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Environmental Considerations

Ebola Virus Disease Evidence Brief Series

Issue and Research Question

Evidence of the role that the environment plays in the spread of infectious diseases is constantly evolving. A growing body of published evidence, health organization guidelines and field evidence suggests that most Ebola virus transmission comes from direct contact with blood and other infected body fluids during the acute phase of illness. Little is known about the persistence of Ebola virus in the environment and the risk of transmission of infection posed by other modes of transmission such as having contact with contaminated patient care environments and medical equipment; collection and testing of clinical laboratory specimens; or the handling of medical waste, including wastewater management. While methods of virus inactivation have been studied, further information is required about appropriate concentration and contact time of products and about inactivation of the virus using newer technologies. Little is known about the ability of the virus to remain in small aerosol particles and the role this may play in forward transmission of the virus.

This evidence brief provides a summary of current evidence related to Ebola virus persistence in the environment and potential associated risks.

Summary of Recommendations

Ebola virus is able to survive for periods of time in various body fluids in the environment, in both liquid and dried states during the acute, convalescent and postmortem periods. Body fluids that have been shown to shed viable Ebola virus include blood, saliva, stool, nasal blood and tears during the period of acute viremia; and breast milk and semen in convalescence. When dried onto various solid substrates such as glass, plastic, polyethylene fibre, cotton, and some metal alloys, the virus is reported to have been recovered after various lengths of time (ranging from < 24 hours to 50 days) at various temperatures (ranging from 4°C to 27°C).

Different environmental conditions such as temperature and humidity, fluid type(s)/consistencies and environmental surface characteristics influence the ability of Ebola virus to persist in the environment.

Ebola virus is inactivated by a variety of currently recommended disinfectant agents such as sodium hypochlorite 0.5% and ethanol 67% at contact times of 5 and 10 minutes. Materials suspected of being contaminated should be disinfected immediately with appropriate attention given to the applied concentration of disinfectant and contact time. Some virions may be more resistant to decontamination. Virus that has been shed and is suspended in secretions and

excretions containing organic and cellular debris may be protected from environmental decontamination procedures if not routinely cleaned and manually removed prior to decontamination. Evidence-based protocols for manual cleaning, followed by disinfection and high level disinfection/sterilization (as appropriate) are recommended for cleaning of medical equipment and patient care environments to effectively control the spread of infection.

Risk of transmission is low from convalescent patients and from fomites in clinical settings, when recommended infection control guidelines of the viral hemorrhagic fevers are followed. It is possible that the transmission risk from environmental contamination and fomites may vary in the household or other settings where decontamination would be less frequent and thorough, especially if linens or other household materials were to become visibly soiled by blood.

Target User

This evidence brief is of interest to health care providers in acute care and community settings, public health professionals, laboratory professionals involved in clinical care or research, environmental cleaning professionals and waste management professionals.

Type and Quality of Evidence

In total, eight studies on environmental considerations were identified as meeting the inclusion criteria. Six were analytic studies using laboratory based experimental design of which three were appraised as being of higher quality and three were of moderate quality. The remaining two studies were reviews of the literature and were appraised as being of lower methodological quality and did not report any new or experimental work.

Main Findings/Synthesis

Viral Lifespan in Liquid Media, on Solid Substrates and in Dynamic Aerosols

The ability of Ebola virus to persist in the environment, under various conditions has been described in the literature. Studies have demonstrated that under ideal conditions, the virus can persist in various liquid media (i.e. human clinical specimens, laboratory culture and sera) and when dried on various substrates found in the environment (i.e. glass, plastic, metal, polyethylene fibre, cotton). The factors creating ideal conditions for this environmental persistence are less clearly understood.

To further the knowledge about persistence of EBV in various liquids and on solid substrates, an experimental study by Piercy et al (2010), tested the survival of several filoviruses, including the Ebola virus variant Zaire Ebolavirus (ZEBOV), in liquid media and on solid substrates (glass,

plastic and metal) at various temperatures over a time period of 50 days. The decay rate of ZEBOV in a dynamic aerosol was also measured.

