine can cause corrosive damage to materials in the area and may result in items being exposed to chlorine other than those intended.
- In situations where spraying is done, a low-pressure spray should be utilized in order to help reduce the risk of aerosol generation.
  - If spraying is conducted, those who are conducting the spraying need to be properly protected with PPE and have received training on the technique.
- This recommendation relates to patient-care areas, including home (community) and other health-care settings, including ambulances, etc.

Evidence To Decision

Benefits and harms

The systematic review did not identify any studies that met the eligibility criteria for the effects of spraying surfaces (compared to wiping surfaces) on the outcome of infection with Ebola or Marburg nor for adverse events.

Contextual data was also reviewed based on a total of 10 studies identified during the study selection process.

A systematic review was conducted that looked at chlorine-based surface disinfection efficacy to inform recommendations for low-resource outbreak settings *[174]*. Because disinfection is often combined with cleaning procedures, wiping was investigated and was found to have an effect on viruses and spores in the absence of disinfectant use, suggesting that the mechanical action of wiping contributes to reducing contamination levels of surfaces.

The same study also compared wiping and spraying and results showed similar efficacies against *C.difficile* (bacterial) spores, though spraying was considered less appropriate for health-care settings as it required extended drying times and would not remove dirt and debris *[174]*.

An experimental study looked at the efficacy of disinfectants to prevent emerging infectious disease transmission *[176]*. The results suggest that: (1) surface type influenced disinfection efficacy; (2) chlorine type and soil load did not affect disinfection efficacy when using 0.5% chlorine; (3) contact time did affect efficacy against Phi6; and (4) wiping or covering did not increase disinfection efficacy, but the latter could limit splashing. The authors suggest that surface cleaning with 0.5% chlorine solutions with a 15-min exposure time is efficacious in reducing transmission risk.

GDG judgement was that the desirable effects of spraying versus wiping as it relates to transmission were small.

The systematic review did not identify any evidence for the effects of spraying surfaces (compared to wiping surfaces) for the outcome of adverse effects of the use of disinfectants. A judgement by the GDG members on the undesirable effects of spraying versus wiping was deemed to be moderate. Some of the undesirable effects included the risk of droplet and aerosol formation when spraying and thereby inadvertent exposure to the health workers; perceived lack of respect for the dead body by family members/community members; as well as inhalation risk to those spraying or in the area where the spraying is taking place.

The balance of discussion compared the above benefits and harms, the GDG members judgement probably favours wiping (rather than spraying).

Certainty of the Evidence

Very low

The certainty of the evidence was found to be very low.

Values and preferences

Substantial variability is expected or uncertain

Data from the mixed-methods study found that 82% of health workers considered adverse events related to chlorine exposure as critical (49%) or important (33%), and 90% felt that *Ebolavirus* transmission was a critical outcome.

The GDG judged that there was important or possibly important uncertainty or variability in how much people value the risk of Ebola transmission and adverse effects of the intervention. It was noted that patients are more concerned about adverse effects; however, the HWs are more concerned about transmission, rather than the adverse effects of the chlorine.

Resources

Based on data from the mixed-methods study, 17% of respondents felt there was a larger cost; 25% a moderately large cos; 32% a negligible difference in costs and savings; 14% stated there was a larger savings/moderately larger savings; and 5% stated that it varies. Seventeen (17%) did not know.

The rationale stated by the participants for the larger/moderate costs was that spraying requires specialized device and technique, more disinfectant and more manpower. Rationale for the negligible difference in costs/savings was that spraying requires little time and a pump and the product, while wiping requires buckets, clothes and other products as well. Those who thought that there was a larger cost savings/moderate large savings for spraying indicated that wiping was more expensive, given the materials and human resources needed, as spraying can reach anywhere.

There is a huge cost effect on metals since those materials are no longer usable due to corrosion and destruction of the equipment and that wiping takes more personnel.

The GDG judged that there was a moderate cost associated with spraying.

Equity

Data from the mixed-methods study found that, regarding equity, 59% of participants said there were no equity issues and 17% said they're were; the rest did not know. The reasons for equity concerns cited by the participants included low-resource settings, individuals with respiratory issues and those who cannot stand the smell of disinfectants.

Equity issues stated by participants in the study included low-resource settings, affordability of spraying materials and cleaners (particularly if there was a misconception that higher concentration of chlorine is better). There was a concern that cleaners/hygienists do not get to negotiate their working conditions.

Some felt that equity could be reduced in particular depending upon the socioeconomic status in terms of affordability of products. Individuals with respiratory issues and those who can't stand the smell of disinfectant could face reduced equity by spraying versus wiping.

The GDG judged that there is probably reduced equity for spraying versus wiping.

Acceptability

The mixed-methods study showed that, for spraying versus wiping, 67% of HWs said it was less acceptable/probably less acceptable. Seven percentstated it was probably more acceptable and 18% said it was more acceptable; 7% said it varied and 1% did not know. Those who said it was more acceptable/probably more acceptable stated this was because it was more effective and more reassuring since it increases the coverage of the surfaces and penetration of cracks; would help cover heavily soiled areas; and the equipment used for wiping could be a source of contamination. Reasons for the spraying versus wiping on surfaces being less acceptable/probably less acceptable included that it increases the risk of aerosol production; that spraying might miss spots, and that wiping was generally more effective at “physically” removing the virus, reaching surfaces, and that it causes disinfectant to stay longer on the surface.Those who stated it varied indicated they did not like spraying, given the risk of breathing in the disinfectant and possible infection. They also stated that the danger to the sprayers is less if they stay back and spray from farther away, but added that it could be harmful for people in the area.

This decision is made in a variety of settings so might not necessarily be in the absence of other patients. GDG judgement indicated that the acceptability of spraying varies. Acceptability of spraying might be better if no people are around when spraying is occurring so there isn’t a risk of inadvertent exposure. Points were raised that patients would typically prefer wiping, but that hygienists would prefer spraying.

Feasibility

The mixed-methods study data regarding spraying versus wiping surfaces found that 31% said it was less feasible; 10% probably less feasible; 18% probably more feasible; 31% more feasible; 7% said it varied; and 1% said they did not know.

Reasons stated for more feasible/probably more feasible included the fact that a sprayer does not need cloth/wipe; the procedure is easy to perform; requires less energy and less time; can be done at a distance; and is adaptable to all surfaces, even non-cement floors .

Those who thought it less feasible/probably less feasible noted that wipes are easily stored and used, and that wiping takes less time and is more economical.

Those who stated it varied indicated that it depended on the surface and the equipment, time available for decontamination as well as training.

The GDG judged that it is probably feasible to conduct wiping but added that sustainability is also an important consideration to remember within feasibility.

Justification

The systematic review did not identify any evidence for the effects of spraying surfaces (compared to wiping surfaces) on the

following outcomes of Infection with *Ebolavirus* or *Marburgvirus*.

Current infection prevention and control standard practices for environmental cleaning and disinfection are to wipe surfaces with soap and water, rinse with clean water, then apply disinfectant for required contact time. The contact time between the disinfectant and the entirety of the surface is important and it is critical that the surface remains wet for the required contact time of the disinfectant used. Ensuring contact between disinfectant and test organisms can be challenging with spraying. In addition, chlorine loss during spraying − from spray nozzle to the targeted surface − is a concern, especially in light of the fact that the type of spraying used is typically low-pressure.

A systematic review of chlorine-based surface disinfection efficacy to inform recommendations for low-resource outbreak settings found that, because disinfection is often combined with cleaning procedures, wiping was investigated and was found to have an effect on viruses and spores even in absence of disinfectant, suggesting that the mechanical action of wiping contributes to reducing contamination levels on surfaces *[174]*.

Results of an experimental study to test the efficacy of disinfectants to prevent emerging infectious disease transmission suggested that: (1) surface type influenced disinfection efficacy; (2) chlorine type and soil load did not affect disinfection efficacy when using 0.5% chlorine; (3) contact time did affect efficacy against Phi6; and (4) wiping or covering did not increase disinfection efficacy, but the latter could limit splashing *[176]*. The authors suggest that surface cleaning with 0.5% chlorine solutions with a 15-min exposure time is efficacious in reducing transmission risk.

As no data were found on the efficacy of wiping compared to spraying for any disinfection agent, the GDG based its decision upon accepted standard environmental cleaning and disinfection practices while considering that the balance of benefits and harms probably favours wiping over spraying and that health workers indicated they find wiping more acceptable. It was noted that a false sense of security can also occur with the act of spraying with chlorine.

The GDG acknowledged that, in some settings such as in ambulances, it is hard to wipe all surfaces. However, the focus should be on high-touch areas, i.e. on surfaces/areas that are in contact with the patient and not on surfaces/areas that are not frequently touched or exposed (i.e. the ceiling of an ambulance). Wiping would be required for removal of any organic matter and spraying chlorine may provide better access to difficult-to-reach surfaces and surfaces that are challenging to wipe.

Research Needs

- Better surrogates are needed in the lab for organic material (e.g. vomit, etc.) surrogates, to better simulate the field, given that the ASTM lab standards are not indicative of what is occurring in the field.
- Consideration for continuous decontamination of PPE.
- Is spraying better in achieving a better film than wiping? How do they compare when considering different surfaces (porous versus non-porous)?
- Although there are data for other pathogens and Phi6, data on the effect of surface type (porous surfaces versus non-porous surfaces) and superiority of spraying versus wiping for *Ebolavirus/Marburgvirus* are lacking.
- Field data are needed to support laboratory data with key outcomes of *Ebolavirus/Marburgvirus* transmission and if this is a risk with current disinfection protocols and disinfection methods (spraying vs wiping).
- Even when virus is found on surfaces in lab data, it is not clear whether this is associated with transmissibility.
- Research into other products as alternatives to chlorine should be conducted.

15.2 Linen and laundry

Providing a safe method for decontaminating linen/laundry, mainly those items that may be heavily soiled with blood or body fluids of individuals infected with Ebola virus or Marburg virus, presents unique challenges, primarily in LMICs. In most HICs, methods such as machine washing and/or autoclave technology reduce the handling required to clean linens, thereby providing safer methods for their decontamination and reuse. In many LMICs, however, where outbreaks of Ebola or Marburg tend to occur, these technologies are restricted or not available. In such cases, the capacity to safely decontaminate these items in health facilities, TCs and community settings is limited.

Current disinfection practices, in particular the use of chlorine, differ widely among organizations that provide support to countries experiencing these outbreaks. The background question, "Should chlorine with 0.05% or with 0.10% concentration be used for low-temperature laundry (manual or mechanical)?" was developed and a rapid evidence search was undertaken as described in the Methods section. No direct evidence was found. One laboratory study that tested disinfection characteristics of Ebola virus variants found that, with 0.05% chlorine, a three log10 TCID50/ml of virus was still recovered even after 10 minutes of contact. It could therefore be inferred that 0.05% chlorine may not be effective for low-temperature laundry *[160]*. Some disinfectant activity and less virus detected with the use of 0.10% chlorine and 0.50% chlorine for 10-minute contact was described. However, real-world studies are needed to confirm the presence of virus upon decontamination of laundry with different disinfectants, different

concentrations and different methods, including machine washing versus handwashing.

Conditional recommendation for , Very low certainty evidence

WHO **suggests** that heavily soiled linens resulting from care of patients with Ebola disease or Marburg disease in health-care facilities, TCs or community settings be safely disposed of (e.g. incinerated rather than disinfected/decontaminated) following existing WHO guidelines on waste management.

Remarks:

- *This recommendation is conditional due to very low certainty of evidence rather than specific conditions where reuse would be appropriate.*
- *Depending on the degree of soilage (e.g. if the mattress is not visibly soiled and is of nonporous material), disinfection/ decontamination might be considered in the community setting.*
- *In situations where the cost to replace destroyed items is high, disinfection/decontamination via other methods (such as desiccation with ultraviolet (UV) light, etc.) might be considered.*
- *Engagement with community or family members is essential prior to determining if items such as mattresses will be disposed of or decontaminated.*

Practical Info

Implementation considerations:

- Though incineration is the ideal method of elimination, various methods for elimination can be considered and should follow existing WASH recommendations *[184]*.
  - Cost of some elimination methods (e.g. incinerators) is high and may not be available at all sites.
- In community settings, items deemed as "waste," e.g soiled linens that are to be eliminated, should be marked as infectious waste, and transported for elimination to a treatment facility/appropriate elimination facility with the capacity for this.
  - Open burning using burn-pits in the community settings should be discouraged.
  - The disposal of the incinerated material should follow WASH processes.
  - A conversation should be held with sensitivity towards the family whose items are being eliminated, as stigma can occur even if waste elimination is occurring away from the community.
  - Materials that have been eliminated should be replaced.
  - Final elimination of soiled linens should take place at a designated facility (whether at a health-care facility or elsewhere) by trained health workers and not at the home/community site itself.
- In health-care settings and TCs, a risk assessment should be conducted to determine if soiled linens can be safely decontaminated (safely handled, washed and disinfected by machine or by hand) or if they should be eliminated.
  - Staff should have access to the required PPE for handling soiled linens for patients suspected/confirmed to have *Ebolavirus* or *Marburgvirus*.
  - Training of health and care workers should include how to handle, wash and disinfect linens, how to use PPE appropriately and how to perform hand hygiene.
  - Linen/laundry should be washed and then disinfected.
- Other items such as non-linen items, e.g. cell phones and other personal items, might be appropriate for disinfection/ decontamination.

Evidence To Decision

Benefits and harms

The systematic review did not identify any evidence for the effects of elimination of heavily soiled linen (compared to disinfection) on the outcomes of infection with *Ebolavirus* or *Marburgvirus* or adverse effects of disinfectants.

Contextual data were presented and included six studies that looked at implementation of current practices for disinfection/ decontamination of heavily soiled/highly contaminated waste from *Ebolavirus* or Lassa fever patients*[177] [144][178][179] [180][181]*. A hazard-analysis study identified waste products from the care of patients with Ebola disease and found that collection, transportation, cleaning and shared use of blood-soiled fomites and the use of latrines contaminated with blood and bloodied faeces appeared to be associated with particularly high levels of risk of

Ebolavirus transmission *[177]*. Most moderate levels of risk were associated with the collection and transportation of material contaminated with body fluids other than blood, shared use of latrines soiled with such fluids, the cleaning and shared use of fomites soiled with such fluids, and contamination of the environment during the collection and transportation of blood-contaminated waste.

In a description of the Johns Hopkins biocontainment and treatment unit, autoclave protocols were developed and validated through a rigorous process that used biological indicators embedded within mock patient trash loads*[180]*. This ensured that effective killing of organisms was achieved in solid trash, liquid waste and soiled linens. Items that were reused on the unit were transported into a room off the waste-handling area, where they underwent disinfection with a hydrogen peroxide vapor system. This system also decontaminated the patient-care area after discharge. A subsequent validation study by the same author was conducted on autoclave protocols for successful decontamination of category-A medical waste generated from the care of patients with serious communicable diseases *[181]*. This study found the most difficult loads to sterilize were those containing saturated linens (soaked with 1 liter of water) comprising a cotton blanket, sheets, pillowcases, which required a vacuum cycle of at least 60 minutes to achieve adequate sterilization using settings as described for dry waste. One hundred percent of the nine runs containing multiple saturated linens and using a shorter sterilizing time (three runs each of 1, 30 and 45 minutes) failed. While autoclave sterilization may be an effective and safe way to process infectious waste for transport for disposal, this study shows that factory-default settings and laboratory-waste guidelines are likely to be insufficient to adequately sterilize pathogens in the center of medical waste autoclave loads.

The undesirable effects of elimination versus disinfection including potential toxicity of fumes to the community and stigma/shame (regardless of where the elimination process is taking place) were judged to be moderate by the GDG.

Although there were limited data, on review of contextual data, the GDG judged that the desirable effects of elimination compared to disinfection was thought to be large.

Certainty of the Evidence

Very low

No studies met the eligibility criteria. The majority of studies excluded at the full-text were excluded because they were non-comparative studies that did not compare outcomes for incineration vs. disinfection of heavily soiled linens. The GDG judged the certainty of evidence to be very low.

Values and preferences

There were no direct data presented from the mixed-methods study on values and preferences. The GDG judged that there was probably no uncertainty/variability.

Resources

Based on the data from the mixed-methods study regarding incineration versus disinfection of heavily soiled linens, 37% felt that there was a larger cost associated with incineration; 19% thought there was a moderately larger cost; 12% said it there was a negligible difference in cost and savings; 20% indicated there was a moderately larger savings or larger savings. Seven percent stated it varied and 6% did not know. In the in-depth interview, the respondents stated that the reasons for larger/moderately costs included cost is high for equipment needed for incineration, electricity, and needs high technical expertise. There was also a need to replenish the supplies during incineration. No data are available for those who felt there was a negligible difference in cost and savings. Reasons for larger savings/moderately larger savings included more reagents/water/chemicals would be required to disinfect the linens. Those who stated that it varies said they did so because it was difficult to evaluate the costs and that this might depend on the extent of the contamination of the linen.

The GDG judged that there were moderate costs for elimination versus disinfection/decontamination.

Equity

The mixed-methods study showed that 20% of participants felt that there were equity concerns when comparing

incineration versus disinfection of heavily soiled linen. Fifty percent felt there were no equity concerns and 30% did not know. Reasons for equity concerns included groups in low-resource settings where incinerators may not be available.

Pros and cons of equity effects were discussed. GDG discussion included considerations that elimination of soiled linens improves equity across genders, as washing of linens would likely decrease equity as often this is not done by men.

Another consideration is that when linens in the home(community setting) are eliminated this can result in inequity. The environmental impact where the elimination is occurring might result in equity issues. In addition, funds for the system for elimination might be taken from other areas. The stigmatization when elimination is done in the community on site can affect the families directly but also the overall public health response due to fear.

Overall, the GDG judged that the effect on equity varied.

Acceptability

Data from the mixed-methods study indicated that 25% found incineration versus disinfection of heavily soiled linen to be less acceptable; 10% probably less acceptable; 17% probably more acceptable; and 42% more acceptable. Six percent stated that it varies. For the respondents who stated it was more/probably more acceptable to incinerate, reasons given included that it reduces transmission;reusing linen is difficult; and there could be a risk of exposure to the laundry staff. It was also indicated that disinfecting linen is very difficult and that incineration was easier.

The reasons stated for incineration being less acceptable included that this resulted in a waste of linen, a need to replace linens, and that the virus can be killed with disinfection. The risk to the community of incineration and the implementation and challenges associated with it were also cited in the qualitative study. Reasons that the acceptability varies included consideration for the facility policies, the incinerator capacity, availability of new linens and cost.

The acceptability of elimination versus disinfection/decontamination for stakeholders (community members, patients, families and HWs) probably did affect acceptability. Acceptability concerns included risk of stigma associated with burning in the community. The GDG judged that the acceptability might depend on which stakeholder is being asked.

Feasibility

The mixed-methods study showed that 20% of HWs stated incineration was less feasible than disinfection; 9% thought it was probably less feasible; 21% stated it was probably more feasible; and 37% said it was more feasible. Ten percent felt that it varied and 3% did not know. The reasons given for incineration being more feasible/probably more feasible (58% of survey, 5 interviewees) included that it likely reduces transmission and risk of exposure; it requires less effort as it is easier to burn linens than to wash them; and it would do away with any risk that linens are not disinfected properly.

Some of the 29% of survey respondents who felt it was less feasible stated that, in some settings, incinerators are not available; they cost money to run and consume resources; they cause pollution; and there is a risk of contamination.

Reasons cited by the 10% of survey respondents and one interviewee who stated that the feasibility varies included facility polices and limited availability of new linen.

The feasibility of elimination versus disinfection/decontamination, which includes things like pooling of incineration, transport to incineration facilities, etc. was thought to be probably favourable by the GDG .

Justification

There was no evidence found. Contextual data were reviewed and included the current 2014 WHO guidance, which provides procedures for low-temperature machine washing. In these guidelines, washing by hand is not recommended. However, procedures were provided as it was recognized that washing by hand may the only option available in many LMICs. The use of 0.05% chlorine for 15-minute contact time was advised for disinfection. Contextual data from MSF guidelines found from the *MSF 2008 Filovirus Haemorrhagic Fever (FHF) Guideline – IPC practices in Ebola/Marburg outbreaks[182]*, based on “lessons learned” from Ebola disease outbreaks in 2007 in DRC and Uganda were reviewed. However, GDG members representing MSF noted that, with the current MSF recommendations, anything in the TC would be destroyed since cleaning/disinfecting is time-consuming and disinfection cannot be guaranteed. Disinfection of linens is sometimes done in outreach settings (ambulances) and if the linens are not visibly soiled.

The GDG noted that, for the limited evidence presented, some information is missing regarding what biological markers were used to determine decontamination in the autoclave; there was a lack of information on temperature and pressures used in the decontamination process; and the studies presented were carried out in completely different contexts (HICs versus LMICs) and therefore the decontamination done in the studies presented in HICs is unlikely to be available in LMICs *[181]*.

The GDG noted that, in many LMICs, washing machines are not readily available in health facilities or in households. They would be expensive to install during an outbreak and would require WASH infrastructure. The issue of availability of functioning incinerators in LMICs was also discussed.

The GDG discussed the implications of elimination of linens versus decontamination with a focus on impact in the community setting and the environment. Historically, when burning of linens has occurred at community/household sites, concerns about toxicity in the community have been raised. In many settings, WASH colleagues caution against use of burn pits, as burn pits may contain fly ash. The GDG discussed balancing risk of transmission when waste/soiled linens are transported elsewhere to be eliminated or managed versus the shame and humiliation that can be felt by families as their belongings are being burned in front of their homes, as well as possible lack of clarity on what happens to the waste/soiled linens once they are removed.

WASH has provided some guidance, which can be found in the Ebola Virus Disease (EVD): Key questions and answers concerning health-care waste *[183]*. Although burn pits are often used in the field, WASH teams operating in health-care settings have been moving toward using actual incinerators, particularly in health-care settings. With incineration, temperatures exceed 850 degrees C, hotter than what is typically being done in the field.

The GDG noted that it is difficult to define “heavily soiled” linen. The risks of exposure of staff handling contaminated linen versus the costs, risks to communities and potential environmental impact of “eliminating" soiled linens compared to decontaminating them were discussed. Based on the uncertainty of the evidence presented that there is a safe and effective way to safely decontaminate/disinfect linen for reuse in the field, the GDG determined that a conditional recommendation in favour of elimination of "heavily soiled" linen was warranted, particularly in areas where safe decontamination practices may not be implementable or consistent.

Research Needs

More research is needed on effectiveness of washing/disinfection of linen/laundry including appropriate chemicals and methods.

16. Waste management

According to infection prevention and control standard precautions, health-care facilities should have a policy for minimizing, segregating, collecting, treating and disposing of waste.

The background question on survival of *Ebolavirus* or *Marburgvirus* in the environment found that:

- *Ebolavirus* survives for longer periods of time in low-humidity, low-temperature settings (less likely to be realized in an African context).
- *Ebolavirus* maintains viability longer in liquid substrate than dried. *Ebolavirus* survival is significant in dried blood and has been shown for up to 16 days in a dried, organic substance on a nonporous surface.
- *Ebolavirus* has been shown to survive in wastewater. Though viable virus rapidly diminishes after 24 hours, it may still be recovered after as many as eight days. Standard levels of chlorine used for water disinfection inactivate Ebola virus in wastewater.

This section addresses general considerations for waste management for items or wastewater generated during the care of a patient suspected of having or confirmed to be infected with *Ebolavirus* or *Marburgvirus*. Please use additional existing WHO recommendations on waste management available below as supplementary information.

1. Ebola Virus Disease (EVD): Key questions and answers concerning health-care waste.*[183]*
2. Safe management of wastes from health-care activities *[185]*,
3. Ebola Virus Disease (EVD) Key questions and answers concerning water, sanitation and hygiene.*[186]*

For details on appropriate treatment and disposal methods of health-care associated waste, including infectious waste, please refer to "Overview of technologies for the treatment of infectious and sharp waste from health care facilities. World Health Organization.*[187]*"

Good practice statement

All waste generated from the care of a patient with suspected or confirmed Ebola disease or Marburg disease, including waste generated during decontamination processes, should be treated as infectious waste.

Practical Info

Implementation considerations:

- Waste should be segregated at the point of generation to enable appropriate and safe handling.
- Ideally, waste should not be stored for longer than 24 hours before being destroyed.
- Sharp objects (e.g. needles, syringes, glass articles) and tubing that has been in contact with blood or body fluids should be placed inside puncture-resistant waste containers and sealed.
- All solid, non-sharp, infectious waste should be collected using leak-proof waste bags in covered bins.
- Where possible, transportation of infectious waste is discouraged. If transportation is required, then appropriate IPC precautions should be followed to prevent infection in those transporting the waste.
- Safe disposal of infectious waste is important.
- Appropriate PPE recommendations should be followed when handling infectious waste.
- Though incineration is the ideal method of elimination, various methods for elimination can be considered that follow existing WASH recommendations *[184]*.

