Ebola in Sewage and Wastewater

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The findings and conclusions in this presentation are those of the author and do not represent the official position of the Centers for Disease Control and Prevention

Overview

- **Background on the virus**
  - Description
  - Ecology
- **Transmission**
- **Characteristics of Disease**
- **Outbreaks**
  - Historical
  - Current West African Outbreak and Local transmission
- **Environmental Persistence**
- **Recommendations for handling human wastes**

Ebola

- **Family Filoviridae: enveloped single stranded negative sense RNA viruses**
- **Genera: *Cuevavirus*, *Ebolavirus*, *Marburgvirus***
- **Species: *Bundibugyo ebolavirus*, *Reston ebolavirus*, *Sudan ebolavirus*, *Taï Forest ebolavirus*, and *Zaire ebolavirus***
- Enveloped virus

Ebolavirus Ecology

- **Natural Reservoir has not been identified**
- **In outbreaks index case thought to become infected through contact with an infected animal**
  - Fruit bat
  - Primates (apes and monkeys)
- **Then person-to-person transmission follows**

Ebola Virus Transmission

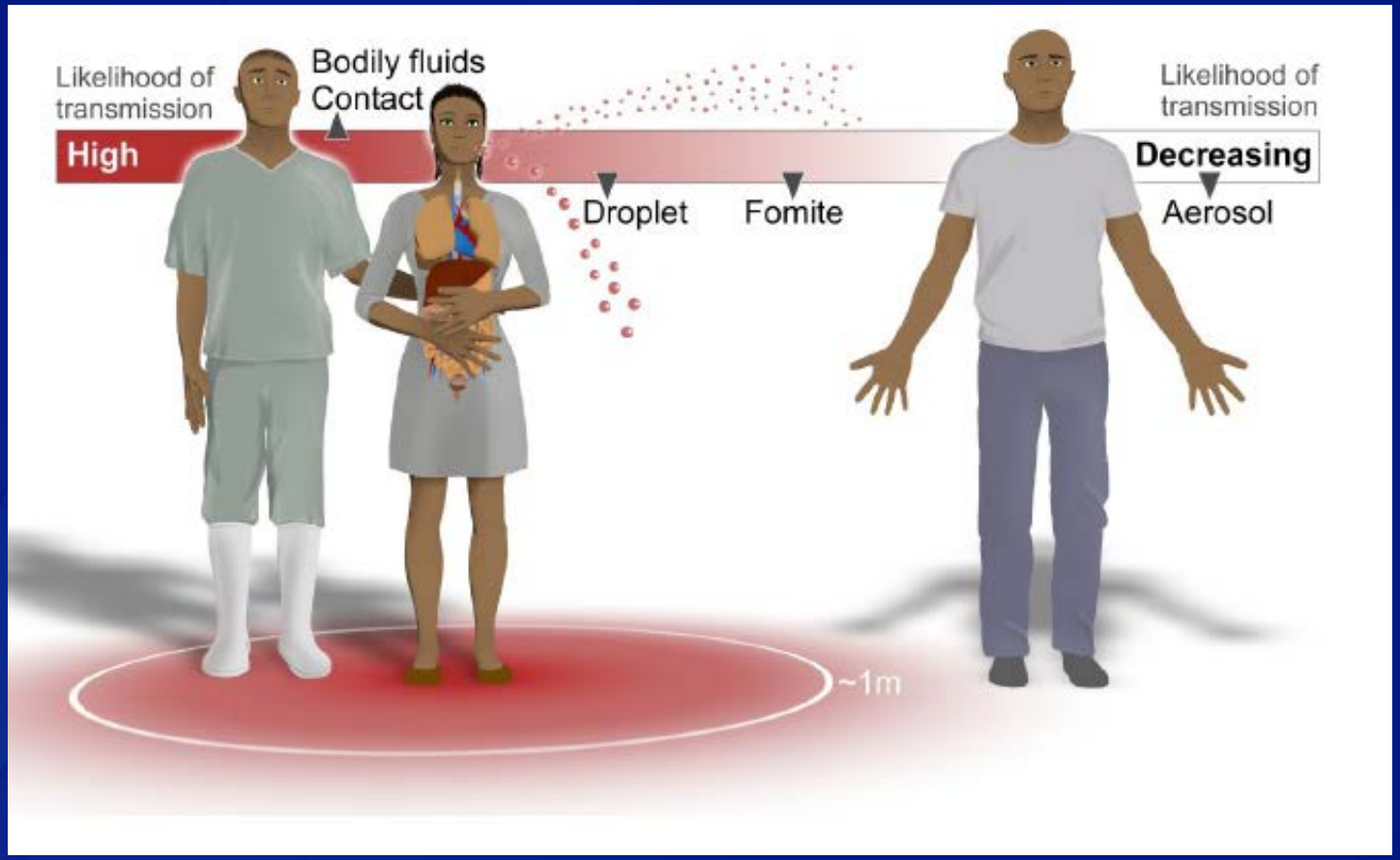
- Virus present in high quantity in blood, body fluids, and excreta of *symptomatic* EVD-infected patients*
- Opportunities for human-to-human transmission
  - Direct contact (through broken skin or unprotected mucous membranes) with an EVD-infected patient's blood or body fluids
  - Sharps injury (with EVD-contaminated needle or other sharp)
  - Direct contact with the corpse of a person who died of EVD
  - Indirect contact with an EVD-infected patient's blood or body fluids via a contaminated object (soiled linens or used utensils)
- Ebola can also be transmitted via contact with blood, fluids, or meat of an infected animal
  - Limited evidence that dogs become infected with Ebola virus
  - No reports of dogs or cats becoming sick with or transmitting Ebola

