

Guide F – Environmental Control of Smallpox Virus

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A. Purpose:

This document provides general guidance on environmental infection control and decontamination for use in any setting where care is given to smallpox patients. This information will be beneficial to:

- Healthcare workers,
- Housekeeping and laundry personnel,
- Mortuary personnel and morticians,
- Public health officials,
- Emergency responders in handling cases of smallpox, and
- Persons who manage the treatment and disposal of regulated medical waste.

B. Introduction:

Variola virus is a member of the genus *Orthopoxvirus* within the family *Poxviridae*. Poxviruses are large, brick-shaped, enveloped viruses with a double-stranded DNA genome. Of the four orthopoxviruses known to infect humans, variola virus (major and minor) produces the most significant clinical disease (smallpox).

C. Transmission and Engineering Controls:

Smallpox is transmitted routinely person-to-person (a form of direct contact) via inhalation of variola virus present in droplets generated from the respiratory tract of infected, symptomatic patients. Since disease transmission is via direct contact, infection control and prevention measures are based primarily on contact and droplet precautions.¹ Historically, secondary transmission of infection has been limited to susceptible contacts in the immediate vicinity of patients. Patients become infectious at onset of their rash. Lesions develop primarily on the skin soon after onset and eventually form scabs that can slough off. Viable viruses can be present in these scabs, and the protein material of the scab can protect the viruses from desiccation. Poxviruses shed during the course of infection therefore tend to be more resistant to the effects of drying compared to other enveloped viruses (e.g., influenza viruses, rubella virus). Poxviruses (e.g., vaccinia virus, variola virus) are tightly bound with the fibrin matrices of the scab, however, and this limits the efficiency of virus transfer from environment to persons via reaerosolization.² There are limited reports of airborne spread of variola virus in healthcare facilities and laboratories^{3,4} and reaerosolized transmission from fabric or bedding fomites.^{5,6} The mechanisms of virus spread as described in these reports, however, may represent potentially important exceptions to the usual mode of transmission. Additional factors present in these situations (e.g., enhanced efficiency of viral shedding from oral and pharyngeal lesions, poorly engineered facility ventilation) may have contributed to and facilitated viral dispersion in ways that might not be consistently duplicated in contemporary healthcare facilities.³

A properly engineered heating, ventilation, and air-condition (HVAC) system can minimize the possibility of airborne spread of variola virus in facilities providing care for smallpox patients. Placing smallpox patients in airborne infection isolation (AII) rooms (i.e., rooms under negative air pressure relative to the corridor or other adjacent space) can help to limit distribution of virus in the air.⁷ Existing AII rooms in healthcare facilities need not be modified beyond the current engineering specifications.⁸ A more in-depth discussion of variola virus transmission can be found in [Guide A—Smallpox Surveillance and Case Reporting; Contact Identification, Tracing, Vaccination, and Surveillance; and Epidemiologic Investigation](#)

Variola virus could hypothetically be used as a weapon either through airborne dispersion or through intentionally infecting one or more persons and encouraging them to circulate among groups of people, thereby exposing these contacts to variola virus infection. If introduced into the air, it is likely that the virus would be inactivated within 24 hours, and certainly would not be present in the environment by the time any cases might occur 7-17 days later. The expected outcome resulting from this form of release would most likely be large numbers of cases with clustered onsets. Establishing epidemiologic association among these cases could be problematic, depending on the site and extent of virus dispersion. If introduced through intentionally infected persons, the origin of the virus (i.e., the index case) and the extent of the outbreak could likely be tracked using standard epidemiologic and laboratory methods.

D. Occupational Issues:

The following activities should be limited preferably to persons with active immunity to smallpox:

- Patient-care activities,
- Laundry ,
- Decontamination procedures, and
- Mortuary procedures.