Justification

There are well-established, globally recognized categories of health-care waste. Considering these established categories and the survivability of the *Ebolavirus* and *Marburgvirus* in the environment, the GDG judged that a good practice statement classifying such waste as infectious waste was warranted.

17. Safe management of dead bodies

As noted in the Modes of Transmission section, behaviours that involve direct physical contact with an Ebola patient or Marburg patient, including contact with body fluids from infected patients or touching deceased bodies, are associated with risk of infection with *Ebolavirus* or *Marburgvirus*. Those engaged in behaviours such as washing, dressing and preparing a body for a funeral are at high risk *[65]*. However, the evidence is inconsistent (range from unadjusted OR 1.07, 95% CI 0.63–1.82, to matched OR 13.1, 95% CI 1.4–631) and not all studies reviewed on transmission (direct contact and fomite) found an association between attending funerals and disease risk. For more details, review the Modes of Transmission section specific to transmission during funeral practices.

This section of the document addresses elements specific to safe handling of the deceased and does not address use of personal protective equipment when conducting burials in a community setting.

Good practice statement

The handling of remains of deceased humans with suspected or confirmed Ebola disease or Marburg disease should be done in a safe, culturally sensitive manner, and only when necessary in order to reduce exposure and transmission.

Remarks:

- *The family and community have agreed to adhere to procedures for safe and dignified burials, including not touching (no contact with) the body.*
- *The team or individuals involved in the burial are not undressing or redressing the deceased.*
- *Standard and transmission-based precautions can be followed.*
- *Individuals who will conduct the handling of the body and the burial are wearing the recommended PPE and are working in an environment where they can follow safe procedures for putting on and taking off PPE.*
- *The body will be placed into an appropriate body bag.*

Body bag parameters include:

- *Impermeable, vinyl, minimum thickness 400 microns*
- *Able to hold 100-125 kilos (220-275 lbs)*
- *Equipped with at least four handles to allow safe hand carry*
- *Fully contain bloodborne pathogens*

Practical Info

Implementation considerations:

- Deceased individuals should be correctly identified and handled with dignity.
- Only trained personnel should handle remains during an outbreak.
- The handling of human remains should be kept to a minimum (e.g. only for post-mortem specimen collection, transport or burial of the body).
- Post-mortem examination of patient remains should be limited to essential evaluations only and should be performed by a trained person; alternatives to post-mortem examinations (e.g. needle biopsies) should be considered.
- IPC and safe-burial recommendations should be adhered to in principle, but may need to be adapted to take into account cultural and religious concerns (e.g. discussion with religious leader/local chief or equivalent about their practices and adaptations to ensure that the greatest respect is given to removal and disposal of the deceased).
- PPE should be put on at the site of collection of human remains; worn during the process of collection and placement of the body into a body bag; and removed immediately afterwards.
- PPE is not required for individuals driving or riding in a vehicle to collect human remains, provided that neither drivers nor riders will be handling a dead body of someone who was suspected of having or confirmed to have Ebola disease or Marburg disease.

Justification

When developing this good practice statement, the GDG took into consideration the modes of transmission; the fact that viral load for *Ebolavirus* is often highest at time of death; and the behaviours associated with increased risk, such as contact with blood and body fluids when touching bodies of deceased individuals who were infected with *Ebolavirus* or *Marburgvirus*, and determined that handling of human remains should be kept to a minimum to reduce exposure risks *[65]*.

Conditional recommendation against , Very low certainty evidence

WHO **suggests** that disinfection of a dead body suspected or confirmed to be infected with *Ebolavirus* or *Marburgvirus* **is not required** prior to handling or placing the body into a body bag.

Practical Info

Implementation considerations

- The burial team should be able to adapt to the context and negotiate the safe and dignified burial process with the family and community. Religious leaders may influence safe burial behaviours.
- The body should be handled by trained personnel wearing the recommended PPE (eye protection, medical mask, coverall, two pairs of gloves [outer glove should be heavy duty] and rubber boots).
- Minimal handling of body is needed to minimize exposure.
- The body bag used should meet recommended parameters.
- There should be capacity for the burial team to perform hand hygiene.
- In situations where IPC practices cannot be implemented or there is concern the body bag containing the deceased may be reopened by the family or community, disinfection of the body prior to placing in the body bag may be considered if deemed culturally acceptable by the family and community.

Evidence To Decision

Benefits and harms

The systematic review did not identify any evidence on the desirable effects of disinfection when compared to no disinfection on the outcomes of exposure during handling of dead bodies or infection with *Ebolavirus* or *Marburgvirus*.

Regardless of lack of evidence, the GDG judged that the desirable effects (benefits) of disinfection were large.

The systematic review did not identify any evidence for the undesirable effects of disinfection (compared to no disinfection) on the outcomes of symptoms of chemical exposure from spraying dead bodies. Although evidence did not identify specific harms (or undesirable effects) with disinfecting a body, the GDG identified that such practices may give those involved in the burial a false sense of security, leading to breaches in infection prevention and control. It is unclear if a body can be disinfected. In some situations, there are challenges with implementing a safe and dignified burial procedure, depending upon negotiations with the family and community members and events that may occur. For example, moves by family members to open the body bag to insert mementos may increase transmission risks.

The GDG judged that the undesirable effects (harms) of disinfection were small.

On the balance of effects, the GDG judged that it probably favoured no disinfection of the dead body.

Certainty of the Evidence

Very low

On initial screening, only three studies were deemed to provide information on the risk of EVD acquisition/exposure from post-mortem contact *[55][61][188]*. The systematic review also identified five additional studies comparing the risk of transmission after contact with a dead body to contact with a person alive but infected with *Ebolavirus* or *Marburgvirus* (for a total of eight studies)*[189][190][191][63][192]*, but, following a GRADE assessment, the certainty of evidence was judged to be very low.

Values and preferences

The systematic review did not find any evidence on values and preferences. The GDG discussed whether communities and health and care workers would value the benefits of the intervention (disinfection of dead bodies) in terms of reducing transmission, compared to risk of harm of chemical exposure, and judged that there was probably important uncertainty or variability in how much people value the main outcomes.

Resources

Although the systematic review did not identify any evidence on resource use, the GDG judged that the costs and savings associated with disinfection (by either spraying or wiping) were negligible (compared with no disinfection).

Although the systematic review did not identify any evidence on cost effectiveness, the GDG members judged that there was no difference in cost effectiveness.

Equity

Although the systematic review did not identify any evidence related to the impact on health equity, the GDG members judged that there was probably no impact on health equity.

Acceptability

There was some indirect evidence related to burial practices and behaviours that may be associated with risk of transmission.

Some barriers to community acceptance of safe and dignified medical burials during an Ebola disease or Marburg disease outbreak include fears about how bodies are handled; the lack of ability to view the body or participate in the burial; and the potential for quarantine and stigma following a burial*[193]*. In addition, the use of plastic body bags; failure to change to burial clothes; and the absence of women from the burial team have been seen as showing a lack of honour for the deceased*[194]*. Some cultures require the deceased to be changed into different clothes and the burial team may prefer to disinfect the body prior to changing the clothes*[194][193]*.

Factors that can improve acceptability of safe, dignified burials may include community participation in digging the grave and participating in the burial team (with appropriate training). Allowing an opportunity for community prayer; involving community members and religious leaders under the supervision of community health workers may improve acceptability*[195][193][194][196]*.

Changing burial practices has been identified by communities as one of the most difficult practices to accept during an Ebola or Marburg outbreak.

When community leaders, religious leaders, community members and community HW supervisors were asked which unsafe practice was the most difficult to give up, they most-frequently cited dead-body management and greetings by touching such as shaking hands*[197][195]*.

Based on this indirect evidence and the experiences of many GDG members in relation to the acceptability of conducting safe, dignified burials, the GDG judged that acceptability of disinfection of a body as part of a safe, dignified burial varies, and is context dependent.

Feasibility

The systematic review did not find any direct evidence on feasibility of disinfecting or not disinfecting bodies of deceased individuals suspected or confirmed to be infected with *Ebolavirus* or *Marburgvirus*. Some indirect evidence found public health messages promoted by community and religious leaders may have influenced safe-burial behaviour during the Ebola disease outbreak in Sierra Leone*[195]*. The GDG judged that community and family engagements in the process were important factors and, if implemented, the intervention was feasible.

Justification

In the absence of published evidence, the GDG noted that adherence to infection prevention and control measures, including minimal handling of the body, wearing the recommended PPE, and hand hygiene, were essential to preventing transmission. The GDG agreed that, if the infection prevention and control measures are in place and applied appropriately, there is likely no benefit to disinfecting a dead body.

There are some behaviours that may present higher risk for transmission, such as touching a dead body without PPE and having contact with blood and other body fluids of the deceased *[65]*. Communication and negotiation with the family and community throughout the process are critical to preventing transmission.

When comparing the handling of dead bodies to contact with living patients, the GDG found eight studies that provided information

on the risk of Ebola disease acquisition or exposure through contact with a dead body. Those studies included some evidence of a slightly increased transmission risk from contact with dead bodies*[191][192][55][190][189][63][188][61]*. Evidence does suggest that the viral load is often highest at the time of death.

Evidence regarding the effectiveness of disinfecting a dead body (with chlorine solution, for example) was not found and only some indirect evidence was identified related to burial practices during past outbreaks*[190]*. Considering issues with acceptability, equity and potential harms, the GDG judged that a conditional recommendation against disinfection of a dead body was required.

There were no specific benefits identified. It is generally accepted that chlorine is inactivated in the presence of organic material (e.g. blood and other body fluids), although there is some emerging laboratory evidence that suggests 0.5 % chlorine (50,000 ppm) is not rendered ineffective in the presence of organic material. However, the GDG noted this has not been demonstrated on dead bodies which, when infected with *Ebolavirus*, are often contaminated at death with blood and other body fluids. Furthermore, viral load is high at time of death and evidence has shown a slightly increased risk of transmission.

Research Needs

Research gaps

- The lack of available evidence on the risk of transmission from handling dead bodies highlights the need for additional research.

Some additional area for research includes:

- Amount of virus potentially on PPE as a result of preparing a body compared to other care activities for patients (alive) confirmed to be infected with *Ebolavirus* or *Marburgvirus*.
- Ability to disinfect bodies, including use of Phi6 as a surrogate for *Ebolavirus*.

References

1. International Labour Organization : International Standard Classification of Occupations (ISCO 2008). 21 June 2016. International Labour Organization Website

2. World Health Organization : Health Workforce-related terminology;Terminology work carried out by the WHO Language department at the request of the Health Workforce department. 8 June 2021. World Health Organization Website

3. Centers for Disease Control and Prevention, Infection Control Africa Network : Best Practices for Environmental Cleaning in Healthcare Facilities: in Resource-Limited Settings. 2019. Centres for Disease Control and Prevention Website

4. World Health Organization 2022 : Environmental cleaning and infection prevention and control in health care facilities in low- and middle-income countrie:s trainer's guide. World Health Organization Website

5. World Health Organization : Transmission-based precautions for the prevention and control of infections: aide-memoire. 2022. Website

6. World Health Organization : Decontamination and reprocessing of medical devices for health-care facilities. 2016. World Health Organization Website

7. World Health Organization : Ebola virus disease. Website

8. Merriam Webster Dictionary 2023. Website

9. World Health Organization : The world health report 2006: working together for health. World Health Organization Website

10. World Health Organization : Infection prevention and control. Website

11. World Health Organization : Marburg virus disease. Website

12. World Health Organization : Health products policy and standards. World Health Organization Website

13. Operational considerations for case management of COVID-19 in health facility and community. Website

14. World Health Organization, OPENWHO.org : Clinical management of patients with COVID-19: Initial approach to the acutely ill patient. 5 May 2021.OPENWHO.org Website

15. World Health Organization : Standard precautions for the prevention and control of infections: aide-memoire. 2022. Website

16. World Health Organization : Zoonoses. World Health Organization Website

17. World Health Organization : Personal protective equipment for use in a filovirus disease outbreak: rapid advice guideline. 2016. World Health Organization Website

18. World Health Organization : Guideline on hand hygiene in health care in the context of filovirus disease outbreak response : rapid advice guideline, November 2014. World Health Organization Website

19. World Health Organization : Interim infection prevention and control guidance for care of patients with suspected or confirmed filovirus haemorrhagic fever in health-care settings, with focus on Ebola. 2014. World Health Organization Website

20. World Health Organization : Ebola viruses-vaccine standardization. World Health Organization Website

21. Kuhn JH, Adachi T, Adhikari NKJ, Arribas JR, Bah IE, Bausch DG, et al. : New filovirus disease classification and nomenclature. Nature reviews. Microbiology 2019;17(5):261-263 Pubmed Journal

22. Lupi O, Tyring SK, Cosenza PP, Motta RN, Kouri G, Guzman MG, et al. : 12 - Hemorrhagic Fever and Arboviruses. Tyring SK, Lupi O, Hengge UR, (Eds.), null, null: Elsevier 2017; 127-151 Journal Website

23. Lebarbenchon C, Goodman SM, Hoarau A, Le Minter G, Dos Santos A, Schoeman M, et al. : Bombali Ebolavirus in Mops condylurus Bats (Molossidae), Mozambique. Emerging Infectious Diseases 2022;28(12):2583-2585. Journal Website

24. World Health Organization : Optimized supportive care for Ebola virus disease.2019. Website

25. World Health Organization : Therapeutics for Ebola virus disease. 2022. Website

26. UN Women : Ebola outbreak takes its toll on women. UN Women 2014 Website

27. Binagwaho A, Mathewos K : Infectious disease outbreaks highlight gender inequity. Nature Microbiology 2022;7(3):361-362 Journal Website

28. Nkangu MN, Olatunde OA, Yaya S : The perspective of gender on the Ebola virus using a risk management and population health framework: a scoping review. Infectious diseases of poverty 2017;6(1):135 Pubmed Journal

29. Fawole OI, Bamiselu OF, Adewuyi PA, Nguku PM : Gender dimensions to the Ebola outbreak in Nigeria. Annals of African medicine 2016;15(1):7-13 Pubmed Journal

30. World Health Organization : Infection prevention and control of epidemic- and pandemic-prone acute respiratory infections in health care. 2014. World Health Organization Website

31. The National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention : The National Institute for Occupational Safety and Health (NIOSH) Hierarchy of Controls. Website

32. World Health Organization, International Labour Organization : Occupational safety and health in public health emergencies: a manual for protecting health workers and responders. 2018. World Health Organization Website

33. World Health Organization : WHO handbook for guideline, 2nd ed. World Health Organization Website

34. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. : GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008;336(7650):924 Journal Website

35. World Health Organization : WHO guidelines on hand hygiene in health care: a summary. 2009. World Health Organization Website

36. Den Boon S, Vallenas C, Ferri M, Norris SL : Incorporating health workers' perspectives into a WHO guideline on personal protective equipment developed during an Ebola virus disease outbreak. F1000Research 2018;7 45 Pubmed Journal

37. Guyatt GH, Alonso-Coello P, Schünemann HJ, Djulbegovic B, Nothacker M, Lange S, et al. : Guideline panels should seldom make good practice statements: guidance from the GRADE Working Group. J Clin Epidemiol 2016;80 3-7 Pubmed Journal

38. Bausch DG, Nichol ST, Muyembe-Tamfum JJ, Borchert M, Rollin PE, Sleurs H, et al. : Marburg Hemorrhagic Fever Associated with Multiple Genetic Lineages of Virus. N Engl J Med 2006;355(9):909-919 Journal Website

39. Nsio J, Kapetshi J, Makiala S, Raymond F, Tshapenda G, Boucher N, et al. : 2017 Outbreak of Ebola Virus Disease in Northern Democratic Republic of Congo. The Journal of Infectious Diseases 2019; Journal Website

40. Bratcher A, Hoff NA, Doshi RH, Gadoth A, Halbrook M, Mukadi P, et al. : Zoonotic risk factors associated with seroprevalence of

Ebola virus GP antibodies in the absence of diagnosed Ebola virus disease in the Democratic Republic of Congo. PLoS Negl Trop Dis 2021;15(8):e0009566 Journal Website

41. Smiley Evans T, Tutaryebwa L, Gilardi KV, Barry PA, Marzi A, Eberhardt M, et al. : Suspected Exposure to Filoviruses Among People Contacting Wildlife in Southwestern Uganda. The Journal of Infectious Diseases 2018;218(suppl_5):S277-S286 Journal Website

42. Mulangu S, Borchert M, Paweska J, Tshomba A, Afounde A, Kulidri A, et al. : High prevalence of IgG antibodies to Ebola virus in the Efé pygmy population in the Watsa region, Democratic Republic of the Congo. BMC Infect Dis 2016;16(1):263 Journal Website

43. Swanepoel R, Smit SB, Rollin PE, Formenty P, Leman PA, Kemp A, et al. : Studies of Reservoir Hosts for Marburg Virus. Emerg Infect Dis 2007;13(12):1847-1851 Journal Website

44. Bausch DG, Borchert M, Grein T, Roth C, Swanepoel R, Libande ML, et al. : Risk Factors for Marburg Hemorrhagic Fever, Democratic Republic of the Congo. Emerg Infect Dis 2003;9(12):1531-1537 Journal Website

45. Adjemian J, Farnon EC, Tschioko F, Wamala JF, Byaruhanga E, Bwire GS, et al. : Outbreak of Marburg Hemorrhagic Fever Among Miners in Kamwenge and Ibanda Districts, Uganda, 2007. The Journal of Infectious Diseases 2011;204(suppl_3):S796-S799 Journal Website

46. Towner JS, Pourrut X, Albariño CG, Nkogue CN, Bird BH, Grard G, et al. : Marburg Virus Infection Detected in a Common African Bat. PLoS One 2007;2(8):e764 Journal Website

47. Towner JS, Amman BR, Sealy TK, Carroll SAR, Comer JA, Kemp A, et al. : Isolation of Genetically Diverse Marburg Viruses from Egyptian Fruit Bats. PLoS Pathog 2009;5(7):e1000536 Journal Website

48. Amman BR, Bird BH, Bakarr IA, Bangura J, Schuh AJ, Johnny J, et al. : Isolation of Angola-like Marburg virus from Egyptian rousette bats from West Africa. Nat Commun 2020;11(1):510 Journal Website

49. Amman BR, Carroll SA, Reed ZD, Sealy TK, Balinandi S, Swanepoel R, et al. : Seasonal Pulses of Marburg Virus Circulation in Juvenile Rousettus aegyptiacus Bats Coincide with Periods of Increased Risk of Human Infection. PLoS Pathog 2012;8(10):e1002877 Journal Website

50. Nyakarahuka L, Schafer IJ, Balinandi S, Mulei S, Tumusiime A, Kyondo J, et al. : A retrospective cohort investigation of seroprevalence of Marburg virus and ebolaviruses in two different ecological zones in Uganda. BMC Infect Dis 2020;20(1):461 Journal Website

51. Nyakarahuka L, Shoemaker TR, Balinandi S, Chemos G, Kwesiga B, Mulei S, et al. : Marburg virus disease outbreak in Kween District Uganda, 2017: Epidemiological and laboratory findings. PLoS Negl Trop Dis 2019;13(3):e0007257 Journal Website

52. Knust B, Schafer IJ, Wamala J, Nyakarahuka L, Okot C, Shoemaker T, et al. : Multidistrict Outbreak of Marburg Virus Disease—Uganda, 2012. J Infect Dis 2015;212(suppl 2):S119-S128 Journal Website

53. Skrip LA, Fallah MP, Gaffney SG, Yaari R, Yamin D, Huppert A, et al. : Characterizing risk of Ebola transmission based on frequency and type of case–contact exposures. Phil Trans R Soc B 2017;372(1721):20160301 Journal Website

54. Reichler MR, Bangura J, Bruden D, Keimbe C, Duffy N, Thomas H, et al. : Household Transmission of Ebola Virus: Risks and Preventive Factors, Freetown, Sierra Leone, 2015. The Journal of Infectious Diseases 2018;218(5):757-767 Journal Website

55. Diallo MSK, Rabilloud M, Ayouba A, Touré A, Thaurignac G, Kabinet Keita A, et al. : Prevalence of infection among asymptomatic and paucisymptomatic contact persons exposed to Ebola virus in Guinea: a retrospective, cross-sectional observational study. The Lancet Infectious Diseases 2019;19(3):308-316 Pubmed Journal Website

56. Miglietta A, Solimini A, Djeunang Dongho GB, Montesano C, Rezza G, Vullo V, et al. : The Ebola virus disease outbreak in Tonkolili district, Sierra Leone: a retrospective analysis of the Viral Haemorrhagic Fever surveillance system, July 2014–June 2015. Epidemiol Infect 2019;147 e103 Journal Website

57. Senga M, Koi A, Moses L, Wauquier N, Barboza P, Fernandez-Garcia MD, et al. : Contact tracing performance during the Ebola virus disease outbreak in Kenema district, Sierra Leone. Phil Trans R Soc B 2017;372(1721):20160300 Journal Website

58. Bower H, Johnson S, Bangura MS, Kamara AJ, Kamara O, Mansaray SH, et al. : Exposure-Specific and Age-Specific Attack Rates for Ebola Virus Disease in Ebola-Affected Households, Sierra Leone. Emerg Infect Dis 2016;22(8):1403-1411 Journal Website

59. Barry A, Ahuka-Mundeke S, Ali Ahmed Y, Allarangar Y, Anoko J, Archer BN, et al. : Outbreak of Ebola virus disease in the Democratic Republic of the Congo, April 2013;May, 2018: an epidemiological study. The Lancet 2018;392(10143):213-221 Journal Website

60. Cleaton JM, Viboud C, Simonsen L, Hurtado AM, Chowell G : Characterizing Ebola Transmission Patterns Based on Internet News Reports. Clin Infect Dis 2016;62(1):24-31 Journal Website

61. Curran K, Gibson JJ, Marke D, Caulker V, Bomeh J, Redd JT, et al. : Cluster of Ebola Virus Disease Linked to a SIngle Funeral-Moyamba District,Sierra Leone, 2014. MMWR Mor Mortal Weekly Rep 2016 (65):202-205 Journal Website

62. Stehling-Ariza T, Rosewell A, Moiba SA, Yorpie BB, Ndomaina KD, Jimissa KS, et al. : The impact of active surveillance and health education on an Ebola virus disease cluster — Kono District, Sierra Leone, 2014–2015. BMC Infect Dis 2016;16(1):611 Journal Website

63. Tiffany A, Dalziel BD, Kagume Njenge H, Johnson G, Nugba Ballah R, James D, et al. : Estimating the number of secondary Ebola cases resulting from an unsafe burial and risk factors for transmission during the West Africa Ebola epidemic. PLoS Negl Trop Dis 2017;11(6):e0005491 Journal Website

64. Glynn JR, Bower H, Johnson S, Turay C, Sesay D, Mansaray SH, et al. : Variability in Intrahousehold Transmission of Ebola Virus, and Estimation of the Household Secondary Attack Rate. The Journal of infectious diseases 2018;217(2):232-237 Pubmed Journal

65. Brainard J, Hooper L, Pond K, Edmunds K, Hunter PR : Risk factors for transmission of Ebola or Marburg virus disease: a systematic review and meta-analysis. Int J Epidemiol 2016;45(1):102-116 Pubmed Journal Website

66. Dean NE, Halloran ME, Yang Y, Longini IM : Transmissibility and Pathogenicity of Ebola Virus: A Systematic Review and Meta-analysis of Household Secondary Attack Rate and Asymptomatic Infection. Clin Infect Dis 2016;62(10):1277-1286 Journal Website

67. Selvaraj SA, Lee KE, Harrell M, Ivanov I, Allegranzi B : Infection Rates and Risk Factors for Infection Among Health Workers During Ebola and Marburg Virus Outbreaks: A Systematic Review. The Journal of Infectious Diseases 2018;218(suppl_5):S679-S689 Journal Website

68. Poliquin PG, Vogt F, Kasztura M, Leung A, Deschambault Y, Van den Bergh R, et al. : Environmental Contamination and Persistence of Ebola Virus RNA in an Ebola Treatment Center. J Infect Dis 2016;214(suppl 3):S145-S152 Journal Website

69. Palich R, Irenge LM, Barte de Sainte Fare E, Augier A, Malvy D, Gala J-L : Ebola virus RNA detection on fomites in close proximity to confirmed Ebola patients; N'Zerekore, Guinea, 2015. PLoS One 2017;12(5):e0177350 Journal Website

70. Brainard J, Pond K, Hooper L, Edmunds K, Hunter P : Presence and Persistence of Ebola or Marburg Virus in Patients and Survivors: A Rapid Systematic Review. PLoS Negl Trop Dis 2016;10(2):e0004475 Journal Website

71. Jones RM, Brosseau LM : Aerosol Transmission of Infectious Disease. J Occup Environ Med 2015;57(5):501-508 Journal Website

72. Lalle E, Biava M, Nicastri E, Colavita F, Di Caro A, Vairo F, et al. : Pulmonary Involvement during the Ebola Virus Disease. Viruses 2019;11(9):780 Journal Website