This study demonstrated that filoviruses are able to survive and remain infectious in cell cultures or guinea pig blood for extended periods when suspended within liquid media at various temperatures. On day 46 ZEBOV was detectable in liquid media stored at 4 degrees Celsius and at room temperature with virus viability decreasing significantly at room temperature ($P< 0.001$, two-way ANOVA).

When dried onto solid substrates over 14 days no virus was recovered on any substrate stored at room temperature. Nor could it be recovered from metal substrate at any time. However, it could be recovered on plastic stored at 4 degrees Celsius at day 14 and glass at day 50 when stored at 4 degrees Celsius.

In this study, the authors also measured the inactivation rates of ZEBOV within small particle aerosols for a period of over 90 minutes. A bacterial tracer was used as an internal control. Resultant decay rates reported suggest that ZEBOV was able to survive and remain infectious in aerosols for at least 90 minutes. Although human transmission of Ebola Virus via airborne route is not established and requires further investigation, this study shows that transmission is at least theoretically possible by the airborne route.

In another experimental study by Fischer et al (2015), the stability of Guinea Ebola Virus (Makona variant) was tested on stainless steel, plastic and polyethylene fabric (used in personal protective equipment) surfaces as well as in various liquid media including water, spiked human blood and the blood of infected non-human primates (NHP). Experiments were conducted at 21°C, 40% relative humidity (RH); and at 27°C, 80% RH to simulate a climate controlled hospital and the environment in West-Africa respectively.

Virus concentration was reduced at a significantly slower rate on all surfaces in controlled hospital setting environments* than in tropical conditions** (polyethylene fabric (14 days* vs 4 days**); plastic (11 days* vs 3 days**) and stainless steel (8 days* vs 3 days**) respectively ($p<0.0001$ for all surfaces). The authors further reported that EBV remained viable in drying blood for up to 5 days and in liquid blood for up to 14 days at both environmental conditions in NHP blood; and in water for as long as 3 days (27°C) or 6 days (21°C).

Cook et al (2015) also examined the robustness of the EBV Makona variant when suspended in a simulated organic soil load and dried onto items commonly found in a clinical setting including stainless steel, surgical masks, cotton gown and waterproof plastic gown. This organic soil load was representative of virus shed in a variety of profuse secretions (such as vomit, diarrhea) that would be generated during periods of high viremia. Results indicated that virus suspended in an organic soil load showed prolonged environmental persistence (192 hours) on some surfaces common to a clinical setting including the surgical mask, plastic gown and steel. The cotton

surface showed a 47% reduction in viral titre after 1 hour exposure followed by complete inactivation at 24 hours.

Bausch et al (2007) tested various acute and convalescent clinical specimens from 26 laboratory-confirmed cases of Ebola hemorrhagic fever (EHF) in a hospital setting in Gulu, Uganda, as well as environmental specimens collected from a hospital isolation ward, for presence of Ebola Virus. The ward routinely followed environmental decontamination procedures as recommended by the World Health Organization (WHO).

Of the 33 environmental samples taken from the isolation ward, six hours after the last routine cleaning, only the positive controls, a bloody medical glove and contaminated IV tubing, were RT-PCR positive (culture negative). The authors offer some discussion regarding possible rationale for results including the potential impact of routine environmental cleaning and disinfection performed on the ward on the study results. They recommend that environmental samples obtained in future studies be analyzed with an assay validated for EBOV detection be performed to confirm their results.

Sagripanti, Rom and Holland (2010) also examined Ebola viruses dried onto solid surfaces to measure the inactivation kinetics of the virus in the dark, on glass substrate, under controlled environmental conditions (corresponding to nighttime inactivation). The Zaire strain of EBV was used in the study. Results indicated that EBV could not be detected after 5.9 days. The results of this study support other published work referenced in this brief that Ebola virus is hardier and survives on non-porous material for longer periods than often expected. The relatively long time required to inactivate in the dark even small amounts of viruses highlights the challenge to remediate environments that could be contaminated with viral agents.

Decontamination and virus inactivation

The ability to decontaminate a room or other location potentially containing the Ebola virus by fumigation, or other remote technologies, has become a topic of importance given the risks of virus transmission for health care workers implementing manual cleaning protocols.