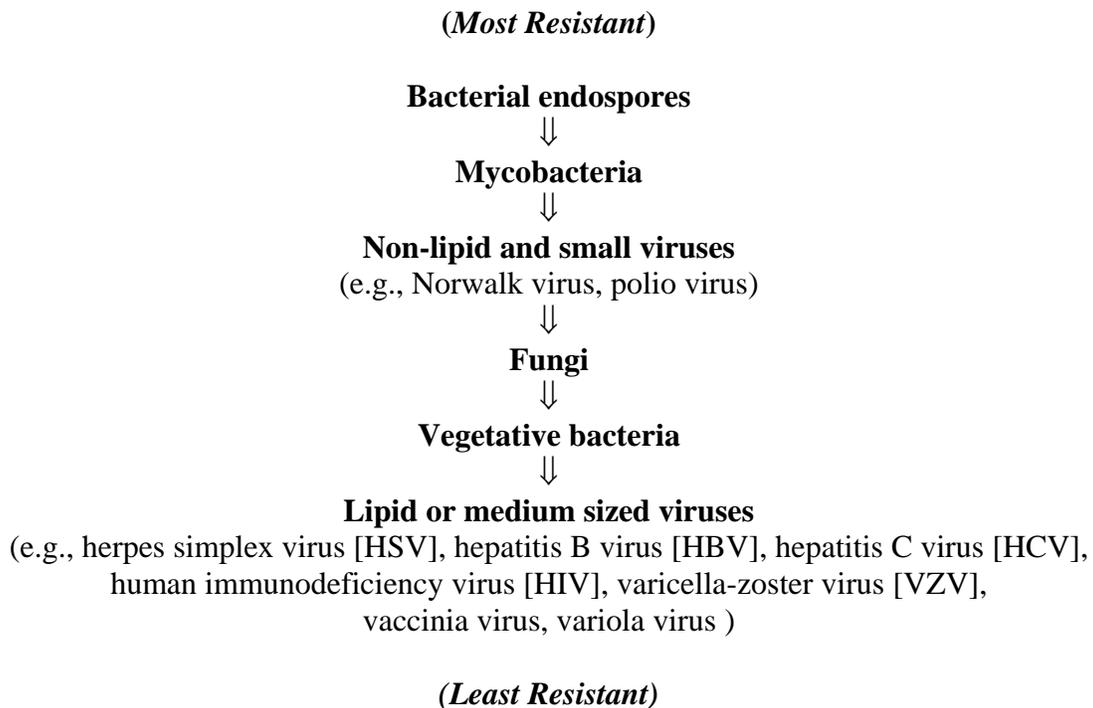
Refer to Guide B—Vaccination Guidelines for State and Local Health Agencies [part 1](#), [part 2](#), and [part 3](#) for information on vaccination strategies for workers who provide these services and for those not involved with these functions. Personal respiratory protection (i.e., N95 respirators) may be indicated for those workers who provide direct care to smallpox patients. Whenever possible, disposable versions of PPE should be used as appropriate and discarded after use as per routine medical waste disposal practices.⁹ All personnel should adhere to hand hygiene practices as per current recommendations.¹⁰ Refer to [Guide C part one—Infection Control Measures for Healthcare and Community Settings](#) for information about the appropriate types of PPE and indications for their use.

E. Decontamination and Disinfection:

In general, large enveloped viruses have less intrinsic resistance to inactivation by either physical or chemical methods of disinfection compared to nonenveloped viruses

and many types of bacteria or fungi. The envelope surrounding the core particle of a large virus (e.g., variola virus) contains lipids, and this biochemical property renders this and other enveloped viruses particularly sensitive to chemical disinfection (Figure 1).

Figure 1. Relative Resistance of Microorganisms to Chemical Disinfection*



* Note: Modified from reference #11

There are no disinfectant products registered by the U.S. Environmental Protection Agency (EPA) specifically for the inactivation of variola virus on surfaces, nor have any products been evaluated for this purpose using this specific virus in potency testing. It has been established, however, that viruses with biophysical and biochemical properties similar to those of variola virus (i.e., vaccinia virus) are readily inactivated by a variety of active ingredients found in EPA-registered chemical germicides that provide low- or intermediate-level disinfection during general use (Table 1).^{12, 13} If a manufacturer has submitted data to EPA showing that the product inactivates vaccinia virus, and the EPA has accepted those data and approved such a claim (as it has for a number of products), then the product's label would bear specific use directions for killing vaccinia virus on environmental surfaces. The empiric presumption is that such products would be expected to have sufficient potency to inactivate variola virus on nonporous surfaces.