73. Mekibib B, Ariën K : Aerosol Transmission of Filoviruses. Viruses 2016;8(5):148 Journal Website

74. Osterholm MT, Moore KA, Kelley NS, Brosseau LM, Wong G, Murphy FA, et al. : Transmission of Ebola Viruses: What We Know and What We Do Not Know. mBio 2015;6(2):e00137-00115 Journal Website

75. Vetter P, Fischer WA, Schibler M, Jacobs M, Bausch DG, Kaiser L : Ebola Virus Shedding and Transmission: Review of Current Evidence. J Infect Dis 2016;214(suppl 3):S177-S184 Pubmed Journal Website

76. Passi D : Ebola Virus Disease (The Killer Virus): Another Threat to Humans and Bioterrorism: Brief Review and Recent Updates. JCDR 2015; Journal Website

77. Leffel EK, Reed DS : Marburg and Ebola Viruses as Aerosol Threats. Biosecur Bioterror 2004;2(3):186-91. 6 Pubmed Journal Website

78. de La Vega MA, Wong G, Wei H, He S, Bello A, Fausther-Bovendo H, et al. : Role of Key Infectivity Parameters in the Transmission of Ebola Virus Makona in Macaques. The Journal of Infectious Diseases 2022;226(4):616-624 Journal Website

79. Piercy TJ, Smither SJ, Steward JA, Eastaugh L, Lever MS : The survival of filoviruses in liquids, on solid substrates and in a dynamic aerosol: Survival of filoviruses. J Appl Microbiol 2010; no-no Journal Website

80. Fischer RJ, Bushmaker T, Judson S, Munster VJ : Comparison of the Aerosol Stability of 2 Strains of *Zaire ebolavirus* From the 1976 and 2013 Outbreaks. J Infect Dis 2016;214(suppl 3):S290-S293 Journal Website

81. Subissi L, Keita M, Mesfin S, Rezza G, Diallo B, Van Gucht S, et al. : Ebola Virus Transmission Caused by Persistently Infected Survivors of the 2014–2016 Outbreak in West Africa. The Journal of Infectious Diseases 2018;218(suppl_5):S287-S291 Journal Website

82. Thorson A, Formenty P, Lofthouse C, Broutet N : Systematic review of the literature on viral persistence and sexual transmission from recovered Ebola survivors: evidence and recommendations. BMJ Open 2016;6(1):e008859 Journal Website

83. Thorson AE, Deen GF, Bernstein KT, Liu WJ, Yamba F, Habib N, et al. : Persistence of Ebola virus in semen among Ebola virus disease survivors in Sierra Leone: A cohort study of frequency, duration, and risk factors. PLoS Med 2021;18(2):e1003273 Journal Website

84. Varkey JB, Shantha JG, Crozier I, Kraft CS, Lyon GM, Mehta AK, et al. : Persistence of Ebola Virus in Ocular Fluid during Convalescence. The New England journal of medicine 2015;372(25):2423-7 Pubmed Journal

85. World Health Organization : Interim advice on the sexual transmission of the Ebola virus disease. 2016. World Health Organization Website

86. World Health Organization : Clinical care for survivors of Ebola virus disease: interim guidance. 2016. World Health Organization Website

87. World Health Organization : International meeting on persistence of Ebola virus RNA in semen and implications for public health. 8 June 2018. World Health Organization Website

88. Jacobs M, Rodger A, Bell DJ, Bhagani S, Cropley I, Filipe A, et al. : Late Ebola virus relapse causing meningoencephalitis: a case report. Lancet (London, England) 2016;388(10043):498-503 Pubmed Journal

89. Mbala-Kingebeni P, Pratt C, Mutafali-Ruffin M, Pauthner MG, Bile F, Nkuba-Ndaye A, et al. : Ebola Virus Transmission Initiated by Relapse of Systemic Ebola Virus Disease. The New England journal of medicine 2021;384(13):1240-1247 Pubmed Journal

90. Medina-Rivera M, Centeno-Tablante E, Finkelstein JL, Rayco-Solon P, Peña-Rosas JP, Garcia-Casal MN, et al. : Presence of Ebola virus in breast milk and risk of mother-to-child transmission: synthesis of evidence. Ann NY Acad Sci 2021;1488(1):33-43 Journal Website

91. World Health Organization : Guidelines for the management of pregnant and breastfeeding women in the context of Ebola virus disease. 2020. World Health Organization Website

92. World Health Organization : Clinical management of patients with viral haemorrhagic fever: A pocket guide for front-line health workers. 2 January 2016. World Health Organization Website

93. World Health Organization : Framework and toolkit for infection prevention and control in outbreak preparedness, readiness and response at the national level. 14 December 2021. World Health Organization Website

94. World Health Organization : Framework and toolkit for infection prevention and control in outbreak preparedness, readiness and response at the health care facility level. 6 September 2022. World Health Organization Website

95. World Health Organization : Minimum requirements for infection prevention and control programmes. 18 November 2019. World Health Organization Website

96. World Health Organization : Guidelines on core components of infection prevention and control programmes at the national and acute health care facility level. 2016. World Health Organization Website

97. Baller A, Padoveze MC, Mirindi P, Hazim CE, Lotemo J, Pfaffmann J, et al. : Ebola virus disease nosocomial infections in the Democratic Republic of the Congo: a descriptive study of cases during the 2018-2020 outbreak. International journal of infectious diseases : IJID : official publication of the International Society for Infectious Diseases 2022;115 126-133 Pubmed Journal

98. Hageman JC, Hazim C, Wilson K, Malpiedi P, Gupta N, Bennett S, et al. : Infection Prevention and Control for Ebola in Health Care Settings - West Africa and United States. MMWR supplements 2016;65(3):50-6 Pubmed Journal

99. Ousman K, Kabego L, Talisuna A, Diaz J, Mbuyi J, Houndjo B, et al. : The impact of Infection Prevention and control (IPC) bundle implementationon IPC compliance during the Ebola virus outbreak in Mbandaka/Democratic Republic of the Congo: a before and after design. BMJ open 2019;9(9):e029717 Pubmed Journal

100. Nyenswah T, Massaquoi M, Gbanya MZ, Fallah M, Amegashie F, Kenta A, et al. : Initiation of a ring approach to infection prevention and control at non-Ebola health care facilities - Liberia, January-February 2015. MMWR Morb Mortal Wkly Rep 2015;64(18):505-508 Pubmed

101. Nyenswah T, Fallah M, Sieh S, Kollie K, Badio M, Gray A, et al. : Controlling the last known cluster of Ebola virus disease - Liberia, January-February 2015. MMWR Morb Mortal Wkly Rep 2015;64(18):500-504 Pubmed

102. Yamin D, Gertler S, Ndeffo-Mbah ML, Skrip LA, Fallah M, Nyenswah TG, et al. : Effect of Ebola progression on transmission and control in Liberia. Ann Intern Med 2015;162(1):11-17 Pubmed Journal

103. Hageman JC HC WKMPGNSKAAB-RKCBGCFAJMHDMKDLDCBMSASMFRANCNPB : Infection Prevention and Control for Ebola in Health Care Settings — West Africa and United States. MMWR and Morbidity and Mortality Weekly Report 2016;65 50-56 Journal Website

104. Mbonye AK, Wamala JF, Nanyunja M, Opio A, Makumbi I, Aceng JR : Ebola viral hemorrhagic disease outbreak in West Africa-lessons from Uganda. African health sciences 2014;14(3):495-501 Pubmed Journal

105. Nyenswah TG, Kateh F, Bawo L, Massaquoi M, Gbanyan M, Fallah M, et al. : Ebola and Its Control in Liberia, 2014-2015. Emerg Infect Dis 2016;22(2):169-177 Pubmed Journal

106. Keïta M, Camara AY, Traoré F, Camara ME, Kpanamou A, Camara S, et al. : Impact of infection prevention and control training on health facilities during the Ebola virus disease outbreak in Guinea. BMC Public Health 2018;18(1):547 Pubmed Journal

107. Palagyi A, Marais BJ, Abimbola S, Topp SM, McBryde ES, Negin J : Health system preparedness for emerging infectious diseases: A synthesis of the literature. Glob Public Health 2019;14(12):1847-1868 Pubmed Journal

108. World Health Organization : Human Rights:fact sheet. World Health Organization Website

109. Pellecchia U, Crestani R, Decroo T, Van den Bergh R, Al-Kourdi Y : Social Consequences of Ebola Containment Measures in Liberia. PLoS One. 2015 Dec 9;10(12):e0143036 Journal Website

110. Richards P, Mokuwa E, Welmers P, Maat H, Beisel U : Trust, and distrust, of Ebola Treatment Centers: A case-study from Sierra

Leone. PLoS One. 2019 Dec 2;14(12):e0224511 Journal Website

111. Centers for Disease Control and Prevention : CDC Releases New Reports on Ebola Cases in Liberia and the United States 2014. US Centres for Disease Control and Prevention

112. Forrester JD, Hunter JC, Pillai SK, Arwady MA, Ayscue P, Matanock A, et al. : Cluster of Ebola Cases Among Liberian and U.S. Health Care Workers in an Ebola Treatment Unit and Adjacent Hospital — Liberia, 2014. Morbidity and Mortality Weekly Report (MMWR) 63(41):6 Website

113. Centers for Disease Control and Prevention : CDC Releases New Reports on Ebola Cases in Liberia and the United States. November 2014. Centres for Disease Control and Prevention Website

114. World Health Organization : Preferred product characteristics for personal protective equipment for the health worker on the frontline responding to viral hemorrhagic fevers in tropical climates. 2018. World Health Organization Website

115. World Health Organization : WHO IPC hand hygiene training tools - 5 Moments for Hand Hygiene. World Health Organization Website

116. Hersi M, Stevens A, Quach P, Hamel C, Thavorn K, Garritty C, et al. : Effectiveness of Personal Protective Equipment for Healthcare Workers Caring for Patients with Filovirus Disease: A Rapid Review. PLoS One 2015;10(10):e0140290 Journal Website

117. Verbeek JH, Rajamaki B, Ijaz S, Sauni R, Toomey E, Blackwood B, et al. : Personal protective equipment for preventing highly infectious diseases due to exposure to contaminated body fluids in healthcare staff. The Cochrane database of systematic reviews 2020;4(4):CD011621 Pubmed Journal

118. Casanova LM, Rutala WA, Weber DJ, Sobsey MD : Effect of single- versus double-gloving on virus transfer to health care workers' skin and clothing during removal of personal protective equipment. Am J Infect Control 2012;40(4):369-374 Pubmed Journal

119. Brainard J, Hall S, van der Es M, Sekoni A, Price A, Padoveze MC, et al. : A mixed methods study on effectiveness and appropriateness of face shield use as COVID-19 PPE in middle income countries. American journal of infection control 2022;50(8):878-884 Pubmed Journal

120. Korniewicz D,Editor : Infection Control for Advance Practice Professionals. Pennsylvania: DESteech Publications, Inc; 2014. 264

121. Siegel JD, Rhinehart E, Jackson M, Chiarello L : 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Health Care Settings. Am J Infect Control 2007;35(10, Supplement 2):S65-S164 Journal Website

122. Pshenichnaya NY, Nenadskaya SA : Probable Crimean-Congo hemorrhagic fever virus transmission occurred after aerosol-generating medical procedures in Russia: nosocomial cluster. Int J Infect Dis 2015;33 120-122 Pubmed Journal Website

123. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J : Aerosol Generating Procedures and Risk of Transmission of Acute Respiratory Infections to Healthcare Workers: A Systematic Review. PLoS One 2012;7(4):e35797 Journal Website

124. Coca A, Quinn T, Kim J-H, Wu T, Powell J, Roberge R, et al. : Physiological Evaluation of Personal Protective Ensembles Recommended for Use in West Africa. Disaster medicine and public health preparedness 2017;11(5):580-586 Pubmed Journal

125. Coca A, DiLeo T, Kim JH, Roberge R, Shaffer R : Baseline Evaluation With a Sweating Thermal Manikin of Personal Protective Ensembles Recommended for Use in West Africa. Disaster Med Public Health Prep 2015;9(5):536-542 Pubmed Journal

126. Suen LKP, Guo YP, Tong DWK, Leung PHM, Lung D, Ng MSP, et al. : Self-contamination during doffing of personal protective equipment by healthcare workers to prevent Ebola transmission. Antimicrob Resist Infect Control 2018;7(1):157 Journal Website

127. Zamora JE, Murdoch J, Simchison B, Day AG : Contamination: a comparison of 2 personal protective systems. Can Med Assoc J 2006;175(3):249 Journal Website

128. Raj D, Hornsey E, Perl TM : Personal protective equipment for viral hemorrhagic fevers. Curr Opin Infect Dis 2019;32(4):337-347 Pubmed Journal Website

129. Guo YP, Li Y, Wong PL : Environment and body contamination: a comparison of two different removal methods in three types of personal protective clothing. Am J Infect Control 2014;42(4):e39-45 Pubmed Journal

130. Grélot L, Koulibaly F, Maugey N, Janvier F, Foissaud V, Aletti M, et al. : Moderate Thermal Strain in Healthcare Workers Wearing Personal Protective Equipment During Treatment and Care Activities in the Context of the 2014 Ebola Virus Disease Outbreak. J Infect Dis 2016;213(9):1462-1465 Pubmed Journal

131. Sprecher AG, Caluwaerts A, Draper M, Feldmann H, Frey CP, Funk RH, et al. : Personal Protective Equipment for Filovirus Epidemics: A Call for Better Evidence. J Infect Dis 2015;212 Suppl 2(Suppl 2):S98-s100 Pubmed Journal

132. Roberts V : To PAPR or not to PAPR?. Can J Respir Ther 50(3):87-90 Pubmed

133. Brainard J, Hall S, van der Es M, Sekoni A, Price A, Padoveze MC, et al. : A mixed methods study on effectiveness and appropriateness of face shield use as COVID-19 PPE in middle income countries. American journal of infection control 2022;50(8):878-884 Pubmed Journal

134. Centers for Disease Control and Prevention : Guidance on Personal Protective Equipment (PPE) To Be Used By Healthcare Workers during Management of Patients with Confirmed Ebola or Persons under Investigation (PUIs) for Ebola who are Clinically Unstable or Have Bleeding, Vomiting, or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE. 2023 Website

135. Brown CK : Protecting Critical US Workers from Occupational Exposure to Emerging Infectious Diseases: Toward a Universal Personal Protective Equipment Selection Matrix for Early Outbreak Response. 2018. American Public Health Association Website

136. Chughtai AA, Chen X, Macintyre CR : Risk of self-contamination during doffing of personal protective equipment. Am J Infect Control 2018;46(12):1329-1334 Journal Website

137. Poller B, Tunbridge A, Hall S, Beadsworth M, Jacobs M, Peters E, et al. : A unified personal protective equipment ensemble for clinical response to possible high consequence infectious diseases: A consensus document on behalf of the HCID programme. J Infect 2018;77(6):496-502 Journal Website

138. European Centre for Disease Prevention and Control : Safe use of personal protective equipment in the treatment of infectious diseases of high consequence. Website

139. Centers for Disease Control and Prevention;The National Institute for Occupational Safety and Health (NIOSH) : Preventing occupational latex allergy in health care workers. (null) Website

140. Hamilton RG : Latex allergy: epidemiology, clinical manifestations, and diagnosis. UpToDate website; 2014 2016 Website

141. Casanova LM, Teal LJ, Sickbert-Bennett EE, Anderson DJ, Sexton DJ, Rutala WA, et al. : Assessment of Self-Contamination During Removal of Personal Protective Equipment for Ebola Patient Care. Infect Control Hosp Epidemiol 2016;37(10):1156-1161 Journal Website

142. Houlihan CF, McGowan CR, Dicks S, Baguelin M, Moore DAJ, Mabey D, et al. : Ebola exposure, illness experience, and Ebola antibody prevalence in international responders to the West African Ebola epidemic 2014–2016: A cross-sectional study. PLoS Med 2017;14(5):e1002300 Journal Website

143. Reidy P, Fletcher T, Shieber C, Shallcross J, Towler H, Ping M, et al. : Personal protective equipment solution for UK military medical personnel working in an Ebola virus disease treatment unit in Sierra Leone. J Hosp Infect 2017;96(1):42-48 Pubmed Journal

144. Cummings KJ, Choi MJ, Esswein EJ, de Perio MA, Harney JM, Chung WM, et al. : Addressing Infection Prevention and Control in the First U.S. Community Hospital to Care for Patients With Ebola Virus Disease: Context for National Recommendations and Future Strategies. Ann Intern Med 2016;165(1):41 Journal Website

145. Mehtar S, Bulabula ANH, Nyandemoh H, Jambawai S : Deliberate exposure of humans to chlorine-the aftermath of Ebola in West Africa. Antimicrobial resistance and infection control 2016;5 45 Pubmed

146. World Health Organization : WHO guidelines on hand hygiene in health care. 2009. World Health Organization Website

147. Casanova LM, Erukunuakpor K, Kraft CS, Mumma JM, Durso FT, Ferguson AN, et al. : Assessing Viral Transfer During Doffing of Ebola-Level Personal Protective Equipment in a Biocontainment Unit. Clin Infect Dis 2018;66(6):945-949 Journal Website

148. Olu O, Kargbo B, Kamara S, Wurie AH, Amone J, Ganda L, et al. : Epidemiology of Ebola virus disease transmission among health care workers in Sierra Leone, May to December 2014: a retrospective descriptive study. BMC Infect Dis 2015;15(1):416 Journal Website

149. Savini H, Janvier F, Karkowski L, Billhot M, Aletti M, Bordes J, et al. : Occupational Exposures to Ebola Virus in Ebola Treatment Center, Conakry, Guinea. Emerging infectious diseases 2017;23(8):1380-1383 Pubmed Journal

150. Jacobs M, Aarons E, Bhagani S, Buchanan R, Cropley I, Hopkins S, et al. : Post-exposure prophylaxis against Ebola virus disease with experimental antiviral agents: a case-series of health-care workers. The Lancet. Infectious diseases 2015;15(11):1300-4 Pubmed Journal

151. Occupational Safety and Health Administration : Occupational Safety and Health Standards; Bloodborne pathogens 1910.1030. United Stated Department of Labor Website

152. World Health Organization, & International Labour Organization : Caring for those who care: guide for the development and implementation of occupational health and safety programmes for health workers. 2022. World Health Organization & International Labour Organization Website

153. Samai M, Seward J, Goldstein S, Mahon B, Lisk D, Widdowson M-A, et al. : The Sierra Leone Trial to Introduce a Vaccine Against Ebola: An Evaluation of rVSVΔG-ZEBOV-GP Vaccine Tolerability and Safety during the West Africa Ebola Outbreak. The Journal of Infectious Diseases 217 S6-S15 Journal

154. Hoff NA, Mukadi P, Mukadi D, Doshi RH, Wasiswa J, Vivian H, et al. : Seroprevalence of Ebola Virus among Health Care Workers in Yambuku Health Zone, Democratic Republic of Congo. American Journal of Tropical Medicine and Hygiene 97 447-447

155. Hoff NA, Mukadi P, Doshi RH, Bramble MS, Lu K, Gadoth A, et al. : Serologic Markers for Ebolavirus Among Healthcare Workers in the Democratic Republic of the Congo. The Journal of Infectious Diseases 2018;219(4):517-525 Journal Website

156. Doshi RH, Hoff NA, Bratcher A, Mukadi P, Gadoth A, Nicholson BP, et al. : Risk Factors for Ebola Exposure in Health Care Workers in Boende, Tshuapa Province, Democratic Republic of the Congo. The Journal of Infectious Diseases 2020; Journal Website

157. Gsell P-S, Camacho A, Kucharski AJ, Watson CH, Bagayoko A, Nadlaou SD, et al. : Ring vaccination with rVSV-ZEBOV under expanded access in response to an outbreak of Ebola virus disease in Guinea, 2016: an operational and vaccine safety report. The Lancet Infectious Diseases 2017;17(12):1276-1284 Journal Website

158. Dunn AC, Walker TA, Redd J, Sugerman D, McFadden J, Singh T, et al. : Nosocomial transmission of Ebola virus disease on pediatric and maternity wards: Bombali and Tonkolili, Sierra Leone, 2014. Am J Infect Control 2016;44(3):269-272 Journal Website

159. Matanock A, Arwady MA, Ayscue P, Forrester JD, Gaddis B, Hunter JC, et al. : Ebola Virus Disease Cases Among Health Care Workers Not Working in Ebola Treatment Units — Liberia, June–August, 2014. 2014;63(46):5

160. Cook BWM, Cutts TA, Nikiforuk AM, Leung A, Kobasa D, Theriault SS : The Disinfection Characteristics of Ebola Virus Outbreak Variants. Scientific reports 2016;6 38293 Pubmed Journal

161. Schuit M, Miller DM, Reddick-Elick MS, Wlazlowski CB, Filone CM, Herzog A, et al. : Differences in the Comparative Stability of Ebola Virus Makona-C05 and Yambuku-Mayinga in Blood. PloS one 2016;11(2):e0148476 Pubmed Journal

162. Fischer R, Judson S, Miazgowicz K, Bushmaker T, Prescott J, Munster VJ : Ebola Virus Stability on Surfaces and in Fluids in Simulated Outbreak Environments. Emerging infectious diseases 2015;21(7):1243-6 Pubmed Journal

163. Bibby K, Fischer RJ, Casson LW, de Carvalho NA, Haas CN, Munster VJ : Disinfection of Ebola Virus in Sterilized Municipal Wastewater. PLoS neglected tropical diseases 2017;11(2):e0005299 Pubmed Journal

164. Youkee D, Brown CS, Lilburn P, Shetty N, Brooks T, Simpson A, et al. : Assessment of Environmental Contamination and Environmental Decontamination Practices within an Ebola Holding Unit, Freetown, Sierra Leone. PloS one 2015;10(12):e0145167 Pubmed Journal

165. Bausch DG, Towner JS, Dowell SF, Kaducu F, Lukwiya M, Sanchez A, et al. : Assessment of the risk of Ebola virus transmission from bodily fluids and fomites. The Journal of infectious diseases 2007;196 Suppl 2 S142-7 Pubmed

166. Puro V, Fusco FM, Petrecchia A, Pittalis S, Antonini M, Bordi L, et al. : Sampling Surfaces for Ebola Virus Persistence After Cleaning Procedures in High-Level Isolation Settings: The Experience With 2 Patients at the Lazzaro Spallanzani National Institute for Infectious Diseases. Infection control and hospital epidemiology 2016;37(6):723-5 Pubmed Journal

167. Palich R, Irenge LM, Barte de Sainte Fare E, Augier A, Malvy D, Gala J-L : Ebola virus RNA detection on fomites in close proximity to confirmed Ebola patients; N'Zerekore, Guinea, 2015. PloS one 2017;12(5):e0177350 Pubmed Journal

168. Wu X, Wang H, Yang Y, Zheng Y, Sha L : Investigation for Ebola virus environmental contamination in an Ebola virus disease convalescent ward. The Journal of hospital infection 2015;91(2):185-6 Pubmed Journal

169. Gallandat K, Wolfe MK, Lantagne D : Surface Cleaning and Disinfection: Efficacy Assessment of Four Chlorine Types Using Escherichia coli and the Ebola Surrogate Phi6. Environ Sci Technol 8 Website

170. Cook B, Cutts T, Nikiforuk A, Poliquin P, Court D, Strong J, et al. : Evaluating Environmental Persistence and Disinfection of the Ebola Virus Makona Variant. Viruses 2015;7(4):1975-1986 Journal Website

171. Smither SJ, Eastaugh L, Filone CM, Freeburger D, Herzog A, Lever MS, et al. : Two-Center Evaluation of Disinfectant Efficacy against Ebola Virus in Clinical and Laboratory Matrices. Emerging infectious diseases 2018;24(1):135-9 Pubmed Journal

172. Smither S, Phelps A, Eastaugh L, Ngugi S, O'Brien L, Dutch A, et al. : Effectiveness of Four Disinfectants against Ebola Virus on Different Materials. Viruses 2016;8(7): Pubmed Journal

173. DUPONT Tyvek : What is Tyvek. Website

174. Gallandat K, Kolus RC, Julian TR, Lantagne DS : A systematic review of chlorine-based surface disinfection efficacy to inform recommendations for low-resource outbreak settings. Am J Infect Control 2021;49(1):90-103 Journal Website

175. United States Environmental Protection Agency : Disinfectants for Emerging Viral Pathogens (EVPs): List Q. Website

176. Lantagne D, Wolfe M, Gallandat K, Opryszko M : Determining the Efficacy, Safety and Suitability of Disinfectants to Prevent Emerging Infectious Disease Transmission. Water 2018;10(10): Journal Website

177. Edmunds KL, Elrahman SA, Bell DJ, Brainard J, Dervisevic S, Fedha TP, et al. : Recommendations for dealing with waste contaminated with Ebola virus: a Hazard Analysis of Critical Control Points approach. Bull World Health Organ 2016;94(6):424-432 Journal Website