*Data on urine and feces based on PCR positivity only

Human-to-Human Transmission

- Infected persons are not contagious until onset of symptoms
- Infectiousness of body fluids (e.g., viral load) increases as patient becomes more ill
  - Remains from deceased infected persons are highly infectious
- Human-to-human transmission of Ebola virus via inhalation (aerosols) has not been demonstrated

Transmission of Ebola



Judson S, Prescott J, Munster V. Understanding Ebola virus transmission. *Viruses* 2015;7:511-521

Transmission

- Direct contact with blood and body fluids from an infected person (alive/dead)
- Portal of entry mucous membranes, through open cut, wound, or abrasion, touching ones eyes, or splash to nose or mouth

How is Ebola not Transmitted

- Airborne: outbreaks have been contained with out the use of airborne precautions
- Routine environmental exposures
- From pets (dogs, cats, etc.)

Clinical Manifestations

- **Incubation period:** 2-21 days; typically 8-10 days after exposure
- **Begin with abrupt onset of fever, usually accompanied with myalgia and headache**
- **Symptoms:**

  Fever
  Severe headache
  Muscle pain
  Weakness
  Fatigue
  Diarrhea
  Vomiting
  Abdominal pain
  Unexplained hemorrhage (bleeding or bruising)

- **Mortality**: can be as high as 90% (Africa); <20% (Patients treated in US Hospitals)

Early Clinical Presentation

- Acute onset; typically 8–10 days after exposure (range 2–21 days)
- Signs and symptoms
  - Initial: Fever, chills, myalgias, malaise, anorexia
  - After 5 days: GI symptoms, such as nausea, vomiting, watery diarrhea, abdominal pain
  - Other: Headache, conjunctivitis, hiccups, rash, chest pain, shortness of breath, confusion, seizures
  - Hemorrhagic symptoms in 18% of cases
- Other possible infectious causes of symptoms
  - Malaria, typhoid fever, meningococcemia, Lassa fever and other bacterial infections (e.g., pneumonia) – all very common in Africa