**Table 1. Chemical Inactivation of Vaccinia Virus on Surfaces:
Inactivation After 10 Minutes Contact Time at Room Temperature^a**

Chemical Disinfectant	Minimum Concentration to Achieve Inactivation
<i>Chemicals Used on Environmental Surfaces for Low- or Intermediate-Level Disinfection</i>	
Ethyl alcohol	40%
Isopropyl alcohol	30%
Benzalkonium chloride	100 ppm ^b
Sodium hypochlorite	200 ppm
<i>Ortho</i> -phenylphenol	0.12%
Iodophor	75 ppm

- a. Modified from references #12, 13, and 14
- b. ppm: Parts per million
- c. Use of this chemical in health care is limited.

Concentrations of the chemicals listed in Table 1 are lower than those commonly used in healthcare applications. It is therefore expected that manufacturer-recommended use-concentrations of EPA-registered germicides will be adequate for routine disinfection of cleaned environmental surfaces for management of smallpox care areas. The nature and extent of surface contamination will dictate the level of disinfection (i.e., low-level or intermediate-level) needed to make the surface safe to handle or use. It is also expected that high-level disinfectants or liquid chemical sterilants cleared by the U.S. Food and Drug Administration (FDA) for the purpose of achieving high-level disinfection of semi-critical instruments and devices will be effective at inactivating vaccinia virus and variola viruses. All sterilization methods currently cleared by FDA for medical instruments and devices will also inactivate these viruses. Use of high-level disinfectants or liquid chemical sterilants on large environmental surfaces (e.g., table tops, floors, walls) is not indicated under any circumstances.

F. Environmental Infection Control of Smallpox:

When developing a strategy for the environmental control of variola virus, the following elements should be included:

1. Control measures to reduce viral contamination on fabrics, clothing, and bedding,
2. Cleaning and disinfection of reusable equipment,
3. Cleaning and appropriate reprocessing of medical instruments,
4. Cleaning and decontamination of large environmental surfaces,
5. Regulated medical waste containment, treatment, and disposal, and
6. Indications (if any) for decontamination of air space in rooms or vehicles.

1. Laundry: Textiles and Bedding:

Textiles and fabrics (e.g., protective clothing, bed linens, clothing) from patients and their immediate contacts should be handled with minimum agitation to avoid contamination of air, surfaces, and persons.¹⁵ This prevents the dispersion of potentially contaminated sloughed-off scabs and skin squames into the air. Textiles and clothing should be bagged or contained at the point of use in accordance with Occupational Safety and Health Administration (OSHA) regulations.⁹ These items should not be sorted prior to laundering. Most, if not all forms of containment used for routine healthcare laundry are acceptable for containing textiles and fabrics generated in care areas for smallpox patients. Wet textiles should be bagged first and then placed in a leak-proof container. Reusable fabric laundry bags commonly used for laundry transport can be laundered along with the clothing and other fabrics. The use of a water-soluble bag is another option for minimizing direct contact and manipulation of these fabrics and clothing prior to washing. If laundry is transported to an off-site facility, the procedures that are currently used for transporting and safe handling of contaminated textiles off-site will be adequate for these situations. Laundry should be labeled in such a way that laundry staff should be prompted to wear appropriate PPE and handle potentially contaminated laundry with a minimum of agitation.⁹

The laundry area in a healthcare facility that receives potentially contaminated textiles and clothing should be set at negative air pressure as per normal operating standards, and be physically separate from the area where clean laundry is dried, folded, and packed for transport and distribution.⁸

Textiles and fabrics from care areas for smallpox patients can be laundered using routine protocols for healthcare facilities (i.e., hot water [71°C or 160°F] washing with detergent and bleach and hot air drying).^{7, 11} No special laundering protocols are needed, nor is it necessary to launder materials from smallpox care areas separately from laundry generated elsewhere in the facility. If contaminated clothing and bed linens are to be washed at home, use the hot water cycle at the highest temperature possible with detergent followed by hot air drying. The use of chlorine bleach during hot-water washing can provide additional measure for safety. The use of cold water washing has not been evaluated with respect to inactivation of variola virus. If no other wash cycles other than cold water are available, use detergents and laundry additives that are specifically formulated for cold-water washing and dry using a hot air cycle for the dryer.⁷