178. Haverkort JJM, Minderhoud ALC, Wind JDD, Leenen LPH, Hoepelman AIM, Ellerbroek PM : Hospital Preparations for Viral Hemorrhagic Fever Patients and Experience Gained from Admission of an Ebola Patient. Emerg Infect Dis 2016;22(2):184-191 Journal Website

179. Otter JA, Barnicoat M, Down J, Smyth D, Yezli S, Jeanes A : Hydrogen peroxide vapour decontamination of a critical care unit room used to treat a patient with Lassa fever. J Hosp Infect 2010;75(4):335-337 Journal Website

180. Garibaldi BT, Kelen GD, Brower RG, Bova G, Ernst N, Reimers M, et al. : The Creation of a Biocontainment Unit at a Tertiary Care Hospital. The Johns Hopkins Medicine Experience. Annals ATS 2016;13(5):600-608 Journal Website

181. Garibaldi BT, Reimers M, Ernst N, Bova G, Nowakowski E, Bukowski J, et al. : Validation of Autoclave Protocols for Successful Decontamination of Category A Medical Waste Generated from Care of Patients with Serious Communicable Diseases. Journal of clinical microbiology 2017;55(2):545-551 Pubmed Journal

182. Sterk E, Borchet M, Coeur C, Dorion C, Fabiansen C, Flevaud L, et al. : FILOVIRUS HAEMORRHAGIC FEVER GUIDELINE 2008. Médecins Sans Frontières Website

183. World Health Organization : Ebola virus disease (EVD): key questions and answers concerning health care waste. World Health Organization Website

184. World Health Organization, United Nations international Children's Emergency Fund (unicef) : Key questions and answers concerning health-care waste. 2021. World Health Organization Website

185. World Health Organization : Safe management of wastes from health-care activities: a summary. 2017. World Health Organization. Website

186. World Health Organization, United Nations Children's Fund : Ebola virus disease (EVD): key questions and answers concerning water, sanitation and hygiene. (null) Website

187. World Health Organization : Overview of technologies for the treatment of infectious and sharp waste from health care facilities. 2019. World Health Organization Website

188. Dietz PM, Jambai A, Paweska JT, Yoti Z, Ksiazek TG : Epidemiology and risk factors for Ebola virus disease in Sierra Leone-23 May 2014 to 31 January 2015. Clin Infect Dis 2015;61(11):1648-1654 Pubmed Journal Website

189. International Ebola Response Team, Agua-Agum J, Ariyarajah A, Aylward B, Bawo L, Bilivogui P, et al. : Exposure Patterns Driving Ebola Transmission in West Africa: A Retrospective Observational Study. PLoS Med 13(11):e1002170 Journal Website

190. Senga M, Pringle K, Ramsay A, Brett-Major DM, Fowler RA, French I, et al. : Factors Underlying Ebola Virus Infection Among Health Workers, Kenema, Sierra Leone, 2014-2015. Clin Infect Dis 2016;63(4):454-459 Pubmed Journal Website

191. Muoghalu IS, Moses F, Conteh I, Swaray P, Ajudua A, Nordström A : The Transmission Chain Analysis of 2014-2015 Ebola Virus Disease Outbreak in Koinadugu District, Sierra Leone: An Observational Study. Front Public Health 2017;5 160 Pubmed Journal Website

192. Tiffany A, Dalziel B, Johnson G, Bedford J, McClelland A : Quantification of the impact of safe and dignified burials during the 2013-2016 west African ebola virus disease epidemic. American Journal of Infectious Diseases 2016;

193. Lee-Kwan SH, DeLuca N, Bunnell R, Clayton HB, Turay AS, Mansaray Y : Facilitators and Barriers to Community Acceptance of Safe, Dignified Medical Burials in the Context of an Ebola Epidemic, Sierra Leone, 2014. J Health Commun 2017;22(sup1):24-30 Pubmed Journal Website

194. Caleo G, Duncombe J, Jephcott F, Lokuge K, Mills C, Looijen E, et al. : The factors affecting household transmission dynamics and community compliance with Ebola control measures: a mixed-methods study in a rural village in Sierra Leone. BMC Public Health 2018;18(1):248 Journal Website

195. Lyons P, Winters M, Zeebari Z, Schmidt-Hellerau K, Sengeh P, Jalloh MB, et al. : Engaging religious leaders to promote safe burial practices during the 2014-2016 Ebola virus disease outbreak, Sierra Leone. Bull World Health Organ 2021;99(4):271-279 Pubmed Journal Website

196. Sikakulya FK, Ilumbulumbu MK, Djuma SF, Bunduki GK, Sivulyamwenge AK, Jones MK : Safe and dignified burial of a deceased from a highly contagious infectious disease ebolavirus: Socio-cultural and anthropological implications in the Eastern DR Congo. One Health 2021;13 100309 Pubmed Journal Website

197. Gautier L, Houngbedji KA, Uwamaliya J, Coffee M : Use of a community-led prevention strategy to enhance behavioral changes towards Ebola virus disease prevention: a qualitative case study in Western Côte d'Ivoire. Glob Health Res Policy 2017;2 35 Pubmed Journal Website

198. Ratnayake R, Finger F, Azman AS, Lantagne D, Funk S, Edmunds WJ, et al. : Highly targeted spatiotemporal interventions against cholera epidemics, 2000-19: a scoping review. Lancet Infect Dis 2021;21(3):e37-e48 Pubmed Journal

199. Dahl BA KRPACKMHM : CDC's Response to the 2014–2016 Ebola Epidemic — Guinea, Liberia, and Sierra Leone. MMWR and Morbidity and Mortality Weekly Report 2016;65 12-20 Journal Website

200. Cooper C, Fisher D, Gupta N, MaCauley R, Pessoa-Silva CL : Infection prevention and control of the Ebola outbreak in Liberia, 2014–2015: key challenges and successes. BMC Med 2016;14(1):2 Journal Website

201. Mobula LM, Samaha H, Yao M, Gueye AS, Diallo B, Umutoni C, et al. : Recommendations for the COVID-19 Response at the National Level Based on Lessons Learned from the Ebola Virus Disease Outbreak in the Democratic Republic of the Congo. Am J Trop Med Hyg 2020;103(1):12-17 Pubmed Journal

202. Hall S, Poller B, Bailey C, Gregory S, Clark R, Roberts P, et al. : Use of ultraviolet-fluorescence-based simulation in evaluation of personal protective equipment worn for first assessment and care of a patient with suspected high-consequence infectious disease. J Hosp Infect 2018;99(2):218-228 Journal Website

203. Honda H, Iwata K : Personal protective equipment and improving compliance among healthcare workers in high-risk settings. Curr Opin Infect Dis 2016;29(4):400-406 Journal Website

204. Kilinc FS : A Review of Isolation Gowns in Healthcare: Fabric and Gown Properties. Journal of Engineered Fibers and Fabrics 2015;10(3):155892501501000 Journal Website

205. Lee YA, Salahuddin M, Gibson-Young L, Oliver GD : Assessing personal protective equipment needs for healthcare workers. Health Sci Rep 2021;4(3):e370 Pubmed Journal

206. Kilinc-Balci FS, Nwoko J, Hillam T : Evaluation of the Performance of Isolation Gowns. American Journal of Infection Control 2015;43(6):S44 Journal Website

207. McLaws M-L, Chughtai AA, Salmon S, MacIntyre CR : A highly precautionary doffing sequence for health care workers after caring for wet Ebola patients to further reduce occupational acquisition of Ebola. Am J Infect Control 2016;44(7):740-744 Journal Website

208. Andonian J, Kazi S, Therkorn J, Benishek L, Billman C, Schiffhauer M, et al. : Effect of an Intervention Package and Teamwork Training to Prevent Healthcare Personnel Self-contamination During Personal Protective Equipment Doffing. Clin Infect Dis 2019;69(Supplement_3):S248-S255 Journal Website

209. Bell T, Smoot J, Patterson J, Smalligan R, Jordan R : Ebola virus disease: The use of fluorescents as markers of contamination for personal protective equipment. IDCases 2015;2(1):27-30 Pubmed Journal

210. Kwon JH, Burnham CD, Reske KA, Liang SY, Hink T, Wallace MA, et al. : Assessment of Healthcare Worker Protocol Deviations and Self-Contamination During Personal Protective Equipment Donning and Doffing. Infect Control Hosp Epidemiol 2017;38(9):1077-1083 Pubmed Journal

211. Lim SM, Cha WC, Chae MK, Jo IJ : Contamination during doffing of personal protective equipment by healthcare providers. Clin Exp Emerg Med 2015;2(3):162-167 Journal Website

212. Mumma JM, Durso FT, Ferguson AN, Gipson CL, Casanova L, Erukunuakpor K, et al. : Human Factors Risk Analyses of a Doffing Protocol for Ebola-Level Personal Protective Equipment: Mapping Errors to Contamination. Clin Infect Dis 2018;66(6):950-958 Pubmed Journal

213. Mumma JM, Durso FT, Casanova LM, Erukunuakpor K, Kraft CS, Ray SM, et al. : Common Behaviors and Faults When Doffing Personal Protective Equipment for Patients With Serious Communicable Diseases. Clin Infect Dis 2019;69(Supplement_3):S214-S220

Journal Website

214. Wolfe MK, Wells E, Mitro B, Desmarais AM, Scheinman P, Lantagne D : Seeking Clearer Recommendations for Hand Hygiene in Communities Facing Ebola: A Randomized Trial Investigating the Impact of Six Handwashing Methods on Skin Irritation and Dermatitis. PLoS One 2016;11(12):e0167378 Journal Website

215. Wolfe MK, Gallandat K, Daniels K, Desmarais AM, Scheinman P, Lantagne D : Handwashing and Ebola virus disease outbreaks: A randomized comparison of soap, hand sanitizer, and 0.05% chlorine solutions on the inactivation and removal of model organisms Phi6 and E. coli from hands and persistence in rinse water. PLoS One 2017;12(2):e0172734 Journal Website

216. Gao P, Horvatin M, Niezgoda G, Weible R, Shaffer R : Effect of multiple alcohol-based hand rub applications on the tensile properties of thirteen brands of medical exam nitrile and latex gloves. J Occup Environ Hyg 2016;13(12):905-914 Journal Website

217. Tomori O, Bertolli J, Rollin Pierre E, Fleerackers Y, Guimard Y, De Roo A, et al. : Serologic Survey among Hospital and Health Center Workers during the Ebola Hemorrhagic Fever Outbreak in Kikwit, Democratic Republic of the Congo, 1995. J Infect Dis 1999;179(s1):S98-S101 Journal Website

218. Lopaz MA, Amela C, Ordobas M, Dominguez-Berjon MF, Alvarez C, Martinez M, et al. : First secondary case of Ebola outside Africa: epidemiological characteristics and contact monitoring, Spain, September to November 2014. Euro Surveill 2015;20(1): Pubmed Journal

219. Musa EO, Adedire E, Adeoye O, Adewuyi P, Waziri N, Nguku P, et al. : Epidemiological profile of the Ebola virus disease outbreak in Nigeria, July-September 2014. The Pan African medical journal 2015;21 331 Pubmed Journal

220. Ngatu NR, Kayembe NJ-M, Phillips EK, Okech-Ojony J, Patou-Musumari M, Gaspard-Kibukusa M, et al. : Epidemiology of ebolavirus disease (EVD) and occupational EVD in health care workers in Sub-Saharan Africa: Need for strengthened public health preparedness. J Epidemiol 2017;27(10):455-461 Journal Website

221. Amadin J : Comparison of the Effectiveness of Disinfectant-Impregnated Wipes Versus Detergent Wipes for Surface Decontamination. 2021;

222. String GM, Kamal Y, Gute DM, Lantagne DS : Chlorine efficacy against bacteriophage Phi6, a surrogate for enveloped human viruses, on porous and non-porous surfaces at varying temperatures and humidity. Journal of Environmental Science and Health, Part A 2022;57(8):685-693 Journal Website

223. Julian TR, Trumble JM, Schwab KJ : Evaluating Efficacy of Field-Generated Electrochemical Oxidants on Disinfection of Fomites Using Bacteriophage MS2 and Mouse Norovirus MNV-1 as Pathogenic Virus Surrogates. Food Environ Virol 2014;6(2):145-155 Journal Website

224. Park GW, Sobsey MD : Simultaneous Comparison of Murine Norovirus, Feline Calicivirus, Coliphage MS2, and GII.4 Norovirus to Evaluate the Efficacy of Sodium Hypochlorite Against Human Norovirus on a Fecally Soiled Stainless Steel Surface. Foodborne Pathog Dis 2011;8(9):1005-1010 Journal Website

225. Rutala WA, Gergen MF, Weber DJ : Efficacy of Different Cleaning and Disinfection Methods against Clostridium difficile Spores: Importance of Physical Removal versus Sporicidal Inactivation. Infect Control Hosp Epidemiol 2012;33(12):1255-1258 Journal Website

226. Swanson KC, Altare C, Wesseh CS, Nyenswah T, Ahmed T, Eyal N, et al. : Contact tracing performance during the Ebola epidemic in Liberia, 2014-2015. PLoS Negl Trop Dis 2018;12(9):e0006762 Journal Website

Annex: All evidence profiles, sorted by sections

1. Foreword

Clinical Question/ PICO

Population: Staff, communities, and organizations responsible for management of Ebola or Marburg disease cases

Intervention: Implementation of the ring approach, which includes identification of nearby health centres, household and public places visited by the positive case for case finding; environmental cleaning/decontamination; IPC assessment; education; PPE supplies

Comparator: Single intervention, single health facility prioritization

Summary

Initially, 141 studies were screened in the CAL tool software and 16 studies were included for full-text screening. Of these 16 studies, none met the eligibility criteria. However, one non-comparative study was included to provide rates of *Ebolavirus* infection associated with the initiation of the approach*[100]*.

A review of contextual data noted the following:

- The IPC ring approach is based upon the premise that early cluster detection can trigger a rapid, localized response in the high-risk radius around one or more health-care facilities to reduce transmission sufficiently to extinguish an outbreak or reduce its spread. This premise is the operating principle that guides case-area targeted interventions against cholera epidemics*[198]*.
- Although the IPC ring approach showed promise for outbreak control in Liberia, Guinea, Sierra Leone and the Democratic Republic of the Congo, it is critically dependent on IPC training, contact tracing and triage capacities*[199][100][101][200] [201]*.
- IPC ring is an IPC approach that requires effectiveness evaluation. It was developed rapidly and collaboratively in response to an urgent public health need; as such, data were not collected and aggregated systematically across all facilities, potentially limiting the generalizability of these results *[100]*.

A conceptual framework potentially relevant to the implementation of IPC ring intervention was developed. It includes six core constructs:(1) Surveillance, (2) Infrastructure and medical supplies, (3) Workforce, (4) Communication mechanisms, (5) Governance, and (6) Trust, all of which are described in detail below*[107]*.

(1) Surveillance

- Gaps in event-based Ebola disease surveillance systems in Guinea and Ghana led to inadequate early case detection and response preparedness to prevent Ebola virus outbreaks and spread. An absence of Ebola surveillance systems was noted during a 2014 assessment of emergency preparedness in south-eastern Liberia and Guinea. This led to a series of surveillance training workshops and creation of an Ebola incident management system, which enhanced preparedness and reduced Ebola case burden in the region, compared to other areas of these countries.

- Collaboration amongst contact tracing teams, active case-finding teams and case investigation teams resulted in the detection of previously unidentified EVD contacts and the locations of missing contacts in a 2015 cluster outbreak in Monrovia, Liberia.
- Community health monitors in active (and early) case finding, contact tracing and the quarantine of high-risk individuals led to the eventual 2014–15 control of Ebola transmission in Liberia.
- The work of community-appointed Village Health Teams in supporting outbreak response activities resulted in the quick containment of the Ebola and Marburg disease outbreak in Uganda. This strategy of strong community mobilization also increased the willingness of community members to take patients to isolation facilities.

(2) Infrastructure and medical supplies

- Existing studies stress the presence of operationally ready isolation centres that are able to treat patients in as safe an environment as necessary. Studies also reinforce the need to ensure that patients have both geographic and financial access to health-care facilities.
- One study described the important role of a government-NGO partnership in strengthening existing health facility infrastructure for the scale up of services for Ebola virus disease patients at the height of the 2014 outbreak in Sierra Leone. That partnership resulted in the bolstering of PPE supply chains. A lack of basic supplies of gloves, gowns and intravenous fluids were noted in another study as limiting the abilities of front-line HWs. The authors commented that the systems required for high-quality care during a crisis are the same as those required for effective routine health care and chronic disease management. The impact of weak existing medical supply chain systems was revealed in a qualitative study of community HWs in Liberia, where the Ebola virus disease outbreak response interrupted the district supply of essential medicines for community case management of diarrhoea and pneumonia.

(3) Workforce

- Three articles reinforced the need for a strong health workforce appropriately distributed at the sub-national level, rather than just a target aggregate number of HWs nationally. Continuity of HW training, particularly around infection, prevention and control, was stressed as a critical aspect of emerging infectious disease prevention.

(4) Communication mechanisms

- A scoping review found 23 articles illustrating communication mechanisms underpinning effective emerging infectious disease prevention and response. Ten of these reinforced the necessity of devising a risk-communication strategy to guide a timely, coordinated and standardized approach to information sharing during outbreak management. The importance of partnerships between national health organizations and media agencies to ensure dissemination of clinically accurate messages supportive of prevention and control efforts during public health emergencies was confirmed in a further eight articles.
- The valuable role of community members as key players in risk communication activities was widely acknowledged.
- Established and documented protocols, guidelines and procedures were widely affirmed by the literature as integral elements of the communications mechanisms associated with emerging infectious disease preparedness. For secondary and tertiary health facilities, these included a HW protocol for infectious disease management, security protocols for both facility infrastructure and personnel, and procedures for patient isolation.

(5) Governance

- Governance here refers to a relational view emphasizing the making, changing, monitoring and enforcing of the rules that govern the demand for and supply of health services. Leadership and coordination across global, regional, national and sub-national levels were presented as critical enablers of an effective, cohesive response to emerging infectious disease threats.
- The capacity of governments to engage and collaborate with non-state actors and civil society was another facet of good governance identified as supporting health system preparedness for emerging infectious diseases. Central to such effective engagement and partnerships is the ability, in the event of an outbreak, to mobilize additional resources – including emergency teams of clinicians and logistics personnel, community resources, and national and international non-government organizations.

(6) Trust

The concept of trust – from the community level through to global governance – emerged as a fundamental element of

health system preparedness for an emerging infectious disease (EID) outbreak, extending across each of the five identified core constructs. The notion of trust has been defined as encompassing both interpersonal trust between, for example, patient and provider, as well as institutional trust between individuals/communities and the health system or government.

Outcome Timeframe	**Study results and measurements**	**Comparator** Single intervention, Single health facility prioritization	**Intervention** Implement the ring approach, which includes identification of n	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Transmission of Ebola or Marburg, score of IPC standard in the HCF	(Observational (non-randomized))			Very low Due to serious risk of bias, Due to serious imprecision [1]	We are uncertain whether implementing the ring approach, increases or decreases transmission of Ebola or Marburg disease, or improves IPC scores in health care facilities

1. **Risk of Bias: serious.** 4/9 on NOS; downrated for lack of comparator group, no demonstration that the outcome of interest was not present at the start of study and a lack of reporting of outcome follow-up for study participants. due to [reason]. **Inconsistency: no serious. Indirectness: no serious. Imprecision: serious.** Only data from one study.

11.1. Isolation and management of suspect or confirmed cases

11.1.1. Patient placement

11.2. Screening and triage recommendations

11.2.1. Screening and triage activities

12. Personal protective equipment (PPE)

12.1. Medical scrubs and footwear

12.2. PPE for screening and triage activities for Ebola virus disease or Marburg virus disease

12.2.1. PPE when screening for Ebola or Marburg virus disease

Clinical Question/ PICO

Population: Health workers conducting Ebola disease or Marburg disease related screening activities when a distance of at least 1m cannot be maintained

Intervention: Face shield and medical mask

Comparator: Face shield alone

Summary

Initial searches and screening for key questions on face shields versus masks and gowns versus coveralls were performed together due to the similarity of the questions under the theme of personal protective equipment use for health and care workers during screening and triage activities. A total of 393 studies were screened in the CAL tool software and 86 studies were included for full-text screening. Two systematic reviews were identified to be of potential interest *[116][117]*.The included studies in these reviews were reviewed to determine if they addressed the key questions. While the reviews provided some contextual information, none of the 86 reviewed studies or the studies included in the two systematic reviews met the eligibility criteria for either key question.

With respect to the extraction of contextual data, the key findings are as follows:

- Basic PPE ensemble (gloves,surgical mask and visor)did not seem to work as well as more protected PPE ensemble('gown model' or a 'coverall model')*[202]*.
- PPEs with more protective gear protected against contamination in simulation studies slightly better but felt more uncomfortable to health and care workers including *[117]*:
  - gowns led to less contamination than aprons
  - two pairs of gloves led to less contamination than only one pair of gloves.
- The peak of contagiousness is around the time of death but patients presenting to health-care facilities and undergoing screening/triage often do so after the onset of symptoms, or they are contagious at the time of screening and triage *[7]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** face shield alone	**Intervention** face shield and medical mask	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg.				The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: Infection with Ebola or Marburg	No studies were found that looked at infection with ebola or marburg.
PPE breaches,(touching face)				The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in	No studies were found that looked at ppe breaches,(touching face)

Outcome Timeframe	**Study results and measurements**	**Comparator** face shield alone	**Intervention** face shield and medical mask	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
				combination with a medical mask) on the following outcomes: PPE breaches.	
Compliance and/or breaches (touching face) related to heat/ humidity and comfort,				The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: Compliance related to heat/ humidity and comfort, human factors, health worker confidence.	No studies were found that looked at compliance related to heat/humidity and comfort,

Clinical Question/ PICO

Population: Health workers performing screening activities in health care facility or ETU ;Health care facilities, ETU *Contexts to consider: ETU use vs. healthcare facility; outbreak vs readiness vs. high alert scenario.

Intervention: Wearing a gown (in addition to medical scrubs, mask and face shield, gloves)

Comparator: Wearing coverall (in addition to medical scrubs, mask and face shield, gloves)

Summary

Initial searches and screening for key questions on face shields versus masks and gowns versus coveralls were performed together due to the similarity of the questions under the theme of personal protective equipment use for health and care workers during screening and triage activities. A total of 393 studies were screened in the CAL tool software and 86 studies were included for full-text screening. Two systematic reviews were identified to be of potential interest *[116][117]*. The included studies in these reviews were reviewed to determine if they addressed the key questions. While the reviews provided some contextual information, none of the 86 reviewed studies or the studies included in the two systematic reviews met the eligibility criteria for either key question.

With respect to the extraction of contextual data, the key findings are as follows:

- Basic PPE ensemble (gloves, surgical mask and visor) did not seem to work as well as more protected PPE ensemble ('gown model' or a 'coverall model')*[202]*.
- PPEs with more protective gear protected against contamination in simulation studies slightly better but felt more uncomfortable to health and care workers including *[117]*:
  - gowns led to less contamination than aprons
  - two pairs of gloves led to less contamination than only one pair of gloves.

- The peak of contagiousness is around the time of death but patients presenting to health-care facilities and undergoing screening/triage often do so after the onset of symptoms, or they are contagious at the time of screening and triage *[7]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** wearing coverall (in addition to medical scrubs, mask and face	**Intervention** wearing a gown (in addition to medical scrubs, mask and face s	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg.	(Observational (non-randomized))			The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: Infection with Ebola or Marburg	No studies were found that looked at infection with Ebola or Marburg.
PPE breaches.				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: PPE breaches	No studies were found that looked at ppe breaches.
Heat and comfort, human factors, health worker confidence.				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: Compliance related to heat and comfort, human factors, health worker confidence	No studies were found that looked at heat and comfort, human factors, health worker confidence.

Clinical Question/ PICO

Population: Health workers conducting screening activities where 1 m distance and no touch technique can be maintained and PPE (such as gown, and facial protection) is not expected

Intervention: No gloves and perform hand hygiene

Comparator: 1 pair of gloves

Summary

A total of 273 studies were screened in the CAL tool software and 74 studies were included for full-text screening.No studies met the eligibility criteria. The majority of studies at the full-text stage were excluded because HWs in the studies were not performing screening or triage activities, or because there was no relevant intervention/comparator.

A summary of contextual data is below:

- Infection risk among health workers conducting screening while distancing is unknown.
- Infection risk among health workers conducting triage is virtually unknown
- Among 82 contacts identified in Sierra Leon 2014, 6 contacts (7%) involved taking vital signs with short gloves and none of the six contacts developed EVD*[158]*.
- No data on the context for PPE screening as well as its effectiveness.
- In a simulation study of *contact precaution* PPE, which consists of gloves and a gown, deviations from doffing protocol and self-contamination were common.