Within the literature a variety of physical and chemical methods to decontaminate the environment and inactivate microorganisms have been described and play an important role in preventing and controlling the spread of infection in healthcare settings.

Sagripanti and Lytle (2011) performed an experimental study to determine the inactivation kinetics produced by exposure to germicidal UV (UVC, 254 nm radiation) of the Zaire virus variant that had been dried on glass. Results of the study indicated that Ebola virus is sensitive to UVC radiation, however survival rates may relate to the environmental conditions surrounding the dried virus particles. The presence of significant amounts of dried protein from serum and cellular debris from the growth medium in the study, provided some protection from inactivation

by UV radiation to 3-10% of the virus in the inoculum. This protected virus population had a four and sixfold lower UVC sensitivity than the general virus population. Virions that were less shielded by debris (lying on or near the top of the protein layer) were more readily inactivated while particles shielded from UV radiation by other virions, proteins and other debris, were more resistant to inactivation. Thus virus inactivation would vary with the amount of chemical or cellular components available to shield the virus, a finding echoed in the research by Cook et al 2015. In settings where high levels of environmental contamination with complex fluids can be anticipated, UVC alone may not be appropriate to achieve environmental decontamination.

Cook et al (2015) further examined virus inactivation using sodium hypochlorite at 0.1%, 0.5% and 1% concentrations on steel carriers. The 0.5% and 1% sodium hypochlorite solutions performed similarly with viable virus recoverable at 1 minute contact time, while all carriers used considered sterile following a five minute contact time. Efficiency of virus disinfection correlated positively to the concentration of solution and length of contact time with higher concentrations of sodium hypochlorite at longer contact times achieving greater disinfection. Similar findings were reported when using 67% ethanol as a disinfecting agent, with virus inactivation on 3 of 9 samples after one minute and no recoverable virus found after 5 and 10 minute contact times.

In their review of the literature, Raabe and colleagues (2015) describe findings related to infection control practices during EVD and other filoviral hemorrhagic fever outbreaks in developing settings. These authors summarize the findings of three studies they found related to environmental considerations:

- Use of bleach concentrations of the order of 1:10 for disinfecting human excreta, human bodies and body bag exteriors and large spills which are categorized as heavily contaminated and require decontamination; 1:100 for disinfection of “everyday” objects.
- Use of calcium hypochlorite solution of 0.02% to 2% concentration as a substitute for bleach for highly contaminated items such as latrines used for patients and safe body burial.
- Difficult to disinfect items should be covered in plastic to facilitate decontamination.
- Contaminated disposable objects should be disinfected and incinerated following removal from an isolation unit.

The topic of effective disinfection was also addressed by Missair et al (2015) in their review of the literature on Anesthesia and Ebola. These authors describe the findings of one study in their review related to environmental considerations:

- Effective disinfection can be accomplished with 2% sodium hypochlorite solution or registered hospital grade disinfectant for heavily contaminated items such as equipment, body bags and large spills.
- Blood spills or body fluid spills should be managed by removal of bulk spill matter, cleaning of the site followed by disinfection using a registered disinfectant with microbial coverage of nonenveloped viruses.

- Disposable materials should be placed in leak-proof containers and labelled as biohazard prior to removal.

Recommendations for Future Research

Within the literature there is some incongruence of results regarding the viability of Ebola virus on various substrates over time. Although it is understood that different environmental conditions such as temperature and humidity, fluid type(s) and environmental surface characteristics influence the ability of Ebola virus to persist in the environment, it is recommended that further research be done with a greater number and variety of environmental samples using standardized procedures.

It is recommended that environmental samples obtained in future studies be analyzed with an assay validated for EBOV detection and that standardized procedures for obtaining, storing and handling of specimens to avoid inactivation be developed and utilized.

Future studies that evaluate potential differences in the characteristics of Ebola virus variants, and their abilities to persist in the environment would be invaluable. Understanding the unique characteristics of Ebola virus variants may provide further clarity into required IPAC practices and theoretically may provide possible rationale for differences in findings described in the literature.

There is very little available research in the area of decontamination, and virus inactivation. Further research in these key areas is required to identify effective measures to decontaminate environments and objects contaminated with the Ebola virus to reduce this as a potential route of virus transmission.

References

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