2. Reusable Medical Equipment:

The surfaces of reusable medical equipment should be cleaned and then subjected to either low- or intermediate-level disinfection with an EPA-registered chemical germicide in accordance with label instructions. Current protocols and procedures for cleaning and disinfection need not be changed.^{7, 11}

3. Medical Instruments:

Disposable medical instruments and patient-care devices should be placed in containment for safe handling and discarded as per state regulations for the routine handling of medical waste. All reusable medical instruments should be cleaned after use as per standard protocols. These instruments should then be either sterilized or subjected to high-level disinfection depending on their intended use as per the Spaulding classification.¹¹ There is no need to presoak the instruments unless the instruments cannot be cleaned and reprocessed immediately after use. In this situation, water or saline with or without detergents are adequate soaking agents.

4. Environmental Surfaces:

Environmental surfaces that are touched frequently by hand can be cleaned and subjected to low- to intermediate-level disinfection with EPA-registered chemical germicides according to label instructions.⁷ Large housekeeping surfaces such as floors and tabletops can be cleaned using an EPA-registered detergent disinfectant according to manufacturer's instructions.⁷ There is no evidence for transmission of variola virus from nonporous surfaces. Therefore, there is no indication to use extraordinary procedures to clean and disinfect the interior surfaces of ambulances or other spaces occupied by smallpox patients. Routine approaches for cleaning and disinfection are adequate in these areas.

Current procedures and schedules can be used for management of floors and furniture.⁷ Use a vacuum cleaner equipped with a high efficiency particulate air (HEPA) filter for cleaning carpeted floors or upholstered furniture. Disinfection of the vacuum cleaner is not required when a HEPA filter is properly installed and remains intact during use. Full vacuum cleaner bags can be placed in another closable container and discarded as a routine solid waste.⁷ If carpets and upholstered furniture require cleaning to remove visible soil, commercially available products for this purpose are acceptable for use as per usual.

5. Regulated Medical Waste:

Regulated medical waste should be placed in containment, subjected to a decontamination treatment, and discarded in accordance with medical waste regulations of the state or other appropriate jurisdiction. This includes the use of offsite medical waste treatment services. However, if healthcare facilities have the capability of treating/decontaminating medical waste onsite, this capacity should be the first option for medical waste management.⁷ All currently approved methods of medical waste decontamination can be expected to inactivate pox viruses.

State health departments or other authorities having jurisdiction should partner with state environmental agencies to develop appropriate policies and/or regulations to ensure the safe disposal of treated regulated medical wastes. These agencies should provide

assurance to landfill operators that these treated wastes will not pose significant risk of smallpox exposure to either the landfill workers or to the general public. There is no scientific basis for refusing landfill disposal of these treated wastes.

Many, if not all states, consider anatomical and pathological wastes as regulated medical wastes, but the remains of a decedent are usually excluded from this category. Incineration is one option for effectively treating anatomical and pathological wastes prior to disposal; other treatment options may be allowed for this waste category as per state regulations or the regulations of the authority having jurisdiction. Remains can be safely managed in mortuary settings using the current practices of barrier protection, Standard precautions, and other appropriate safety procedures during embalming or otherwise preparing the body for cremation (e.g., safe handling and disposal of embalming chemicals, proper ventilation, environmental surface clean-up and disinfection).

The public health authority may choose to exercise the powers regarding the safe disposal of human remains as outlined in Section 504 of the Model State Emergency Health Powers Act if it is determined that a state of public health emergency exists.¹⁶

6. Indications for Decontamination of Air Space in Rooms or Vehicles:

There is no evidence to support air space decontamination of rooms, facilities, or vehicles (e.g., fumigation). Therefore, fumigation is not indicated for environmental control of variola virus. In controlled laboratory dispersion studies using aerosolized vaccinia virus, infectious virions were rapidly inactivated in the environment, such that only 10% viable particles were detectable 24 hrs after the release.¹⁷ Factors affecting the rate of viral inactivation in this study included:

- Temperature,
- Humidity, and
- Exposure to ultraviolet irradiation (i.e. a release outdoors).¹⁷

An additional laboratory study of variola virus aerosols under controlled conditions has shown that increasing levels of humidity have little effect on viral inactivation (biological decay) compared to other viruses.¹⁸ In this study, only 10%–30% of viable variola viruses were recovered from controlled aerosols after 1 hour.