Outcome Timeframe	**Study results and measurements**	**Comparator**	**Intervention**	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
EVD/Marburg transmission to health workers conducting screening activities				**Very low** No studies met the eligibility criteria.	No studies were found that looked at evd/ marburg transmission to health workers conducting screening activities wearing no gloves versus 1 pair of gloves

12.2.2. PPE for triage for Ebola or Marburg virus disease

Clinical Question/ PICO

Population: Health workers conducting EVD or Marburg virus disease related triage activities .

Intervention: Face shield and medical mask

Comparator: Face shield alone

Summary

Initial searches and screening for key questions on face shields versus masks and gowns versus coveralls were performed together due to the similarity of the questions under the theme of personal protective equipment use for health and care workers during screening and triage activities. A total of 393 studies were screened in the CAL tool software and 86 studies were included for full-text screening. Two systematic reviews were identified to be of potential interest *[116][117]*. The included studies in these reviews were reviewed to determine if they addressed the key questions. While the reviews provided some contextual information, none of the 86 reviewed studies or the studies included in the two systematic reviews met the eligibility criteria for either key question.

With respect to the extraction of contextual data, the key findings are as follows:

- Basic PPE ensemble (gloves,surgical mask and visor) did not seem to work as well as more protected PPE ensemble('gown model' or a 'coverall model')*[202]*.
- PPEs with more protective gear protected against contamination in simulation studies slightly better but felt more uncomfortable to health and care workers including *[117]*:
  - gowns led to less contamination than aprons
  - two pairs of gloves led to less contamination than only one pair of gloves.
- The peak of contagiousness is around the time of death but patients presenting to health-care facilities and undergoing screening/triage often do so after the onset of symptoms, or they are contagious at the time of screening and triage *[7]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** face shield alone	**Intervention** face shield and medical mask	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg.				The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: Infection with Ebola or Marburg	No studies were found that looked at infection with Ebola or Marburg.
PPE breaches,(touching face)				The systematic review did not identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: PPE breaches.	No studies were found that looked at ppe breaches,(touching face)
Compliance related to heat/				The systematic review did not	No studies were found that looked at

Outcome Timeframe	**Study results and measurements**	**Comparator** face shield alone	**Intervention** face shield and medical mask	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
humidity and comfort, human factors, health worker confidence				identify any evidence for the effects of wearing a face shield (compared to wearing a face shield in combination with a medical mask) on the following outcomes: Compliance related to heat/ humidity and comfort, human factors, health worker confidence	compliance related to heat/humidity and comfort, human factors, health worker confidence

Clinical Question/ PICO

Population: Health workers conducting Ebola or Marburg virus disease related triage activities
Intervention: Coverall
Comparator: Gown

Summary

Initial searches and screening for key questions on face shields versus masks and gowns versus coveralls were performed together due to the similarity of the questions under the theme of personal protective equipment use for health and care workers during screening and triage activities. A total of 393 studies were screened in the CAL tool software and 86 studies were included for full-text screening. Two systematic reviews were identified to be of potential interest *[116][117]*. The included studies in these reviews were reviewed to determine if they addressed the key questions. While the reviews provided some contextual information, none of the 86 reviewed studies or the studies included in the two systematic reviews met the eligibility criteria for either key question.

With respect to the extraction of contextual data, the key findings are as follows:

- Basic PPE ensemble (gloves, surgical mask and visor) did not seem to work as well as more protected PPE ensemble ('gown model' or a 'coverall model')*[202]*.
- PPEs with more protective gear protected against contamination in simulation studies slightly better but felt more uncomfortable to health and care workers including *[117]*:
  - gowns led to less contamination than aprons
  - two pairs of gloves led to less contamination than only one pair of gloves.
- The peak of contagiousness is around the time of death but patients presenting to health-care facilities and undergoing screening/triage often do so after the onset of symptoms, or they are contagious at the time of screening and triage *[7]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** gown	**Intervention** coverall	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg,				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown)	No studies were found that looked at infection with Ebola or Marburg wearing a gown versus a coverall when conducting triage
PPE breaches				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) for PPE breaches.	No studies were found that looked at ppe breaches
Compliance related to heat and comfort, human factors, health worker confidence				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: Compliance related to heat and comfort, human factors, health worker confidence	No studies were found that looked at compliance related to heat and comfort, human factors, health worker confidence.

Clinical Question/ PICO

Population: Health workers conducting screening and/or triage activities where at least 1 m distance cannot be maintained, and PPE (such as gown, and facial protection) is expected

Intervention: 2 pair of gloves

Comparator: 1 pair of gloves

Summary

A total of 273 studies were screened in the CAL tool software and 74 studies were included for full-text screening.

Two systematic reviews were identified to be of potential interest*[116][117]*. The included studies in these reviews were reviewed to determine if they met the eligibility criteria for either key question. No studies met the eligibility criteria. The *[118]* majority of studies at the full-text stage were excluded because HWs in the studies were not performing screening or triage activities, or because there was no relevant intervention/comparator.

From the Verbeek at al. systematic review *[117]*, one additional article was identified which discussed the compared effect of wearing double gloves versus single gloves on Ebola contamination rates while performing PPE donning/doffing activities *[118]*. Although it did not meet the eligibility criteria (not in HWs performing screening/triage activities), the results were noted and are discussed in the contextual data.

Double vs. Single Gloves during Doffing

Casanova et al 2012 compared HCW self-contamination after the simulation of doffing PPE (not performing screening or triage activities) with single gloves versus double gloves, using MS2 as a marker. Although double gloves reduced viral transfer, MS2 was still recovered from the hands of 23% of HCWs after doffing double gloves. This is compared to participants who wore single gloves, where MS2 was recovered from hands in 78% of HCWs. The authors concluded that glove removal appears to be a high-risk opportunity for HCW self-contamination *[118]*.

Honda et al. published a narrative review of advantages/disadvantages of PPE used among HCWs in high-risk settings including EVD outbreaks. Regarding double gloving, potential advantages mentioned were that (1) it decreases the potential risk of transmission of highly virulent pathogens through glove holes or glove damage due to using disinfectant, (2) reduces the risk of contamination of hands when removing gloves, and (3) it reduces the risk of needlestick injury. Disadvantages mentioned were (1) decreased tactile sensation and dexterity, and (2) a cumbersome removal process *[203]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** 1 pair of gloves	**Intervention** 2 pair of gloves	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
EVD/Marburg transmission to health workers conducting screening and/or triage activities				**Very low** No studies met the eligibility criteria The majority of studies at the full-text stage were excluded because HCWs in the studies were not performing screening or triage activities, or because there was no relevant intervention/comparator.	We are uncertain whether 2 pair of gloves increases or decreases evd/marburg transmission to health workers conducting screening and/or triage activities

12.3. PPE for those providing direct and indirect care to patients

Clinical Question/ PICO

Population: Health workers in health care facilities

Intervention: Goggles
Comparator: Face shield

Summary

No comparative evidence found. No estimate of effectiveness

Outcome Timeframe	Study results and measurements	Comparator Face shield	Intervention Goggles	Certainty of the Evidence (Quality of evidence)	Plain language summary
Prevention of virus transmission to health care provider [1]				Very low	No studies were found that looked at prevention of virus transmission to health care provider
Fogging, reduced visibility. [2]				Very low	No studies were found that looked at fogging, reduced visibility.
Inadvertent touching of face				Very low	No studies were found that looked at inadvertent touching of face.

1. No comparative evidence. No estimate of effectiveness
2. No comparative evidence. No estimate of effectiveness.

Clinical Question/ PICO

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.

Summary

No comparative evidence. No estimate of effectiveness.

Outcome Timeframe	**Study results and measurements**	**Comparator** medical (surgical) mask.	**Intervention** particulate respirators (N95 or equivalent mask) for use by sta	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Prevention of virus transmission to health care providers				**Low** Low quality evidence comparing medical or surgical mask with particulate respirator.	No studies were found that looked at prevention of virus transmission to health care providers
Comfort and dexterity with use under conditions of high ambient temperature				**Low** Low quality evidence comparing medical or surgical mask with particulate respirator	No studies were found that looked at comfort and dexterity with use under conditions of high ambient temperature

Clinical Question/ PICO

Population: Health workers conducting Ebola or Marburg virus disease related triage activities
Intervention: Coverall
Comparator: Gown

Summary

Initial searches and screening for key questions on face shields versus masks and gowns versus coveralls were performed together due to the similarity of the questions under the theme of personal protective equipment use for health and care workers during screening and triage activities. A total of 393 studies were screened in the CAL tool software and 86 studies were included for full-text screening. Two systematic reviews were identified to be of potential interest *[116][117]*. The included studies in these reviews were reviewed to determine if they addressed the key questions. While the reviews provided some contextual information, none of the 86 reviewed studies or the studies included in the two systematic reviews met the eligibility criteria for either key question.

With respect to the extraction of contextual data, the key findings are as follows:

- Basic PPE ensemble (gloves, surgical mask and visor) did not seem to work as well as more protected PPE ensemble ('gown model' or a 'coverall model')*[202]*.
- PPEs with more protective gear protected against contamination in simulation studies slightly better but felt more uncomfortable to health and care workers including *[117]*:
  - gowns led to less contamination than aprons
  - two pairs of gloves led to less contamination than only one pair of gloves.
- The peak of contagiousness is around the time of death but patients presenting to health-care facilities and undergoing screening/triage often do so after the onset of symptoms, or they are contagious at the time of screening and triage *[7]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** gown	**Intervention** coverall	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg,				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown)	No studies were found that looked at infection with Ebola or Marburg wearing a gown versus a coverall when conducting triage
PPE breaches				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) for PPE breaches.	No studies were found that looked at ppe breaches
Compliance related to heat and comfort, human factors, health worker confidence				The systematic review did not identify any evidence for the effects of wearing a coverall (compared to wearing a gown) on the following outcomes: Compliance related to heat and comfort, human factors, health worker confidence	No studies were found that looked at compliance related to heat and comfort, human factors, health worker confidence.

Clinical Question/ PICO

Population: Health workers conducting screening and/or triage activities where at least 1 m distance cannot be maintained, and PPE (such as gown, and facial protection) is expected

Intervention: 2 pair of gloves

Comparator: 1 pair of gloves

Summary

A total of 273 studies were screened in the CAL tool software and 74 studies were included for full-text screening. Two systematic reviews were identified to be of potential interest*[116][117]*. The included studies in these reviews were reviewed to determine if they met the eligibility criteria for either key question. No studies met the eligibility criteria. The *[118]* majority of studies at the full-text stage were excluded because HWs in the studies were not performing screening or triage activities, or because there was no relevant intervention/comparator.

From the Verbeek at al. systematic review *[117]*, one additional article was identified which discussed the compared effect of wearing double gloves versus single gloves on Ebola contamination rates while performing PPE donning/doffing activities *[118]*. Although it did not meet the eligibility criteria (not in HWs performing screening/triage activities), the results were noted and are discussed in the contextual data.

Double vs. Single Gloves during Doffing

Casanova et al 2012 compared HCW self-contamination after the simulation of doffing PPE (not performing screening or triage activities) with single gloves versus double gloves, using MS2 as a marker. Although double gloves reduced viral transfer, MS2 was still recovered from the hands of 23% of HCWs after doffing double gloves. This is compared to participants who wore single gloves, where MS2 was recovered from hands in 78% of HCWs. The authors concluded that glove removal appears to be a high-risk opportunity for HCW self-contamination *[118]*.

Honda et al. published a narrative review of advantages/disadvantages of PPE used among HCWs in high-risk settings including EVD outbreaks. Regarding double gloving, potential advantages mentioned were that (1) it decreases the potential risk of transmission of highly virulent pathogens through glove holes or glove damage due to using disinfectant, (2) reduces the risk of contamination of hands when removing gloves, and (3) it reduces the risk of needlestick injury. Disadvantages mentioned were (1) decreased tactile sensation and dexterity, and (2) a cumbersome removal process *[203]*.

Outcome Timeframe	**Study results and measurements**	**Comparator** 1 pair of gloves	**Intervention** 2 pair of gloves	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
EVD/Marburg transmission to health workers conducting screening and/or triage activities				**Very low** No studies met the eligibility criteria The majority of studies at the full-text stage were excluded because HCWs in the studies were not performing screening or triage activities, or because there was no relevant intervention/comparator.	We are uncertain whether 2 pair of gloves increases or decreases evd/marburg transmission to health workers conducting screening and/or triage activities

Clinical Question/ PICO

Population: Staff working in health care facilities, ETU
Intervention: Wear a disposable waterproof apron
Comparator: 1) Wear a reusable waterproof heavy-duty apron, 2) wear a biodegradable waterproof apron

Summary

A total of 120 studies were screened in the CAL tool software and 39 studies were included for full-text screening. No studies met the eligibility criteria.

With respect to the extraction of contextual data, the key findings are as follows:

Disposable (single-use) isolation gowns are designed to be discarded after a single use and are typically constructed of nonwoven materials alone or in combination with materials that offer increased protection from liquid penetration, such as plastic films. They can be produced using a variety of nonwoven fiber-bonding technologies (thermal, chemical, or mechanical) to provide integrity and strength rather than the interlocking geometries associated with woven and knitted materials. The basic raw materials typically used for disposable isolation gowns are various forms of synthetic fibers (e.g. polypropylene, polyester, polyethylene). Fabrics can be engineered to achieve desired properties by using particular fiber types, bonding processes, and fabric finishes (chemical or physical treatments*[204]*.

Reusable (multi-use) gowns are laundered after each use. Reusable isolation gowns are typically made of 100% cotton, 100% polyester, or polyester/cotton blends. These fabrics are tightly woven plain weave fabrics that are chemically finished and may be pressed through rollers to enhance the liquid barrier properties. Reusable garments generally can be used for 50 or more washing and drying cycles. The number of laundering/drying cycles is suggested by the manufacturer. According to a guidance by the Association for the Advancement of Medical Instrumentation, a verifiable tracking system, such as a manual check off, bar code, or radio frequency chip, a verifiable tracking system, must be in place*[204]*.

According to the setup of a simulation study*[129]*, personal protective clothing PPC2 was composed of absorbent cotton fabric (zero value for water repellency and liquid penetration pressure) with the greatest thickness. PPC1 and PPC3 had grades 4 and 5 of water repellency, high resistance to liquid water penetration, and thinner fabric. PPC2 carried the lowest contaminative hazards to the hands, shoes, and surroundings compared with PPC1 and PPC3. Cotton through its material and properties can absorb droplet contaminants and thereby reduce opportunities for such contaminants to spread to the environment. However, the absorbent fabric likewise increased underwear contamination by liquid crossing outerwear.

Plastic aprons (PPC3) had a higher chance of contaminating the environment than PPC1 and PPC2*[129]*. Because plastic had the lowest water-absorbing properties, the droplets that cannot be absorbed by the surface of the plastic might then drop to the floor or spread to the surrounding area, which especially increased contamination with large patches. The plastic apron had a smaller covered area, which also caused heavier underwear contamination (or the contamination of the next layer of the PPE ensemble).

The results of this simulation study indicate that the traditional cotton surgical gown (woven gown) can absorb liquid contaminants and thus reduces environmental contamination. The other gown (nonwoven gown) can resist the absorption of liquid contaminants when the covered area is sufficient and thus provides better physical barrier protection than the woven gown. However, the nonwoven gown has weak liquid absorption ability. The liquid contaminant may easily drop to the floor or splash to the surrounding environment during movement. More important, an extra force added to the movement, such as by pulling off the isolation gown without unfastening the ties, tearing off the plastic apron, or removing the gown or apron forcefully, spreads droplet contaminants that can splash not only to the surrounding environment but also to nearby patients*[129]*.

The present results suggest that double gowns with outer absorbent cotton reduce the spread of contaminants to the environment, whereas inner water repellency gowns can resist contaminants and prevent them from penetrating into underwear and even the skin, providing better protection than a single gown in preventing HW from coming into contact with patients' blood and body fluids during splashing procedures*[129]*.

Lee et al. 2021 assessed PPE needs for health workers by surveying a convenient sample of 200 HWs in the US *[205]*. PPE design features were assessed on a five-point Likert-type scale, ranging from "strongly disagree" (1) to "strongly agree" (5). The mean values of PPE were higher than 3 (on the 1-5 scale) for fit (mean = 3.45, SD = 0.56), comfort (M = 3.38, SD = 0.72), mobility (M = 3.44, SD = 0.69), and donning and doffing (M = 3.71, SD = 0.87), suggesting that HWs think that current PPE (scrubs, gowns, coveralls, and apron) for body protection meet their needs of fit, comfort, mobility, and donning and doffing.

With respect to body protection, 31% of the participants considered comfortability as the biggest challenge when wearing PPE, followed by sizing and fit (27%), donning and doffing (14%), movement (12%), material durability (12%), and others (3%) such as easy to use and PPE weight. HWs are more likely "Strongly agree" than "Strongly disagree" to accept PPE based on the donning and doffing feature, odds ratio = 2.37, 95% confidence interval [0.48, 11.61], which means that the donning and doffing feature plays a vital role on HWs' overall PPE acceptance *[205]*.

Poller et al 2018*[137]*conducted a simulation study and organized a consensus panel to identify a unified PPE ensemble for clinical response to possible high consequence infectious diseases in the United Kingdom. The consensus ensemble provided full protection against contamination in the simulation study. This ensemble included wide, extra-long medium thickness plastic apron (such as those worn for endoscopy). A higher fit to protect the upper chest is desired and no such apron existed. Tearing the neck loop in the middle so both the neck and waist areas were tied was deemed an acceptable and simple modification, which significantly improved protection.

Kilinc-Balci et al. 2015 *[206]* tested 22 commercial single-use isolation gowns for barrier and strength properties using American Society of Testing and Materials International ASTM (D5034, D5733, D1683, F1671) and American

Association of Textile Chemists and Colorists (AATCC 42 and 127) test methods and the Association for the Advancement of Medical Instrumentation (AAMI) PB70 liquid barrier classification standard requirements. Testing results demonstrated that there is a large variation in the barrier and strength properties of existing isolation gowns in the marketplace. It was also found that nine (41%) of the 22 tested isolation gowns failed to meet the AAMI PB70 requirements for the liquid barrier performance at the level specified by the manufacturer. The results support the use of aprons for additional protection.

Outcome Timeframe	**Study results and measurements**	**Comparator** 1) wear a reusable waterproof heavy-duty apron, 2) Wear a biode	**Intervention** Wear a disposable waterproof apron	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Environmental impact of single-use disposable PPE,				No studies met the eligibility requirements.	No studies were found that looked at environmental impact of single-use disposable ppe.
Exposures while cleaning and disinfecting aprons,				No studies met the eligibility criteria.	No studies were found that looked at exposures while cleaning and disinfecting aprons,
Breaches in cleaning and disinfection practice				No studies met the eligibility criteria.	No studies were found that looked at breaches in cleaning and disinfection practice
Infection/ transmission of EVD,				No studies met the eligibility criteria.	No studies were found that looked at infection/ transmission of evd,
PPE breaches/ exposures, ease of doffing PPE				No studies met the eligibility criteria.	No studies were found that looked at ppe breaches/exposures, ease of doffing ppe.

Clinical Question/ PICO

Population: Health workers in direct contact and/or indirect contact to patients with Ebola Virus Disease (EVD) or Marburg virus disease

Intervention: A cover for the head and neck

Comparator: No cover for the head and neck

Summary

Initially, 137 studies were screened in the CAL tool software and 42 studies were included for full-text screening. Four studies met the eligibility criteria and were included.

No studies provided direct information on the transmission or incidence of EVD or Marburg virus disease related to the use of personal protective equipment (PPE) for head and neck skin protection. Two simulation studies that addressed outcomes related to heat stress for health care workers (HCW) donning extra head/neck covering PPE (hoods) were included *[124][125]*. Additionally, two crossover randomized controlled trials that simulated contamination events for HCWs while doffing PPE ensembles with and without neck covering were included*[126][127]*.

Overall, for heat tolerance outcomes, very low certainty evidence that PPE ensembles with additional head/neck covering increased both physiological and subjective measures of heat exhaustion, compared to PPE with no cover of the head and neck was found. Low to very low certainty of evidence that PPE ensembles with head/neck covering resulted in less contamination than PPE with no cover for the head and neck and low to very low certainty evidence that PPE ensembles that covered the head/neck resulted in more human errors during donning/doffing of equipment, compared to ensembles without head/neck cover was found.

With respect to the extraction of contextual data, the key findings are as follows .

- Zamora et al. 2006 *[127]* conducted a prospective, randomized, controlled crossover study to compare two PPE ensembles. The PPE ensemble E-RCP (enhance respiratory and contact precautions) included a head covering (without covering the neck skin), goggles and a face shield. The PAPR system in use had outer and inner protective layers. According to the results, participants wearing E-RCP were more likely to experience skin and base-clothing contamination; their contamination episodes measuring ≥1 cm2 were more frequent, and they had larger total areas of contamination (all p < 0.0001> The anterior neck, forearms, wrists and hands were the likeliest zones for contamination. Participants donning powered air-purifying respirator (PAPR) committed more donning procedure violations (p = 0.0034). Donning and removing the PAPR system took longer than donning and removing E-RCP garments (p < 0.0001).

- Suen et al. 2018 *[36]* conducted an experimental study using a group of 59 participants who randomly performed PPE donning and doffing. The study consisted of PPE donning, applying fluorescent solution on the PPE surface, PPE doffing of participants, and estimation of the degree of contamination as indicated by the number of fluorescent stains on the working clothes and environment. They monitored protocol deviations during PPE donning and doffing. They tested three PPE ensembles: PPE1 consists of a neck-to-ankle outfit, N95 respirator, **hood,** disposable face shield, surgical gown, boots and double gloves. PPE2 consists of a *head-to-ankle* coverall, N95 respirator, hood, disposable face shield, boots and double gloves. PPE3 consists of neck-to-ankle outfit, N95 respirator, **no hood**, disposable face shield, isolation gown, shoes and single latex gloves. Everything else being equal, PPE1 differed from PPE3 with respect to hood (PPE1) vs no hood (PPE3), double gloves (PPE1) vs single gloves (PPE3), and boots (PPE1) vs shoes (PPE3). During doffing of the PPE, PPE1 was less contaminated in regions purportedly protected by the hood, including hair, head and neck than PPE3. The results seemed to support covering the head and neck skin.

- Coca et al. 2015 *[125]* conducted a simulation study using a thermal manikin to assess the time to achievement of a critical core temperature of 39°C while wearing 4 different PPE ensembles similar to those recommended by the World Health Organization and Médecins Sans Frontières at 2 different ambient conditions: temperature/humidity of 32°C/92% relative to 26°C/80%). The results suggest that encapsulation of the head and neck region resulted in higher model-predicted subjective impressions of heat sensation.

- Coca et al. 2017 *[124]* conducted a simulation study with six healthy individuals in an environmental chamber (32°C, 92% relative humidity) while walking (3 Metabolic equivalent of tasks, 2.5 mph, 0% incline) on a treadmill for 60 minutes. All subjects wore medical scrubs and PPE items. Ensemble E1 had a face shield, **no hood**, and fluid-resistant surgical gown; E2 additionally included goggles, coverall, and separate **hood**; and E3 also contained a highly impermeable coverall, separate **hood**, and surgical mask cover over the N95 respirator. They showed that heart rate and core temperature at the end of the exercise were significantly higher for E2 and E3 than for E1.

Subjective perceptions of heat and exertion were significantly higher for E2 and E3 than for E1.

- Den Boon et al. 2014 *[36]* conducted a survey of frontline physicians' and nurses' perspectives about PPE use during the 2014-2016 EVD outbreak in West Africa. The aim was to incorporate these findings into the development process of a WHO rapid advice guideline. They surveyed 44 frontline physicians and nurses deployed to West Africa between March and September of 2014. They report that heat and dehydration were a major issue for 64% of the surveyees using a hood. In terms of preferences, a hood was perceived as pausing extremely low risk or low risk in term of safety by 93% (38/41) of surveyees, none or minor impairment in term of communication by 58% (18/42), no reduction or minor reduction in term of the ability to provide patient care by 60% (18/30), no issues or minor issues in term of personal wellbeing (heat or dehydration) by 13% (4/30), and comfortable or fairly comfortable by 53% (16/30).

- Grélot et al. 2016 *[130]* assessed thermal strain of 25 HWs in the 2014 Ebola virus disease outbreak. The PPE was used in accordance with the World Health Organization regulations. Its ensemble was comprised of waterproof garments from head to toe (DuPont Tychem), European standard EN 143–approved class 2 respirators (3M Company), 2-layered gloves, **surgical hoods** covering the head and neck, leg-covering waterproof boot covers, and waterproof aprons covering the torso to the level of the mid-calf. They report a mean (standard deviation) working ambient temperature of 29.6°C (2.0°C) and a mean relative humidity of 65.4% (10.3%), a mean time wearing PPE of 65.7 (13.5) minutes, and a mean core body temperature increase of 0.46°C (0.20°C). Four HCWs (16%, 4/25) reached or exceeded a mean core body temperature of ≥38.5°C. The results suggest that HWs wearing PPE for approximately 1 hour exhibited moderate but safe thermal strain.

- Sprecher et al. 2015 *[131]* report on a meeting convened by Médecins Sans Frontières in 2014 to address concerns with PPE. Meeting participants included representatives from the CDC Viral Special Pathogens Branch, the World Health Organization, the National Institutes of Health's Integrated Research Facilities at Frederick, Maryland and Rocky Mountain Laboratories, the Galveston National Laboratory, the Public Health Agency of Canada's Special Pathogens Unit, the PPE divisions of DuPont, 3M, and Microgard, and the CDC National Institute for Occupational Safety and Health. According to the meeting deliberation, *polyethylene fabric hoods* that fully covered the head and neck became favored over surgical head covering. The meeting attendants called for better evidence in the selection of PPE's.

Outcome Timeframe	**Study results and measurements**	**Comparator** No Head/Neck Cover	**Intervention** Head/Neck Cover	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Overall deviation rate (%) during donning of PPE - PP1 vs PPE3	Relative risk Based on data from 118 participants in 1 studies. (Randomized controlled)	**37** per 1000		**Low** Due to serious indirectness, Due to serious imprecision [1]	Head/neck cover may have little or no difference on overall deviation rate (%) during donning of ppe - pp1 vs ppe3
Overall deviation rate (%) during donning of PPE - PPE2 vs PPE3	Based on data from 118 participants in 1 studies. (Randomized controlled)	**37** per 1000		**Low** Due to serious indirectness, Due to serious imprecision [2]	Head/neck cover may have little or no difference on overall deviation rate (%) during donning of ppe - ppe2 vs ppe3

Outcome Timeframe	**Study results and measurements**	**Comparator** No Head/Neck Cover	**Intervention** Head/Neck Cover	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Deviation rate (%) during donning of hood - PPE1 vs PPE3	Based on data from 118 participants in 1 studies. (Randomized controlled)	0 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [3]	Head/neck cover probably has little or no difference on deviation rate (%) during donning of hood - ppe1 vs ppe3
Deviation rate (%) during donning of hood - PPE2 vs PPE3	Based on data from 118 participants in 1 studies. (Randomized controlled)	0 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [4]	Head/neck cover may have little or no difference on deviation rate (%) during donning of hood - ppe2 vs ppe3
Deviation rate (%) during donning of faceshield - PPE1 vs PPE3	Relative risk Based on data from 118 participants in 1 studies. (Randomized controlled)	67 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [5]	Head/neck cover may have little or no difference on deviation rate (%) during donning of faceshield - ppe1 vs ppe3
Deviation rate (%) during donning of faceshield - PPE2 vs PPE3	Based on data from 118 participants in 1 studies. (Randomized controlled)	67 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [6]	Head/neck cover may have little or no difference on deviation rate (%) during donning of faceshield - ppe2 vs ppe3
Overall deviation rate (%) during donning of PPE - PPE1 vs PPE3	Relative risk Based on data from 118 participants in 1 studies. (Randomized controlled)	35 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [7]	Head/neck cover may have little or no difference on overall deviation rate (%) during donning of ppe - ppe1 vs ppe3
Overall deviation rate (%) during donning of PPE - PPE2 vs PPE3	Based on data from 118 participants in 1 studies. (Randomized controlled)	35 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [8]	Head/neck cover may have little or no difference on overall deviation rate (%) during donning of ppe - ppe2 vs ppe3
Deviation rate (%) during doffing of hood	Based on data from 118 participants in 1 studies.	0 per 1000		**Low** Due to serious indirectness, Due to serious	Head/neck cover may have little or no difference on deviation rate (%) during doffing of

Outcome Timeframe	**Study results and measurements**	**Comparator** No Head/Neck Cover	**Intervention** Head/Neck Cover	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
- PPE1 vs PPE3	(Randomized controlled)			imprecision [9]	hood - ppe1 vs ppe3
Deviation rate (%) during doffing of hood - PPE2 vs PPE3	Based on data from 118 participants in 1 studies. (Randomized controlled)	0 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [10]	Head/neck cover may have little or no difference on deviation rate (%) during doffing of hood - ppe2 vs ppe3
Deviation rate (%) during donning of faceshield - PPE1 vs PPE3	Relative risk Based on data from 118 participants in 1 studies. (Randomized controlled)	100 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [11]	Head/neck cover may have little or no difference on deviation rate (%) during donning of faceshield - ppe1 vs ppe3
Deviation rate (%) during donning of faceshield - PPE2 vs PPE3	Relative risk Based on data from 118 participants in 1 studies. (Randomized controlled)	100 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [12]	Head/neck cover may have little or no difference on deviation rate (%) during donning of faceshield - ppe2 vs ppe3
Total donning errors, n (%)	Relative risk 9.5 (CI 95% 2.33 — 38.7) Based on data from 100 participants in 1 studies. (Randomized controlled)	40 per 1000 Difference:	380 per 1000 **340 more per 1000** (CI 95% 53 more — 1,000 more)	**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [13]	We are uncertain whether head/neck cover improves or worsen total donning errors, n (%)
Total doffing errors, n (%)	Relative risk 0.42 (CI 95% 0.17 — 1.03) Based on data from 100 participants in 1 studies. (Randomized controlled)	240 per 1000 Difference:	101 per 1000 **139 fewer per 1000** (CI 95% 199 fewer — 7 more)	**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [14]	We are uncertain whether head/neck cover improves or worsen total doffing errors, n (%)
Error in application of goggles during donning, n (%)	Relative risk 5 (CI 95% 0.25 — 101.6) Based on data from 100 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [15]	We are uncertain whether head/neck cover improves or worsen error in application of goggles during donning, n (%)

Outcome Timeframe	**Study results and measurements**	**Comparator** No Head/Neck Cover	**Intervention** Head/Neck Cover	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Failure to zip up coveralls or put hood over head during donning, n (%)	Based on data from 50 participants in 1 studies. (Randomized controlled)			**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [16]	We are uncertain whether head/neck cover improves or worsen failure to zip up coveralls or put hood over head during donning, n (%)
Error in application of bouffant hair-cover during donning, n (%)	Based on data from 50 participants in 1 studies. (Randomized controlled)	20 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [17]	We are uncertain whether head/neck cover improves or worsen error in application of bouffant hair-cover during donning, n (%)
Error in removal of face shield during doffing, n (%)	Based on data from 50 participants in 1 studies. (Randomized controlled)	20 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [18]	We are uncertain whether head/neck cover increases or decreases error in removal of face shield during doffing, n (%)
Error in removal of hair-cover during doffing, n (%)	Based on data from 50 participants in 1 studies. (Randomized controlled)	40 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [19]	We are uncertain whether head/neck cover increases or decreases error in removal of hair-cover during doffing, n (%)

1. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
2. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
3. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
4. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
5. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

6. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
7. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
8. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
9. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
10. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
11. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
12. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
13. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
14. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
15. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
16. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
17. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
18. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal

information size (OIS) threshold not met. . **Publication bias: no serious.**
19. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

Clinical Question/ PICO

Population: Health care workers in direct contact or indirect contact to patients with EVD or Marburg
Intervention: A cover for the head and neck
Comparator: No cover for the head and neck

Summary

See summary in Health workers in direct contact and/or indirect contact to patients with Ebola Virus Disease (EVD) or Marburg virus disease;Intervention-A cover for the head and neck;Comparator-No cover for the head and neck.

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Overall contamination during doffing of PPE, any size, n (%)	Relative risk 0.27 (CI 95% 0.17 — 0.43) Based on data from 100 participants in 1 studies. (Randomized controlled)	960 per 1000 Difference:	259 per 1000 **701 fewer per 1000** (CI 95% 797 fewer — 547 fewer)	Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [1]	We are uncertain whether a cover for the head and neck increases or decreases overall contamination during doffing of ppe.
Face contamination during doffing of PPE, any size, n (%)	Relative risk 0.2 (CI 95% 0.01 — 4.064) Based on data from 100 participants in 1 studies. (Randomized controlled)	40 per 1000 Difference:	8 per 1000 **32 fewer per 1000** (CI 95% 40 fewer — 123 more)	Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [2]	We are uncertain whether a cover for the head and neck improves or worsen face contamination during doffing of ppe.
Back of the head contamination during doffing of PPE, any size, n (%)	Based on data from 100 participants in 1 studies. (Randomized controlled)	0 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [3]	We are uncertain whether a cover for the head and neck improves or worsen back of the head contamination during doffing of ppe.

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Neck (anterior) contamination during doffing of PPE, any size, n (%)	Relative risk 0.12 (CI 95% 0.038 — 0.353) Based on data from 100 participants in 1 studies. (Randomized controlled)	960 per 1000 Difference:	115 per 1000 **845 fewer per 1000** (CI 95% 924 fewer — 621 fewer)	**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [4]	We are uncertain whether a cover for the head and neck improves or worsen neck (anterior) contamination during doffing of ppe.
Neck (posterior) contamination during doffing of PPE, any size, n (%)	Relative risk 0.13 (CI 95% 0.017 — 0.98) Based on data from 100 participants in 1 studies. (Randomized controlled)	180 per 1000 Difference:	23 per 1000 **157 fewer per 1000** (CI 95% 177 fewer — 4 fewer)	**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [5]	We are uncertain whether a cover for the head and neck improves or worsen neck (posterior) contamination during doffing of ppe.
[DIFFERENCE OF MEDIANS] Overall contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE1 vs PPE3	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 2 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [6]	A cover for the head and neck may have little or no difference on [difference of medians] overall contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe1 vs ppe3
[DIFFERENCE OF MEDIANS] Overall contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE2 vs PPE3	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)		CI 95%	**Low** Due to serious indirectness, Due to serious imprecision [7]	A cover for the head and neck may have little or no difference on [difference of medians] overall contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe2 vs ppe3
[DIFFERENCE OF MEDIANS] Hair and head contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE1 vs PPE3	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 1.5 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [8]	A cover for the head and neck may have little or no difference on [difference of medians] hair and head contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe1 vs ppe3

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
[DIFFERENCE OF MEDIANS] Hair and head contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE2 vs PPE3	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 0.5 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [9]	A cover for the head and neck may have little or no difference on [difference of medians] hair and head contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe2 vs ppe3
[DIFFERENCE OF MEDIANS] Neck (anterior) contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 8.5 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [10]	A cover for the head and neck may have little or no difference on [difference of medians] neck (anterior) contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median
[DIFFERENCE OF MEDIANS] Neck (anterior) contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE2 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 6 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [11]	A cover for the head and neck may have little or no difference on [difference of medians] neck (anterior) contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe2 vs ppe1
[DIFFERENCE OF MEDIANS] Neck (posterior) contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE3 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 16.5 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [12]	A cover for the head and neck may have little or no difference on [difference of medians] hair and head contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe2 vs ppe3

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
[DIFFERENCE OF MEDIANS] Neck (posterior) contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median - PPE2 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 17.5 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [13]	A cover for the head and neck may have little or no difference on [difference of medians] neck (posterior) contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe2 vs ppe1
[DIFFERENCE OF MEDIANS] Overall contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE3 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 8 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [14]	A cover for the head and neck may have little or no difference on [difference of medians] hair and head contamination during doffing of ppe: small sized contaminated patches (< 1 cm2), median - ppe2 vs ppe3
[DIFFERENCE OF MEDIANS] Overall contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE2 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 4 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [15]	A cover for the head and neck may have little or no difference on [difference of medians] overall contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2), median - ppe2 vs ppe1
[DIFFERENCE OF MEDIANS] Hair and head contamination during doffing of PPE: Extra large sized contaminated	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)		CI 95%	**Low** Due to serious indirectness, Due to serious imprecision [16]	A cover for the head and neck may have little or no difference on [difference of medians] hair and head contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2),

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
patches (≥ 5cm2), median - PPE3 vs PPE1					median - ppe3 vs ppe1
[DIFFERENCE OF MEDIANS] Hair and head contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE2 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 17 higher** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [17]	A cover for the head and neck may have little or no difference on [difference of medians] hair and head contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2), median - ppe2 vs ppe1
[DIFFERENCE OF MEDIANS] Neck (anterior) contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE3 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 24 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [18]	A cover for the head and neck may have little or no difference on [difference of medians] neck (anterior) contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2), median - ppe3 vs ppe1
[DIFFERENCE OF MEDIANS] Neck (anterior) contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE2 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)	Difference:	**MD 24 lower** (CI 95% 0 higher — 0 higher)	**Low** Due to serious indirectness, Due to serious imprecision [19]	A cover for the head and neck may have little or no difference on [difference of medians] neck (anterior) contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2), median - ppe2 vs ppe1
[DIFFERENCE OF MEDIANS] Neck (posterior) contamination	Lower better Based on data from 118 participants in 1 studies.		CI 95%	**Low** Due to serious indirectness, Due to serious	A cover for the head and neck may have little or no difference on [difference of medians] neck (posterior)

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE3 vs PPE1	(Randomized controlled)			imprecision [20]	contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2), median - ppe3 vs ppe1
[DIFFERENCE OF MEDIANS] Neck (posterior) contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median - PPE2 vs PPE1	Lower better Based on data from 118 participants in 1 studies. (Randomized controlled)		CI 95%	**Low** Due to serious indirectness, Due to serious imprecision [21]	A cover for the head and neck may have little or no difference on [difference of medians] neck (posterior) contamination during doffing of ppe: extra large sized contaminated patches (≥ 5cm2), median - ppe2 vs ppe1

1. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
2. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
3. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
4. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
5. **Risk of Bias: serious.** Downrated due to concerns with risk of bias. Unclear risk of bias for several domains, including allocation bias, blinding of participants, and unclear if all outcomes were reported. . **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
6. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. .

Publication bias: no serious.
7. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
8. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
9. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
10. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
11. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
12. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
13. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
14. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
15. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
16. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
17. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
18. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
19. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
20. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

21. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment other than just head/ neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

Clinical Question/ PICO

Population: Health care workers in direct contact or indirect contact to patients with EVD or Marburg
Intervention: A cover for the head and neck
Comparator: No cover for the head and neck

Summary

See summary in Health workers in direct contact and/or indirect contact to patients with Ebola Virus Disease (EVD) or Marburg virus disease;Intervention-A cover for the head and neck;Comparator-No cover for the head and neck.

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Time (min) to reach critical core temperature of 39°C under condition A - E4 vs E2	High better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 16 lower** (CI 95% 30.78 lower — 1.22 lower)	Very low Due to serious imprecision [1]	
Time (min) to reach critical core temperature of 39°C under condition A - E3 vs E2	High better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 13 lower** (CI 95% 25.2 lower — 0.79 lower)	Very low Due to serious imprecision [2]	
Time (min) to reach critical core temperature of 39°C under condition A - E4 vs E1	High better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 18 lower** (CI 95% 27.7 lower — 8.2 lower)	Very low Due to serious imprecision [3]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Time (min) to reach critical core temperature of 39°C under condition A - E3 vs E1	High better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 15 lower** (CI 95% 27.7 lower — 8.2 lower)	Very low Due to serious imprecision [4]	
Body surface skin temperature (°C) at time to reach critical core temperature of 39°C under condition A - E4 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.7 higher** (CI 95% 0.62 lower — 2.02 higher)	Very low Due to serious imprecision [5]	
Body surface skin temperature (°C) at time to reach critical core temperature of 39°C under condition A - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.6 higher** (CI 95% 0.14 higher — 1.05 higher)	Very low Due to serious imprecision [6]	
Heat sensation at time to reach critical core temperature of 39°C under condition A - E4 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.3 higher** (CI 95% 0.05 lower — 0.65 higher)	Very low Due to serious imprecision [7]	
Body surface skin temperature (°C)	Lower better Based on data from 6 participants in 1 studies.	Difference:	**MD 1.1 higher** (CI 95% 0.26 lower — 2.46 higher)	Very low Due to serious imprecision [8]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
at time to reach critical core temperature of 39°C under condition A - E4 vs E1	(Observational (non-randomized))				
Body surface skin temperature (°C) at time to reach critical core temperature of 39°C under condition A - E3 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1 higher** (CI 95% 0.42 higher — 1.57 higher)	Very low Due to serious imprecision [9]	
Heat sensation at time to reach critical core temperature of 39°C under condition A - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.2 higher** (CI 95% 0.15 lower — 0.55 higher)	Very low Due to serious imprecision [10]	
Heat sensation at time to reach critical core temperature of 39°C under condition A - E4 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.2 higher** (CI 95% 0.15 lower — 0.55 higher)	Very low Due to serious imprecision [11]	
Heat sensation at time to reach critical core temperature of 39°C under condition A - E3 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.1 higher** (CI 95% 0.25 lower — 0.45 higher)	Very low Due to serious imprecision [12]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Discomfort at time to reach critical core temperature of 39°C under condition A - E4 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.2 lower** (CI 95% 0.42 lower — 0.02 higher)	**Very low** Due to serious imprecision [13]	
Discomfort at time to reach critical core temperature of 39°C under condition A - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.2 lower** (CI 95% 0.42 lower — 0.02 higher)	**Very low** Due to serious imprecision [14]	
Core temperature (°C) after 80 minutes of activity under condition B - E4 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.57 higher** (CI 95% 0.21 higher — 0.92 higher)	**Very low** Due to serious imprecision [15]	
Core temperature (°C) after 80 minutes of activity under condition B - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.37 higher** (CI 95% 0.14 higher — 0.59 higher)	**Very low** Due to serious imprecision [16]	
Core temperature (°C) after 80 minutes of activity under condition B - E4 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.85 higher** (CI 95% 0.49 higher — 1.2 higher)	**Very low** Due to serious imprecision [17]	
Core temperature (°C) after 80 minutes	Lower better Based on data from 6 participants in 1 studies.	Difference:	**MD 0.65 higher** (CI 95% 0.42 higher — 0.87 higher)	**Very low** Due to serious imprecision [18]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
of activity under condition B - E3 vs E1	(Observational (non-randomized))				
Body surface skin temperature (°C) after 80 minutes of activity under condition B - E4 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.2 higher** (CI 95% 0.29 higher — 2.1 higher)	Very low Due to serious imprecision [19]	
Body surface skin temperature (°C) after 80 minutes of activity under condition B - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.5 higher** (CI 95% 0.21 lower — 1.21 higher)	Very low Due to serious imprecision [20]	
Body surface skin temperature (°C) after 80 minutes of activity under condition B - E4 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.8 higher** (CI 95% 0.64 higher — 2.95 higher)	Very low Due to serious imprecision [21]	
Body surface skin temperature (°C) after 80 minutes of activity under condition B - E3 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.1 higher** (CI 95% 0.08 higher — 2.11 higher)	Very low Due to serious imprecision [22]	
Heat sensation after 80 minutes of activity under condition B - E4	Lower better Based on data from 6 participants in 1 studies. (Observational (non-	Difference:	**MD 0.7 higher** (CI 95% 0.66 lower — 2.06 higher)	Very low Due to serious imprecision [23]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
vs E2	randomized))				
Heat sensation after 80 minutes of activity under condition B - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0 higher** (CI 95% 1.15 lower — 1.15 higher)	Very low Due to serious imprecision [24]	
Heat sensation after 80 minutes of activity under condition B - E4 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.8 higher** (CI 95% 0.45 lower — 2.05 higher)	Very low Due to serious imprecision [25]	
Heat sensation after 80 minutes of activity under condition B - E3 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.1 higher** (CI 95% 0.92 lower — 1.12 higher)	Very low Due to serious imprecision [26]	
Discomfort after 80 minutes of activity under condition B - E4 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.6 lower** (CI 95% 1.31 lower — 0.11 higher)	Very low Due to serious imprecision [27]	
Discomfort after 80 minutes of activity under condition B - E3 vs E2	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.4 lower** (CI 95% 1.11 lower — 0.31 higher)	Very low Due to serious imprecision [28]	
Discomfort after 80 minutes of activity under condition B - E4	Lower better Based on data from 6 participants in 1 studies. (Observational (non-	Difference:	**MD 0.9 lower** (CI 95% 1.47 lower — 0.32 lower)	Very low Due to serious imprecision [29]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
vs E1	randomized))				
Discomfort after 80 minutes of activity under condition B - E3 vs E1	Lower better Based on data from 6 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.7 lower** (CI 95% 1.27 lower — 0.12 lower)	Very low Due to serious imprecision [30]	
Core Temperature (°C) at end of exercise - E3 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.73 higher** (CI 95% 0.14 lower — 1.6 higher)	Very low Due to serious risk of bias, Due to serious imprecision [31]	
Core Temperature (°C) at end of exercise - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.6 higher** (CI 95% 0.33 lower — 1.53 higher)	Very low Due to serious risk of bias, Due to serious imprecision [32]	
Skin Temperature (°C) at end of exercise - E3 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.8 higher** (CI 95% 0.75 higher — 2.88 higher)	Very low Due to serious risk of bias, Due to serious imprecision [33]	
Skin Temperature (°C) at end of exercise - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.09 higher** (CI 95% 0 higher — 2.18 higher)	Very low Due to serious risk of bias, Due to serious imprecision [34]	
Heart Rate (beats per minute) at end of exercise - E3	Lower better Based on data from 12 participants in 1 studies. (Observational (non-	Difference:	**MD 27.43 higher** (CI 95% 9.59 lower — 64.45 higher)	Very low Due to serious risk of bias, Due to serious imprecision [35]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
vs E1	randomized))				
Heart Rate (beats per minute) at end of exercise - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 20.43 higher** (CI 95% 15.61 higher — 56.47 higher)	Very low Due to serious risk of bias, Due to serious imprecision [36]	
Average sweat weight loss (kg) per hour - E3 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.54 higher** (CI 95% 0.44 lower — 1.52 higher)	Very low Due to serious risk of bias, Due to serious imprecision [37]	
Average sweat weight loss (kg) per hour - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.32 higher** (CI 95% 0.74 lower — 1.38 higher)	Very low Due to serious risk of bias, Due to serious imprecision [38]	
Heat Sensation at end of exercise - E3 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.57 higher** (CI 95% 0.42 lower — 1.56 higher)	Very low Due to serious risk of bias, Due to serious imprecision [39]	
Heat Sensation at end of exercise - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.57 higher** (CI 95% 0.42 lower — 1.56 higher)	Very low Due to serious risk of bias, Due to serious imprecision [40]	
Thermal Comfort at end of exercise - E3 vs E1	High better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0 higher** (CI 95% 4.28 lower — 4.28 higher)	Very low Due to serious risk of bias, Due to serious imprecision [41]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Thermal Comfort at end of exercise - E2 vs E1	High better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0.86 higher** (CI 95% 0.89 lower — 2.61 higher)	Very low Due to serious risk of bias, Due to serious imprecision [42]	
Rated perceived exertion at end of exercise - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 3.43 higher** (CI 95% 1.82 lower — 8.68 higher)	Very low Due to serious risk of bias, Due to serious imprecision [43]	
Rated perceived exertion at end of exercise - E3 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 2.57 higher** (CI 95% 3.45 lower — 8.59 higher)	Very low Due to serious risk of bias, Due to serious imprecision [44]	
Breathing comfort at end of exercise - E3 vs E1	High better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.57 higher** (CI 95% 0.74 lower — 3.88 higher)	Very low Due to serious risk of bias, Due to serious imprecision [45]	
Breathing comfort at end of exercise - E2 vs E1	High better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 1.72 higher** (CI 95% 0.98 lower — 4.42 higher)	Very low Due to serious risk of bias, Due to serious imprecision [46]	
Wetness at end of exercise - E3 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0 higher** (CI 95% 0.86 lower — 0.86 higher)	Very low Due to serious risk of bias, Due to serious imprecision [47]	
Wetness at end of exercise - E2 vs E1	Lower better Based on data from 12 participants in 1 studies. (Observational (non-randomized))	Difference:	**MD 0 higher** (CI 95% 0.86 lower — 0.86 higher)	Very low Due to serious risk of bias, Due to serious imprecision [48]	

Outcome Timeframe	**Study results and measurements**	**Comparator** NO COVER FOR THE HEAD AND NECK	**Intervention** A COVER FOR THE HEAD AND NECK	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Discomfort at time to reach critical core temperature of 39°C under condition A - E4 vs E1	Lower better	Difference:	**MD 0.2 lower** (CI 95% 0.42 lower — 0.02 higher)		
Discomfort at time to reach critical core temperature of 39°C under condition A - E3 vs E1	Lower better	Difference:	**MD 0.2 lower** (CI 95% 0.42 lower — 0.02 higher)		

1. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/ neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
2. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/ neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
3. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/ neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
4. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/ neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
5. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable

to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

6. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

7. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

8. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

9. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

10. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

11. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

12. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

13. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to

simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

14. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

15. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

16. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

17. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

18. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

19. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

20. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

21. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/

neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

22. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

23. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

24. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

25. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

26. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

27. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

28. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

29. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. .