However, by the time cases appear in the community following an aerosol release, the presumption is that no viable virus would be remaining in the environment from that release. Additionally, modern HVAC systems and current engineering specifications for those systems provide for air cleaning via air changes per hour (ACH).⁷ As stated previously, it is also unlikely that variola virus embedded in the fibrin material from scabs will be easily released from this material and dispersed into the air. If the virus were able to persist in an infectious form in the environment, then additional cases having no contact with infected persons would have been identified. This observation was noted in studies conducted during the smallpox eradication era.¹⁹

References:

1. Garner JS, Hospital Infection Control Practices Advisory Committee. Guideline for isolation precautions in hospitals. *Infect Control Hosp Epidemiol* 1996; 17: 53-80.
2. Henderson DA, Inglesby TV, Bartlett JG, et al. Smallpox as a biological weapon: Medical and public health management. *JAMA* 1999; 281: 2127-2137.
3. Wehrle PF, Posch J, Richter KH, Henderson DA. An airborne outbreak of smallpox in a German hospital and its significance with respect to other recent outbreaks in Europe. *Bull WHO* 1970; 43: 669-679.
4. Hawkes N. Science in Europe: Smallpox death in Britain challenges presumption of laboratory safety. *Science* 1979; 203: 855-856.
5. Dixon CW. *Smallpox*. J & A Churchill Ltd., London, 1962: p. 1460.
6. Downie AW, Meiklejohn G, St Vincent L, et al. The recovery of smallpox from patients and their environments in a smallpox hospital. *Bull WHO* 1965; 33: 615-622.
7. Centers for Disease Control and Prevention. CDC Guideline for Environmental Infection Control in Healthcare Facilities. *MMWR* 2003; 52: in press.
8. American Institute of Architects. *Guidelines for Design and Construction of Hospital and Healthcare Facilities, 2001*. Washington DC; American Institute of Architects Press: 2001
9. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens, final rule. 29 CFR 1910. 1030. *Federal Register* 1991; 56: 64004-64182.
10. Centers for Disease Control and Prevention. Guideline for hand hygiene in healthcare settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *MMWR* 2002; 51 (RR-16): 1-45. Also at: <http://www.cdc.gov/handhygiene/>
11. Garner JS, Favero MS. Guideline on handwashing and hospital environmental control, 1985. *MMWR* 1987; 36 (2S). Also at: http://www.cdc.gov/ncidod/hip/guide/handwash_pre.htm

12. Prince HN, Prince DL. Principles of viral control and transmission. *In: Disinfection, Sterilization, and Preservation*, 5th Ed., Block SS, ed. Philadelphia PA; Lippincott Williams & Wilkins, 2001: p. 881–917.
13. Klein M, DeForest A. Principles of viral inactivation. *In: Disinfection, Sterilization, and Preservation*, 3rd Ed., Block SS, ed. Philadelphia PA; Lea & Febiger;1983:p. 422–434.
14. Prince HN. Disinfectant activity against bacteria and viruses: A hospital guide. *Particulate Microbiol Control* 1983; 2: 55–62.
15. Joint Committee on Healthcare Laundry Guidelines. *Guidelines for Healthcare Linen Services*. Textile Rental Services Association of America. Hallendale, FL; 1999.
16. Centers for Disease Control and Prevention. The Model State Emergency Health Powers Act. Draft 12/21/02. At: <http://www.publichealthlaw.net/MSEHPA/MSEHPA2.pdf>
17. Harper JG. Airborne microorganisms: Survival test with four viruses. *J Hyg* 1961; 59: 479-486.
18. Mayhew CJ, Hahon N. Assessment of aerosol mixture of different viruses. *Appl Microbiol* 1970; 20: 313 – 316.
19. Fenner F, Henderson DA, Arita I, Jerez Z, Ladnyl ID. *Smallpox and its Eradication*. World Health Organization (WHO), Geneva Switzerland; 1988.