Publication bias: no serious.
30. **Risk of Bias: no serious.** Coca et al., 2015 was judged to be at moderate risk of bias. The mannequins were treated in the quality assessment, as if the mannequin were a volunteer. There was a lack of information reported for several ROBINS-I domains, including outcome measurement. There was no outcome assessor blinding, though outcomes were less vulnerable to bias, due to simulated nature of the study. . **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
31. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
32. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
33. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
34. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
35. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
36. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
37. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
38. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
39. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability

for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
40. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
41. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
42. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
43. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
44. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
45. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
46. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
47. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
48. **Risk of Bias: serious.** We rated Coca et al., 2017, at a high risk of bias because of no demonstration of data availability for all the study participants and lack of blinding of the outcome assessor. Outcomes like thermal comfort, heat sensation, rating of perceived exertion, breathing comfort, and wetness were subjective measures which could potentially be more vulnerable to bias.. **Inconsistency: no serious. Indirectness: very serious.** Downrated due to simulation study and non-

human participants, as well as other differences in evaluated PPE equipment other than just head/neck cover vs. no cover. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

Clinical Question/ PICO

Population: HCWs providing direct/indirect care during EVD/Marburg outbreaks
Intervention: Eye protection be worn under head/neck covering
Comparator: Eye protection be worn over head/neck covering

Summary

Initially, 122 studies were screened in the CAL tool software and 33 studies were included for full-text screening. No studies provided direct information on the transmission or incidence of Ebola virus disease (EVD) or Marburg virus disease related to the order in which eye protection and head/neck covering was worn. Two crossover randomized controlled trials that simulated contamination events for health care workers (HCWs) were included. Contamination was recorded during the donning/doffing of Ebola personal protective equipment (PPE) ensembles with differing equipment and orders in which the eye protection (face shields) and head/neck covering (hoods) was worn. Deviation rates from the donning/doffing protocols were also noted.

With respect to the extraction of contextual data, the key findings are as follows:

- Chughtai et al. 2018 *[136]* conducted a simulation study in which they tested 10 different PPE donning and doffing protocols recommended by various health organizations for Ebola. Ten participants were recruited for this study and each was randomly assigned to use three different PPE protocols. After donning of PPE, fluorescent lotion and spray were applied on the external surface of the PPE to simulate contamination, and ultraviolet light was used to count fluorescent patches on the skin after doffing.
  - Two PPE protocols were tested in which the eye-protection PPEs were worn under the head/neck protection PPEs, with 1 protocol (WHO, coverall and N95) was observed with 4 large patches. There were no small patches observed with these two protocols.
  - Eight PPE protocols were tested in which the eye-protection PPEs were worn over the head/neck protection (Table 3). One protocol (North Carolina, coverall and N95) was observed with 1 large patch on a front forehead and 1 large patch on a front right forearm. Two PPE protocols were observed with small patches, including the "CDC, coverall and N95" with 1 small patch on the back of a right hand and the "Health Canada, gown and N95" with 1 small patch on a front forehead and 1 large patch on a front right forearm.
- Suen et al. 2018 *[126]* conducted an experimental study with one group using multiple comparisons. In total, 59 participants randomly performed PPE donning and doffing. The trial consisted of PPE donning, applying fluorescent solution on the PPE surface, PPE doffing of participants, and estimation of the degree of contamination as indicated by the number of fluorescent stains on the working clothes and environment. PPE1 consisted of a neck-to-ankle outfit, N95 respirator, hood, disposable face shield, surgical gown, boots and double gloves. PPE2 consisted of a head-to-ankle coverall, N95 respirator, hood, disposable face shield, boots and double gloves. PPE3 consisted of neck-to-ankle outfit, N95 respirator, no hood, disposable face shield, isolation gown, shoes and single latex gloves.
  - With PPE1, the face shield was worn over the head cover. One contamination with a small patch was observed on the face with PPE1.
  - With PPE2, the face shield was worn under the hood of the coverall. Four contaminations with small patches were observed on the face with PPE2.
  - Neither PPE1 nor PPE2 was observed with large patches on the face.
- Poller et al. 2018 *[137]* conducted a simulation study and consensus panel to identify a unified PPE ensemble for clinical response to possible high consequence infectious diseases (HCID) in the United Kingdom. A simulation-based exercise was developed to assess the safety of PPE ensembles in use in the UK during first assessment of a patient with a possible HCID. A mannequin was adapted to expose volunteer HCWs to synthetic bodily fluids (vomit, sweat, diarrhea and cough), each with a different colored fluorescent tracer, invisible other than under ultraviolet (UV) light. After exposure, HCWs were examined under UV lights to locate fluorescent contamination, and were screened again after PPE doffing to detect any personal contamination. The exercise was videoed, allowing retrospective analysis of contamination events and user errors.
  - The simulation testing identified significant HCW contamination events after doffing, related to protocol failure or complications in PPE doffing. The consensus PPE ensemble were also tested in the study; it attained no contamination events. In the ensemble, a disposable full-face visor was worn over the hood.

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Overall deviation rate (%) during donning of PPE - PPE2 vs PPE1	Relative risk Based on data from 118 participants in 1 studies. (Randomized controlled)	61 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [1]	Eye protection be worn under head/neck covering may have little or no difference on overall deviation rate (%) during donning of ppe - ppe2 vs ppe1
Deviation rate (%) during donning of hood - PPE2 vs PPE1	Based on data from 118 participants in 1 studies. (Randomized controlled)	200 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [2]	
Deviation rate (%) during donning of faceshield - PPE2 vs PPE1	Based on data from 118 participants in 1 studies. (Randomized controlled)	117 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [3]	
Overall deviation rate (%) during doffing of PPE - PPE2 vs PPE1	Based on data from 118 participants in 1 studies. (Randomized controlled)	29 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [4]	
Deviation rate (%) during doffing of hood - PPE2 vs PPE1	Based on data from 118 participants in 1 studies. (Randomized controlled)	50 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [5]	
Deviation rate (%) during doffing of faceshield - PPE2 vs PPE1	Based on data from 118 participants in 1 studies. (Randomized controlled)	67 per 1000		**Low** Due to serious indirectness, Due to serious imprecision [6]	

1. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met.. **Publication bias: no serious.**
2. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met.. **Publication bias: no serious.**
3. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met.. **Publication bias: no serious.**
4. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met.. **Publication bias: no serious.**
5. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met.. **Publication bias: no serious.**
6. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood. . **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met.. **Publication bias: no serious.**

Clinical Question/ PICO

Population: HCWs providing direct/indirect care during EVD/Marburg outbreaks
Intervention: Eye protection be worn under head/neck covering
Comparator: Eye protection be worn over head/neck covering

Summary

See summary in above evidence profile HCWs providing direct/indirect care during EVD/Marburg outbreaks;Intervention-Eye protection be worn under head/neck covering; Comparator- Eye protection be worn over head/neck covering

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Number of participants (n/N, %) with small fluorescent patches after various personal protective	Based on data from 6 participants in 1 studies. (Randomized controlled)	**0** per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [1]	We are uncertain whether eye protection worn under head/neck covering improves or worsens the outcome of contamination or infection

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
equipment (PPE) protocols - WHO, coverall and N95 vs CDC, coverall and PAPR					
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs CDC, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	333 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [2]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs ECDC, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [3]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs Health Canada, gown and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	333 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [4]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs NC, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [5]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs NSW DoH CEC, gown and PAPR	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [6]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs NSW DoH CEC, gown and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [7]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of		0		**Very low**	We are uncertain

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs MSF, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	per 1000		Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [8]	whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with small fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs WHO, gown and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [9]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs CDC, coverall and PAPR	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [10]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with large fluorescent patches after various personal protective	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [11]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
equipment (PPE) protocols - WHO, coverall and N95 vs CDC, coverall and N95					
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs ECDC, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [12]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs Health Canada, gown and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [13]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs NC, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	333 per 1000		Very low Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [14]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs NSW DoH CEC, gown and PAPR	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [15]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs NSW DoH CEC, gown and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [16]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs MSF, coverall and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	0 per 1000		**Very low** Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [17]	We are uncertain whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
Number of		0		**Very low**	We are uncertain

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
participants (n/N, %) with large fluorescent patches after various personal protective equipment (PPE) protocols - WHO, coverall and N95 vs WHO, gown and N95	Based on data from 6 participants in 1 studies. (Randomized controlled)	per 1000		Due to serious risk of bias, Due to serious indirectness, Due to serious imprecision [18]	whether eye protection worn under head/neck covering improves or worsen the outcome of contamination or infection.
[DIFFERENCE OF MEDIANS] Overall contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median	Lower better	Difference:	**MD 2 higher** CI 95%		
[DIFFERENCE OF MEDIANS] Hair and head contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median	Lower better	Difference:	**MD 1 higher** CI 95%		
[DIFFERENCE OF MEDIANS] Neck (anterior) contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median	Lower better	Difference:	**MD 2.5 higher** CI 95%		
[DIFFERENCE		Difference:	**MD 1 lower**		

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
OF MEDIANS] Neck (posterior) contamination during doffing of PPE: Small sized contaminated patches (< 1 cm2), median	Lower better		CI 95%		
[DIFFERENCE OF MEDIANS] Overall contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5 cm2), median	Lower better	Difference:	**MD 4 higher** CI 95%		
[DIFFERENCE OF MEDIANS] Hair and head contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median	Lower better	Difference:	**MD 17 higher** CI 95%		
[DIFFERENCE OF MEDIANS] Neck (anterior) contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median	Lower better	Difference:	**MD 0 lower** CI 95%		
[DIFFERENCE OF MEDIANS]	Lower better	Difference:	**MD 0 lower** CI 95%		

Outcome Timeframe	**Study results and measurements**	**Comparator** over head/neck covering	**Intervention** eye protection be worn under head/neck covering	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
(posterior) contamination during doffing of PPE: Extra large sized contaminated patches (≥ 5cm2), median					

1. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
2. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
3. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
4. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
5. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
6. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
7. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and

optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
8. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
9. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
10. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
11. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
12. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
13. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
14. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
15. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
16. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
17. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the

measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**
18. **Risk of Bias: serious.** No information on randomization, allocation concealment and blinding of participants and outcome assessors. Additionally, the domains' effect of assignment to intervention (Domain 2) and Risk of bias in the measurement of the outcome (Domain 4) were rated to have a high risk of bias. **Inconsistency: no serious. Indirectness: serious.** Downrated due to simulation study: Fluorescent contamination as a surrogate outcome for EVD/Marburg Virus Disease, other differences in evaluated PPE equipment beyond order of face cover and hood.. **Imprecision: serious.** Few participants and optimal information size (OIS) threshold not met. . **Publication bias: no serious.**

Clinical Question/ PICO

Population: Health workers caring for patients with filovirus disease in health care facilities
Intervention: Impermeable gown
Comparator: Surgical gown or coverall

Summary

No comparative evidence. No estimate of effectiveness.

Outcome Timeframe	**Study results and measurements**	**Comparator** surgical gown or coverall	**Intervention** impermeable gown	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
prevention of virus transmission to health care providers				Very low Very low quality evidence comparing gowns and coveralls.	No comparative evidence. No estimate of effectiveness.
personal well-being (heat stress, dehydration, hyperthermia, heat stroke, presyncope and syncope)				Very low	No comparative evidence. No estimate of effectiveness.
dexterity, ability to perform procedures and tasks, and ability				Very low	No comparative evidence. No estimate of effectiveness

Outcome Timeframe	**Study results and measurements**	**Comparator** surgical gown or coverall	**Intervention** impermeable gown	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
to move maximum tolerated time to wear the equipment and thus be available to care for patients.				Very low	No comparative evidence. No estimate of effectiveness

Clinical Question/ PICO

Population: HCWs prior to doffing
Intervention: Chlorine spray of PPE
Comparator: No chlorine spray of PPE

Summary

A total of 164 studies were screened in the CAL tool software and 32 studies were included for full-text screening.

Two studies were included. One non-randomized parallel group simulation study*[141]* assessed viral self-contamination after health care workers performed a 16-step Ebola virus PPE doffing protocol. Participants were assigned to extra glove sanitization through spraying of the hands with hypochlorite solution or use of an alcohol-based hand rub (ABHR). The level of surrogate viruses, MS2 and bacteriophage Φ6, on the hands, face or scrubs of health care workers was ascertained following inner glove removal. Overall, there was no detectable transfer of enveloped bacteriophage Φ6 for any participants and the certainty of evidence was judged to be very low comparing the effects of hypochlorite spray and ABHR for prevention of Φ6 transfer.

Additionally, there was low certainty of evidence that additional glove sanitization with hypochlorite prevented transfer of MS2 compared to ABHR.

One retrospective cohort study*[142]* assessed the level of Ebola virus IgG antibody and prior exposure events among returned responders of the 2014-2016 West African Ebola epidemic. The study collected information on personal protective equipment used, including whether removal of Ebola PPE was performed with or without chlorine spray. The data is unreliable due to collinearity between use of spray and health care worker role. Almost all participants who reported performing clinical work used spray and almost all participants who did not use spray reported having a role in laboratory work. The difference in the likelihood of exposure between these two occupational groups makes it impossible to analyze the independent effect of spraying the PPE with chlorine. The overall certainty of evidence for the effectiveness of spraying PPE with chlorine prior to PPE removal to mitigate the risk of Ebola virus transmission was judged to be very low.

A review of contextual information found13 studies describing steps of the doffing protocols. None of the doffing protocols include a discrete step describing the practice of spraying PPEs*[141][147][207][143][137][144][208][209][136][210][211][212][213]*. Common themes that emerged from the studies included:

- PPE can both protect and put health workers at risk for self-contamination throughout the doffing process, even among experienced HWs doffing with a trained observer.
- During PPE doffing, common protocol deviations included touching outer gloves with inner-gloved hands and touching the outside of gloves with bare hands. Hand hygiene and glove removal are high-risk opportunities for health-worker self-contamination.
- Optimizing doffing protocols may require reinforcing careful handling of scrubs and good glove/hand hygiene with effective agents.
- Hands-free alcohol based hand rub delivered directly into the HCWs' palm keeping the dispenser uncontaminated.

Outcome Timeframe	**Study results and measurements**	**Comparator** no chlorine spray of PPE	**Intervention** chlorine spray of PPE	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Transfer of Phi6 to inner gloves, hands, face or scrubs following doffing protocol	Based on data from 15 participants in 1 studies. (Observational (non-randomized))	0 per 1000		Very low Due to serious indirectness [1]	
Transfer of MS2 to inner gloves following doffing protocol	Based on data from 15 participants in 1 studies. (Observational (non-randomized))	800 per 1000		Very low Due to serious indirectness [2]	
Transfer of MS2 to hands following doffing protocol	Based on data from 15 participants in 1 studies. (Observational (non-randomized))	0 per 1000		Very low Due to serious indirectness [3]	
Transfer of MS2 to face following doffing protocol	Based on data from 15 participants in 1 studies. (Observational (non-randomized))	0 per 1000		Very low Due to serious indirectness [4]	
Transfer of MS2 to scrubs following doffing protocol	Based on data from 15 participants in 1 studies. (Observational (non-randomized))	0 per 1000		Very low Due to serious indirectness [5]	

1. **Risk of Bias: no serious.** The overall risk of bias rated to be "moderate" using the ROBINS-I tool for non-randomized studies. The study was judged to be of low risk of bias for all but one domain. One domain was rated at moderate risk of bias due to a lack of blinding of the participants of the intervention and the trained monitor guiding participants through the

doffing process. . **Inconsistency: no serious.** Judged to be not serious as there was only one relevant study for this outcome. . **Indirectness: serious.** Downrated once due to simulation study. Phi6 is a surrogate for enveloped viruses such as Ebola.. **Imprecision: very serious.** No events in either group, very small sample size and OIS not met.. **Publication bias: no serious.**
2. **Risk of Bias: no serious.** The overall risk of bias rated to be "moderate" using the ROBINS-I tool for non-randomized studies. The study was judged to be of low risk of bias for all but one domain. One domain was rated at moderate risk of bias due to a lack of blinding of the participants of the intervention and the trained monitor guiding participants through the doffing process. . **Inconsistency: no serious.** Judged to be not serious as there was only one relevant study for this outcome. . **Indirectness: serious.** Downrated twice due to simulation study and use of MS2 as surrogate agent (non-enveloped virus surrogate).. **Imprecision: very serious.** Few events, very small sample size and OIS not met. . **Publication bias: no serious.**
3. **Risk of Bias: no serious.** The overall risk of bias rated to be "moderate" using the ROBINS-I tool for non-randomized studies. The study was judged to be of low risk of bias for all but one domain. One domain was rated at moderate risk of bias due to a lack of blinding of the participants of the intervention and the trained monitor guiding participants through the doffing process. . **Inconsistency: no serious.** Judged to be not serious as there was only one relevant study for this outcome. . **Indirectness: serious.** Downrated twice due to simulation study and use of MS2 as surrogate agent (non-enveloped virus surrogate).. **Imprecision: very serious.** Only one event, very small samples size and OIS not met.. **Publication bias: no serious.**
4. **Risk of Bias: no serious.** The overall risk of bias rated to be "moderate" using the ROBINS-I tool for non-randomized studies. The study was judged to be of low risk of bias for all but one domain. One domain was rated at moderate risk of bias due to a lack of blinding of the participants of the intervention and the trained monitor guiding participants through the doffing process. . **Inconsistency: no serious.** Judged to be not serious as there was only one relevant study for this outcome. . **Indirectness: serious.** Downrated twice due to simulation study and use of MS2 as surrogate agent (non-enveloped virus surrogate).. **Imprecision: very serious.** No events in either group, very small sample size and OIS not met.. **Publication bias: no serious.**
5. **Risk of Bias: no serious.** The overall risk of bias rated to be "moderate" using the ROBINS-I tool for non-randomized studies. The study was judged to be of low risk of bias for all but one domain. One domain was rated at moderate risk of bias due to a lack of blinding of the participants of the intervention and the trained monitor guiding participants through the doffing process. . **Inconsistency: no serious.** Judged to be not serious as there was only one relevant study for this outcome. . **Indirectness: serious.** Downrated twice due to simulation study and use of MS2 as surrogate agent (non-enveloped virus surrogate).. **Imprecision: very serious.** Only one event, very small samples size and OIS not met.. **Publication bias: no serious.**

Clinical Question/ PICO

Population:	HCWs prior to doffing
Intervention:	Chlorine spray of PPE
Comparator:	No chlorine spray of PPE

Summary

A total of 164 studies were screened in the CAL tool software and 32 studies were included for full-text screening.

Two studies were included. One non-randomized parallel group simulation study assessed viral self-contamination after health care workers performed a 16-step Ebola virus PPE doffing protocol*[141]*. Participants were assigned to extra glove sanitization through spraying of the hands with hypochlorite solution or use of an alcohol-based hand rub (ABHR). The level of surrogate viruses, MS2 and bacteriophage Φ6, on the hands, face or scrubs of health care workers was ascertained following inner glove removal. Overall, there was no detectable transfer of enveloped bacteriophage Φ6 for any participants and the certainty of evidence was judged to be very low comparing the effects of hypochlorite spray and ABHR for prevention of Φ6 transfer. Additionally, there was low certainty of evidence that additional glove sanitization with hypochlorite prevented transfer of MS2 compared to ABHR.

One retrospective cohort study*[142]* assessed the level of *Ebolavirus* IgG antibody and prior exposure events among returned responders of the 2014-2016 West African Ebola disease epidemic. The study collected information on personal protective equipment used, including whether removal of Ebola PPE was performed with or without chlorine spray. The data is unreliable due to collinearity between use of spray and health care worker role. Almost all participants who reported performing clinical work used spray and almost all participants who did not use spray reported having a role in laboratory work. The difference in the likelihood of exposure between these two occupational groups makes it impossible to analyze the independent effect of spraying the PPE with chlorine. The overall certainty of evidence for the

effectiveness of spraying PPE with chlorine prior to PPE removal to mitigate the risk of *Ebolavirus* transmission was judged to be very low.

Outcome Timeframe	**Study results and measurements**	**Comparator** no chlorine spray of PPE	**Intervention** chlorine spray of PPE	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola Virus	Relative risk 3.52 (CI 95% 1.62 — 7.58) Based on data from 230 participants in 1 studies. (Observational (non-randomized))	**71** per 1000 Difference:	**251** per 1000 **180 more per 1000** (CI 95% 44 more — 470 more)	**Very low** Due to serious risk of bias, Due to serious imprecision [1]	

1. **Risk of Bias: serious.** Risk of bias was judged to be high using the Newcastle Ottawa Scale. The study was awarded 6/9 stars based on use snowball sampling for a convenience sample, relying on self-reports for ascertainment of exposures and lack of reporting of details on PPE equipment or doffing protocols used between HCW roles. . **Inconsistency: no serious.** No inconsistency detected as only one study included for this outcome. . **Indirectness: no serious. Imprecision: serious.** Optimal information size not met and not a large sample size. . **Publication bias: no serious.**

13. Hand hygiene and glove disinfection recommendations

13.1. Hand hygiene

13.2. Glove disinfection

Clinical Question/ PICO

Population: Health workers working in health care facilities, ETU

Intervention: Hand hygiene (including glove disinfection) between patients .

Comparator: 1.Removal of outer glove and hand hygiene (inner glove) w/ soap and water 2.Removal of both gloves and hand hygiene w/ soap and water 3. Disinfecting outer glove w/ soap and water

Summary

A total of 250 studies were screened in the CAL tool software and 39 studies were included for full-text screening. No studies met the eligibility criteria. Although no studies met the eligibility criteria for appropriate interventions and comparators, we noted evidence that addressed hand hygiene protocols for health care workers handling highly infectious diseases. Suen and colleagues performed a simulation study to compare contamination when handwashing with soap and water was performed before/after each PPE doffing step (outer gloves, inner gloves, and bare hands) versus when the removal of both gloves was followed by handwashing with soap and water *[126]*. Other evidence in this area includes the 2020 Cochrane systematic review by Verbeek and colleagues that included evidence on simulated contamination for ABHR for glove sanitization versus no glove sanitization *[117]*.

The contextual data that was examined included the following:

Wolfe et al. 2016 *[214]* conducted a randomized trial with 91 subjects who washed their hands 10 times a day for 28 days to evaluate skin irritation caused by frequent handwashing that may increase transmission risk in Ebola disease-affected communities.

- They reported that subjects using sanitizer had the smallest increases, followed by higher pH chlorine solutions (HTH -calcium hypochlorite, high-test hypochlorite - and stabilized NaOCl-sodium hypochlorite), and soap and water.
- The greatest increases were among neutral pH chlorine solutions (NaDCC - sodium dichloroisocyanurate) and generated NaOCl.
- Signs of irritation related to higher transmission risk were observed most frequently in subjects using soap and least frequently by those using sanitizer or HTH.
- The investigators suggest that each handwashing method has benefits and drawbacks: soap is widely available and inexpensive but requires water and does not inactivate the virus; sanitizer is easy-to use and effective but expensive and unacceptable to many communities; and chlorine is easy to use but difficult to produce and distribute.
- Overall, they recommend Ebola or Marburg disease outbreak responders and communities use whichever handwashing method(s) are most acceptable, available, and sustainable for community handwashing.

Wolfe et al. 2017 *[215]* conducted a randomized simulation study of handwashing and Ebola virus disease outbreaks to compare hand hygiene protocols involving soap, hand sanitizer, and 0.05% chlorine solutions on the inactivation and removal of model organisms Phi6 and *E. coli* from hands and persistence in rinse water. They used organisms *E. coli* and bacteriophage Phi6 to evaluate handwashing with and without organic load added to simulate body fluids. Hands were inoculated with test organisms, washed, and rinsed using a glove juice method to retrieve remaining organisms.

- HTH performed most consistently well, with significantly greater log reductions of organisms than other hand hygiene protocols.
- The magnitude of handwashing efficacy differences was small, suggesting protocols are similarly efficacious.
- The authors recommend responders use the most practical handwashing method to ensure hand hygiene in EBOD contexts, considering the potential benefit of chlorine-based methods in rinse water persistence.

Casanova et al. 2018 conducted a simulation study of PPE doffing practice *[147]*. In a medical biocontainment unit, HWs (n = 10) experienced in EBOD care donned and doffed PPE following unit protocols that incorporate trained observer guidance and ABHR. A mixture of Φ6 (enveloped), MS2 (non-enveloped), and fluorescent marker was applied to 4 PPE sites, approximating body fluid viral load (Φ6, 10^5; MS2, 10^6). The HWs performed a patient care task, then doffed. Inner gloves, face, hands, and scrubs were sampled for virus, as were environmental sites with visible fluorescent marker.

- Among the 10 HWs, there was no Φ6 transfer to inner gloves, hands, or face; 1 participant had Φ6 on scrubs at low levels (1.4 × 102). MS2 transfer (range, 10^1–10^6) was observed to scrubs (n = 2), hands (n = 1), and inner gloves (n = 7), where it was highest. Most (n = 8) had only 1 positive site.
- Environmental samples with visible fluorescent marker (n = 21) were negative.
- Because gloves are repeatedly touching PPE during the doffing process, even use of ABHR on the outside of gloves between doffing steps may not completely prevent inner glove contamination with a non-enveloped virus.
- Human factors analyses suggest that the mishandling of certain items of PPE during doffing contributes considerably to the probability that a HW's gloves, scrubs, and hands become contaminated.
- To minimize viral load on inner gloves, both careful doffing and control measures such as stronger glove-sanitizing agents (such as hypochlorite or povidone-iodine) may be needed, particularly if non-enveloped viruses emerge as high-risk pathogens. However, whether units use ABHR or other hand sanitizers with demonstrated in vitro effectiveness against viruses, contact time and technique are still important. These results highlight the fact that, even when wearing PPE that provides whole-body coverage, hand hygiene after doffing is still critical, with hand hygiene agents that are effective against a range of organisms.

In summary, among experienced HWs, structured, observed doffing using ABHR protected against hand contamination with enveloped virus. Non-enveloped virus was infrequent on hands and scrubs but common on inner gloves, suggesting that inner gloves, *but not necessarily ABHR*, protect against hand contamination.

Casanova et al. 2016 *[141]* conducted a simulation study of doffing practice with 15 HWs who had donned EBOD PPE for the study. Virus was applied to PPE and a trained monitor guided them through the doffing protocol. Of the 15 participants, 10 participants used ABHR for glove and hand hygiene and 5 used hypochlorite for glove hygiene and ABHR for hand hygiene. Inner gloves, hands, face, and scrubs were sampled after doffing.

- After doffing, MS2 virus was detected on the inner glove worn on the dominant hand for 8 of 15 participants, on the non-dominant inner glove for 6 of 15 participants, and on scrubs for 2 of 15 participants. All MS2 on inner gloves was observed when ABHR was used for glove hygiene; none was observed when hypochlorite was used. When using hypochlorite for glove hygiene, 1 participant had MS2 on hands, and 1 had MS2 on scrubs.
- Careful doffing of inner gloves in a manner that minimizes the risk of hand contamination is important. To minimize viral contamination of inner gloves, more conservative control measures may include sanitizing gloves with stronger agents such as hypochlorite. While hypochlorite use directly on hands may not be desirable, its use on gloves does not present the same issues.
- It is reasonable to recommend that HW involved in care of patients with EBOD post-doffing shower using an antiseptic such as chlorhexidine.
- A structured doffing protocol using a trained monitor and ABHR protects against enveloped virus self-contamination. Non-enveloped virus (MS2) contamination was detected on inner gloves, possibly due to higher resistance to ABHR. Doffing protocols protective against all viruses need to incorporate highly effective glove and hand hygiene agents.

Lantagne et al. 2018*[176]* conducted a multiple-thread research study to provide evidence for disinfection guidelines recommendations, including three research strands: (1) impacts of chlorine chemistry; (2) efficacy of surface cleaning recommendations; and (3) safety and efficacy of handwashing recommendations.

- Strand 1 research found that the compound chemistry of the chlorine source has an impact on the chlorine solution shelf-life (<1 day–30 days), with testing of chlorine solutions recommended to ensure accuracy.
- Strand 2 research found that surface cleaning with 0.5% chlorine solutions with a 15-minute exposure time is efficacious in reducing transmission risk.
- Strand 3 research found that community handwashing with chlorine solutions is as safe and efficacious as handwashing with soap and water or sanitizer, which offers a benefit of reducing pathogens in the rinsing water.
  - The safety and efficacy results indicate all handwashing methods were roughly equally efficacious in practice, although: (1) HTH (calcium hypochlorite, high-test hypochlorite) in particular was consistently safer and more efficacious; and (2) chlorine solutions, as compared to soap and water and sanitizer, offer the benefit of reducing pathogen persistence in rinsing water.
  - As all handwashing methods have benefits and drawbacks (see Figure 4), it is recommended that EBOD responders and communities use whichever handwashing method(s) are most acceptable, available and feasible for handwashing, considering that chlorine solutions may offer a benefit in reducing transmission risk from rinsing water.
  - Across all simulations, the chlorine source compound HTH performed particularly well, with chlorine solutions made from this product having the longest shelf life, causing the least hand irritation and resulting in the highest hand-washing efficacy. However, HTH has the operational challenges of being more explosive than NaDCC and having a precipitate form in mixing with water that can clog pipes. In well-maintained ETUs, this can be managed with appropriate training and maintenance. However, explosions did occur in ETUs that were managed by less experienced organizations during the West African outbreak, which posed a great risk to the health and safety of response personnel and patients.

Reidy et al 2017 *[143]* conducted an expert review of PPE solutions for UK military medical personnel working in an Ebola treatment unit (ETU) in Sierra Leone. They suggest that tactility and dexterity through two pairs of gloves was of key importance. They chose 400-mm nitrile, powder-free gloves. Competency in using PPE was developed during a nine-day pre-deployment training program. This allowed over 60 clinical personnel per deployment to practice skills in PPE in a simulated ETU and in classrooms. Overall, the training provided:

- An evidence base underpinning the PPE solution chosen;
- Skills in donning and doffing of PPE;
- Personnel confidence in the selected PPE;
- Testing of each individual's capability to don PPE, perform tasks and doff PPE safely.

Gao et al. 2016 *[216]* performed laboratory testing of gloves according to current US CDC guidance for the disinfection of gloved hands during the doffing of PPE following the care of an Ebola patient. The guidance recommends multiple applications of ABHR on medical exam gloves. The investigators evaluated possible effects of ABHR applications on the integrity of 13 brands of nitrile and latex medical exam gloves from five manufacturers. Two different ABHRs were used in the study.

- In general, tensile strength decreased with each ABHR application. ABHRs had more effect on the tensile strength of the tested nitrile than latex gloves, while ethanol-based ABHR (EBHR) resulted in lesser changes in tensile strength compared to isopropanol-based ABHR (IBHR).
- The results show that multiple EBHR applications on the latex gloves and some of the nitrile gloves tested should be safe for Ebola PPE doffing based on the CDC guidance.

The investigators recommend appropriate hospital staff practice using ABHR applications and doffing gloves so that staff can become familiar with changes in glove properties.

Outcome Timeframe	**Study results and measurements**	**Comparator** 1.Removal of outer glove and hand hygiene (inner glove) w/ alco	**Intervention** Hand hygiene (including glove disinfection) between patients .	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg,				The systematic review did not identify any evidence on the following outcomes: Infection with Ebola or Marburg	No studies were found that looked at infection with ebola or marburg,
Adverse Events (e.g.dermatitis)				The systematic review did not identify any evidence for the effects of A (compared to B) on the following outcomes: Adverse effects (e.g., dermatitis)	No studies were found that looked at adverse events (e.g.dermatitis)
PPE breaches/ exposures				The systematic review did not identify any evidence on the following outcomes: PPE breaches.	No studies were found that looked at ppe breaches/exposures.
Compliance,human factors, health worker confidence				The systematic review did not identify any evidence for the effects of A (compared to B) on the following outcomes: Compliance,human factors, health worker confidence.	No studies were found that looked at compliance,human factors, health worker confidence

Clinical Question/ PICO

Population: Health workers working in health care facilities, ETU

Intervention: Hand hygiene (including glove disinfection) between patients .

Comparator: 1.Removal of outer glove and hand hygiene (inner glove) w/ alcohol-based hand rub 2.Removal of both gloves and hand hygiene w/ alcohol-based hand rub 3.Disinfecting outer glove w/ alcohol-based hand rub

Summary

See summary in PICO onOpen in new window"> Hand hygiene (including glove disinfection) between patients.

Outcome Timeframe	**Study results and measurements**	**Comparator** 1.Removal of outer glove and hand hygiene (inner glove) w/ alco	**Intervention** Hand hygiene (including glove disinfection) between patients .	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg,				The systematic review did not identify any evidence on the following outcomes: Infection with Ebola or Marburg	No studies were found that looked at infection with ebola or marburg,
Adverse Events (e.g.dermatitis)				The systematic review did not identify any evidence for the effects of A (compared to B) on the following outcomes: Adverse effects (e.g., dermatitis)	No studies were found that looked at adverse events (e.g.dermatitis)
PPE breaches/ exposures				The systematic review did not identify any evidence on the following outcomes: PPE breaches.	No studies were found that looked at ppe breaches/exposures.
Compliance,human factors, health worker confidence				The systematic review did not identify any evidence for the effects of A (compared to B) on the following outcomes: Compliance,human factors, health worker confidence.	No studies were found that looked at compliance,human factors, health worker confidence

Clinical Question/ PICO

Population: Health workers working in health care facilities, ETU

Intervention: Hand hygiene (including glove disinfection) between patients .

Comparator: 1.Removal of outer glove and hand hygiene (inner glove) w/ chlorine 2.Removal of both gloves and hand hygiene w/ chlorine 3.Disinfecting outer glove w/ chlorine (concentration)

Summary

See summary in PICO onOpen in new window"> Hand hygiene (including glove disinfection) between patients.

Outcome Timeframe	**Study results and measurements**	**Comparator** 1.Removal of outer glove and hand hygiene (inner glove) w/ alco	**Intervention** Hand hygiene (including glove disinfection) between patients .	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg,				The systematic review did not identify any evidence on the following outcomes: Infection with Ebola or Marburg	No studies were found that looked at infection with ebola or marburg,
Adverse Events (e.g.dermatitis)				The systematic review did not identify any evidence for the effects of A (compared to B) on the following outcomes: Adverse effects (e.g., dermatitis)	No studies were found that looked at adverse events (e.g.dermatitis)
PPE breaches/ exposures				The systematic review did not identify any evidence on the following outcomes: PPE breaches.	No studies were found that looked at ppe breaches/exposures.
Compliance,human factors, health worker confidence				The systematic review did not identify any evidence for the effects of A (compared to B) on the following outcomes:	No studies were found that looked at compliance,human factors, health worker confidence

Outcome Timeframe	**Study results and measurements**	**Comparator** 1.Removal of outer glove and hand hygiene (inner glove) w/ alco	**Intervention** Hand hygiene (including glove disinfection) between patients .	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
				Compliance,human factors, health worker confidence.	

14. Health and care worker exposures

Clinical Question/ PICO

Population: Staff working in health care facilities, ETU ; Subgroup-Intermediate or low risk patient care activities
Intervention: Continue with normal duties (no work exclusion)
Comparator: Exclude from work for 21 days

Summary

Initially, 203 studies were screened in the CAL tool software and 32 studies were included for full-text screening. Of these 32 studies, none met the eligibility criteria for the primary question. However, three studies were deemed to provide information on occupational risks of Ebola disease acquisition and transmission and were included to address the revised question*[156][158][155][154]*. To capture additional information related to vaccination status of health and care workers, an additional 203 studies were reviewed in the CAL tool and 34 of these studies were included. Following full-text screening, an additional 2two studies were deemed relevant*[157][153]*.

Upon review of the literature*[154][155]*, it was deemed uncertain whether any of the exposures deemed as high-risk exposures increased or decreased the risk of acquisition of Ebola disease. High-risk exposures found in literature from (n=3) *[156][158][155]*studies were described as

- washed a cadaver
- performed/assisted in caesarean
- placed urinary catheter
- placed intravenous line
- blood draw
- discontinued intravenous line
- high-risk contact
- high perceived risk of Ebola infection

Similarly, after reviewing exposures deemed as “low-medium risk,” the GDG concluded that it was uncertain whether any of the exposures described in the literature *[153][154][155][156][157][158]* as high-risk exposures increased or decreased the risk of acquisition of EVD. Medium- to low-risk exposures were listed as:

- Had been in a patient’s room
- Performed examinations (clinical or laboratory)
- Gave food to a patient
- Conversed with a patient
- Washed a patient’s clothes
- Had contact with a patient’s body fluids
- Cleaned a patient’s room
- Shared ward\latrine

- Took vital signs
- Cleaned linens
- Cleaned body fluids
- Cleaned surfaces: floor, walls, bed
- Cleaned surgical instruments
- Moved patient
- Gave intravenous medications
- Gave intramuscular medications
- Changed surgical-site dressing
- Touched a patient
- Had direct/indirect contact with patient
- Low/average perceived risk of Ebola infection

A review of contextual data noted the following

Implementation:

The review team found it was challenging matching the risk-assessment data (e.g. odds-ratio estimates of seropositivity) with the prescribed care activities. Therefore, consider the practicality of implementing the risk assessment using a list of patient-care activities that included many items without supporting evidence.

Health workers had numerous risk factors for virus exposure in ETUs, other areas of the hospital, and in the community, making it difficult to ascertain where *Ebolavirus* infection occurred*[190]*. As such, comprehensive assessment of EVD exposure may be challenging and the sensitivity of the prescribed care activities for the detection of Ebola infection is uncertain.

An important feature of the Kikwit DRC, outbreak was that health-care facility workers with jobs that in most settings do not involve patient contact appear to have had broader job descriptions, including patient contact *[217]*.

Health workers with low/intermediate EVD exposure were actively monitored and those with high-risk exposure were quarantined, noting that in the future it may be necessary to apply the quarantine to more people or to contacts who refuse to be quarantined *[218]*.

Resources/costs:

The fact that health and care workers had *Ebolavirus* exposure signifies basic deficiencies in implementation of and adherence to core IPC practices. Building IPC capacity will generally be of great benefit to the safety of patients and health workers *[148]*.

Appropriate infection control precautions and personal protective equipment should be available *[112]*

Impact on health equity:

As observed in previously reported outbreaks in other African countries, including the concurrent outbreak in West Africa subregion, females were the most affected. This may be explained by the role that females play in caregiving and nursing in our society, thereby exposing them to infection *[219]*.

Social and legal implications:

Recent EVD outbreaks had a huge psychological impact on both the members of affected communities and those caring for infected individuals*[220]*. This suggests the necessity for relief care providers to be mentally prepared to respond to such disasters and for them to be taken care of while in the field. “When we left for Monrovia we had made our wills; I made it three times and tore it up three times and the fourth one went through. As you approach Monrovia, you pray and you pray, and as the planes arrive, you wonder what to expect*[220]*.”

WHO and the International Labor Organization recommend that HWs with Ebola disease Marburg disease resulting from work activities should have the right to compensation, as well as free rehabilitation and access to curative services*[67]*.

Acceptability of the risk assessment using the list of patient-care activities may be important since the risk assessment may rely on self-reporting.

Outcome Timeframe	**Study results and measurements**	**Comparator** Exclude from work for 21 days	**Intervention** Continue with normal duties (no work exclusion)	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Infection with Ebola or Marburg virus,	Based on data from participants in 6 studies.			Very low Due to serious risk of bias, serious indirectness, very serious imprecision. [1]	We are uncertain whether continue with normal duties (no work exclusion) increases or decreases infection with ebola or marburg virus,
Health-care associated transmission of Ebola;	Based on data from participants in 6 studies.			Very low Due to serious risk of bias, serious indirectness, very serious imprecision.	We are uncertain whether continue with normal duties (no work exclusion) increases or decreases health-care associated transmission of ebola;

1. **Risk of Bias: serious.** 5/9 on NOS; downrated for lack of controls, no reporting on non-response rate. 6/9 on NOS; downrated for lack of non-exposed cohort, failure to adjust for key confounders. 7/9 on NOS; downrated for failure to adjust for confounders. Both studies rated “serious” to “very serious” risk of bias on NOS. 3/9 on NOS; Downrated for lack of controls, failure to adjust for confounders and no reporting on non-response rate. Some concerns of risk of bias assessed using Cochrane ROB-2. . **Inconsistency: no serious. Indirectness: serious.** Downrated by 1 for failure to provide information on PICO intervention of work exclusion for 21 days. , Direct comparisons not available. **Imprecision: very serious.** 6/9 on NOS; downrated for lack of non-exposed cohort, failure to adjust for key confounders. Downrated by 2 as very few or no events and no relative effects reported. Downrated by 1 due to small sample size; unable to evaluate relative effects. .

15. Environmental cleaning and disinfection recommendations

15.1. Environmental cleaning and disinfection

Clinical Question/ PICO

Population: Surfaces and materials in facilities providing care to patients with EVD or Marburg disease
Intervention: Spraying
Comparator: Wiping

Summary

A total of 80 studies were screened in the CAL tool software and 17 studies were included for full-text screening. One of the 17 studies was a recent systematic review published in 2021 that reviewed the efficacy of chlorine-based surface disinfection against seven pathogens (including *Ebolavirus*)*[174]*. For completeness, we reviewed the titles and abstracts of 89 laboratory studies included in the systematic review, as well 25 more recent studies that had cited the review. Four additional articles were deemed relevant and screened at the full-text screening stage*[221][222][224][223]*

No studies met the eligibility criteria. Most articles excluded at the full-text stage examined the efficacy of different types of disinfection solutions for Ebola (e.g., chlorine, ethanol) in a controlled laboratory setting. No studies were found that provided data on the efficacy of wiping compared to spraying for any disinfection agent.

Contextual data from studies identified during the study selection process is summarized below.

- Gallandat et al. 2021 conducted a systematic review of chlorine-based surface disinfection efficacy to inform recommendations for low-resource outbreak settings*[174]*. Of the 89 studies investigated in the review, the most common disinfectant application modes were pipetting (n = 54, 61%), immersion (n = 20, 22%), spraying (n = 8, 9%), or wiping (n = 5, 6%). Because disinfection is often combined with cleaning procedures, wiping was investigated and was found to have an effect on viruses and spores even in absence of disinfectant, suggesting that the mechanical action of wiping contributes to reducing contamination levels on surfaces.

- A study that compared wiping and spraying showed similar efficacies against C difficile spores, though spraying was considered less appropriate for health care settings as it required extended drying times and would not remove dirt and debris[Ensuring contact between disinfectant and test organisms can be challenging with spraying. In addition, chlorine loss during spraying − from spray nozzle to the targeted surface − is a concern*[225]*

- Lantagne et al. 2018 conducted an experimental study to test the efficacy of disinfectants to prevent emerging infectious disease transmission*[176]*. To support disinfection recommendations, three research strands were conducted: (1) impacts of chlorine chemistry; (2) efficacy of surface cleaning recommendations; and (3) safety and efficacy of handwashing recommendations. A testing matrix was developed that included various surface types that are relevant in emergency health responses (nitrile, heavy duty tarp, stainless steel); chlorine types (NaDCC, HTH, generated NaOCl, stabilized NaOCl); soil load (with and without); and factors that varied between the Médecins Sans Frontières (MSF), WHO and CDC recommendations, including exposure time (10, 15 min) and recommended pre-treatments (none, covering, wiping, covering/wiping). The bacteriophage that was most similar to the Ebola virus was left to dry for one hour on a disc with a surface diameter of 8 cm, disinfection was carried out with or without pre-treatment and the residual contamination on the disc was measured at the end of the exposure time.

- Across the entire test matrix, there was always a reduction of > 99.9% in Phi6*[176]*.The results suggest that: (1) surface type influenced disinfection efficacy; (2) chlorine type and soil load did not impact disinfection efficacy when using 0.5% chlorine; (3) contact time did impact efficacy against Phi6; and (4) wiping or covering did not increase disinfection efficacy, but the latter could limit splashing. The authors suggest that surface cleaning with 0.5% chlorine solutions with a 15-min exposure time is efficacious in reducing transmission risk.

- Gallandat et al. 2017 compared the efficacy of four chlorine solutions (sodium hypochlorite, sodium dichloroisocyanurate, hightest hypochlorite, and generated hypochlorite) for disinfection of three surface types (stainless steel, heavy-duty tarp, and nitrile) with and without pre-cleaning practices (pre-wiping, covering, or both) and soil load*[169]*. The test organisms were Escherichia coli and the Ebola surrogate Phi6. The results support the recommendation of a 15 min exposure to 0.5% chlorine, independently of chlorine type, surface, pre-cleaning practices, and organic matter, as an efficacious measure to interrupt disease transmission from uncontrolled spills in Ebola outbreaks

Outcome Timeframe	**Study results and measurements**	**Comparator** wiping	**Intervention** spraying	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Adverse effects associated with chemical exposure				No studies met the eligibility criteria.	No studies were found that looked at adverse effects associated with chemical exposure
Coverage of surfaces with disinfectant				No studies met the eligibility criteria.	No studies were found that looked at coverage of surfaces with

Outcome Timeframe	**Study results and measurements**	**Comparator** wiping	**Intervention** spraying	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
					disinfectant
Log reduction of virus or surrogate on surface,				No studies met the eligibility criteria.	No studies were found that looked at log reduction of virus or surrogate on surface,
Infection with Ebola				No studies met the eligibility criteria.	No studies were found that looked at infection with ebola or marburg
Psychological effects (stigma) associated with spraying of homes with disinfectants, patient experience				No studies met the eligibility criteria.	No studies were found that looked at psychological effects (stigma) associated with spraying of homes with disinfectants, patient experience

15.2. Linen and laundry

Clinical Question/ PICO

Population: Heavily soiled linen resulting from care to patients with EVD or Marburg disease in health care, ETUs, or community settings

Intervention: Elimination

Comparator: Disinfection

Summary

A total of 72 studies were screened in the CAL tool software and 20 studies were included for full-text screening. No studies met the eligibility criteria. The majority of studies excluded at the full-text were excluded because they were non-comparative studies that did not compare outcomes for incineration vs. disinfection of heavily soiled linens. Articles that discuss the implementation of current practices for disinfection or decontamination of heavily soiled/highly contaminated waste from *Ebolavirus* or Lassa fever patients were noted and are discussed in the contextual data

summarized below.

Contextual data from six studies that were identified during study selection.

- In Edmunds et al. 2016*[177]*, a team with expertise in the Hazard Analysis of Critical Control Points framework identified waste products from the care of individuals with Ebola virus disease and constructed, tested and confirmed flow diagrams showing the creation of such products. After listing potential hazards associated with each step in each flow diagram, the team conducted a hazard analysis; determined critical control points; and made recommendations to mitigate the transmission risks at each control point. They identified 13 critical control points at which there is an opportunity to adopt measures to reduce the risks of transmission.

- Garibaldi et al 2016 *[180]* describe a biocontainment and treatment unit at Johns Hopkins Medicine to care for patients with EVD. They examined published literature and guidelines; visited two U.S. biocontainment units (BCU); and contacted national and international experts to inform the design of the physical structure and patient-care activities of the unit, which has an onsite waste-handling room with two pass-through autoclaves (Primus Sterilizer, Omaha, NE). Items that are reused on the BCU are transported to a room off the waste-handling area, where they undergo disinfection with a hydrogen peroxide vapour system.

- In 2017, Garibaldi et al. *[181]* conducted a validation study of autoclave protocols for successful decontamination of category A medical waste generated from care of patients with serious communicable diseases. The most difficult loads to sterilize were those containing saturated linens (soaked with 1 litre of water) comprising a cotton blanket, sheets, and pillowcases, which required a vacuum cycle of a minimum of 60 min to achieve adequate sterilization using the settings as described for other dry waste. Nine of nine runs (100%) containing multiple saturated linens and using a shorter sterilizing time (three runs each of 15, 30, and 45 min) failed. While autoclave sterilization may be an effective and safe way to process infectious waste for transport and disposal, this study shows that factory default settings and laboratory waste guidelines are likely insufficient to adequately sterilize pathogens in the center of medical waste autoclave loads. Autoclave parameters may need to be adjusted, with particular attention paid to the way that waste loads are packaged prior to treatment.

- Haverkort et al. 2016*[178]* report how the Major Incident Hospital of the University Medical Centre Utrecht prepared to admit Ebola patients. Waste management was the greatest concern, and destruction of waste had to be outsourced. Preparations for waste management were a major concern, given the expected amount of waste and the time-consuming procedures involved (replacing a single waste container in the isolation unit can take as long as 20 minutes). Designated, sealable, 60-L waste containers would be used for waste storage, and waste management procedures were strictly protocolled and repeatedly conveyed through training. In-hospital autoclave capacity appeared insufficient; therefore, waste destruction would be outsourced to an external facility.

- Otter et al. 2010*[179]* report the use of a hydrogen peroxide vapour decontamination of a critical care unit room used to treat a patient with Lassa fever. They based their decontamination strategy on a UK 1996 Health Protection Agency guidance document for the management and control of viral haemorrhagic fevers; it states that “In some circumstances VHF [viral haemorrhagic fever] viruses can survive for two weeks or even longer on contaminated fabrics and equipment.” They therefore decided to decontaminate the critical care unit room, which was contaminated with blood and body fluids, with hydrogen peroxide vapour, a sporicidal and virucidal vapour-phase method that is being used increasingly in health-care settings.

Outcome Timeframe	**Study results and measurements**	**Comparator** disinfection	**Intervention** elimination	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Staff exposure during handling and laundering of linens.				No studies met the eligibility criteria	No studies were found that looked at staff exposure during handling and laundering of linens.

Outcome Timeframe	**Study results and measurements**	**Comparator** disinfection	**Intervention** elimination	**Certainty of the Evidence** (Quality of evidence)	**Plain language summary**
Transmission of Ebola and Marburg				No studies met the eligibility criteria	No studies were found that looked at transmission of ebola and marburg

16. Waste management

17. Safe management of dead bodies