Current Ebola Outbreak in Countries with Widespread Transmission

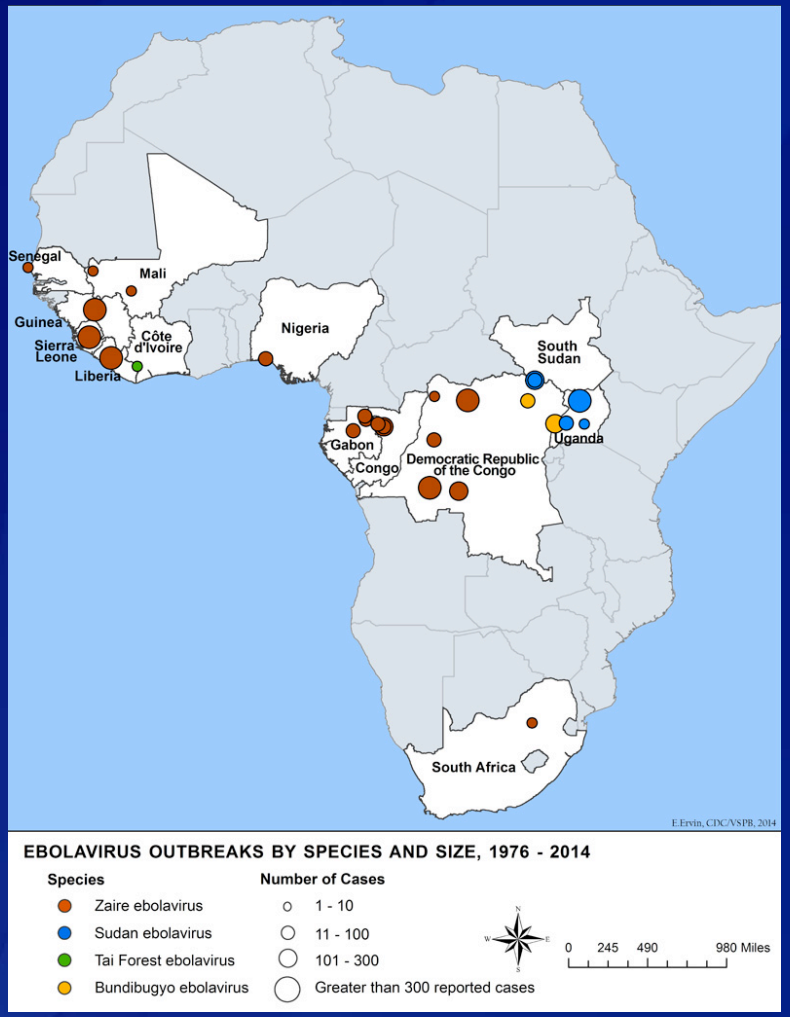
- 23,729 total cases
- 9,604 total deaths

As of February 25, 2015

Guinea, Sierra Leone, Liberia

http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/index.htm

Ebola in Africa, 1976-2014



Country	Number of outbreaks	Years
DRC	10	1976, 1977, 1995, 2001, 2002, 2003, 2007, 2008, 2012, 2014
Multiple	1	2014
Uganda	4	2000, 2007, 2011, 2012
South Sudan	3	1976, 1997, 2004,
Gabon	4	1994,1996, 1996, 2001
South Africa	1	1996
Côte d'Ivoire	1	1994

http://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/distribution-map.html

Previously Affected Countries*

Country	Total Cases (Suspected, Probable, Confirmed)	Lab Confirmed Cases	Total Deaths
Nigeria	20	19	8
Senegal	1	1	0
Spain	1	1	0
United States	4	4	1
Mali	8	7	6
Total	34	32	15

*No active cases

Ebola in the U.S.

- Two patients who had travelled to the endemic area have been diagnosed with Ebola virus disease following their return to the U.S.
- Two nurses who cared for one of the patients were diagnosed with Ebola virus disease

Cases Diagnosed in the United States

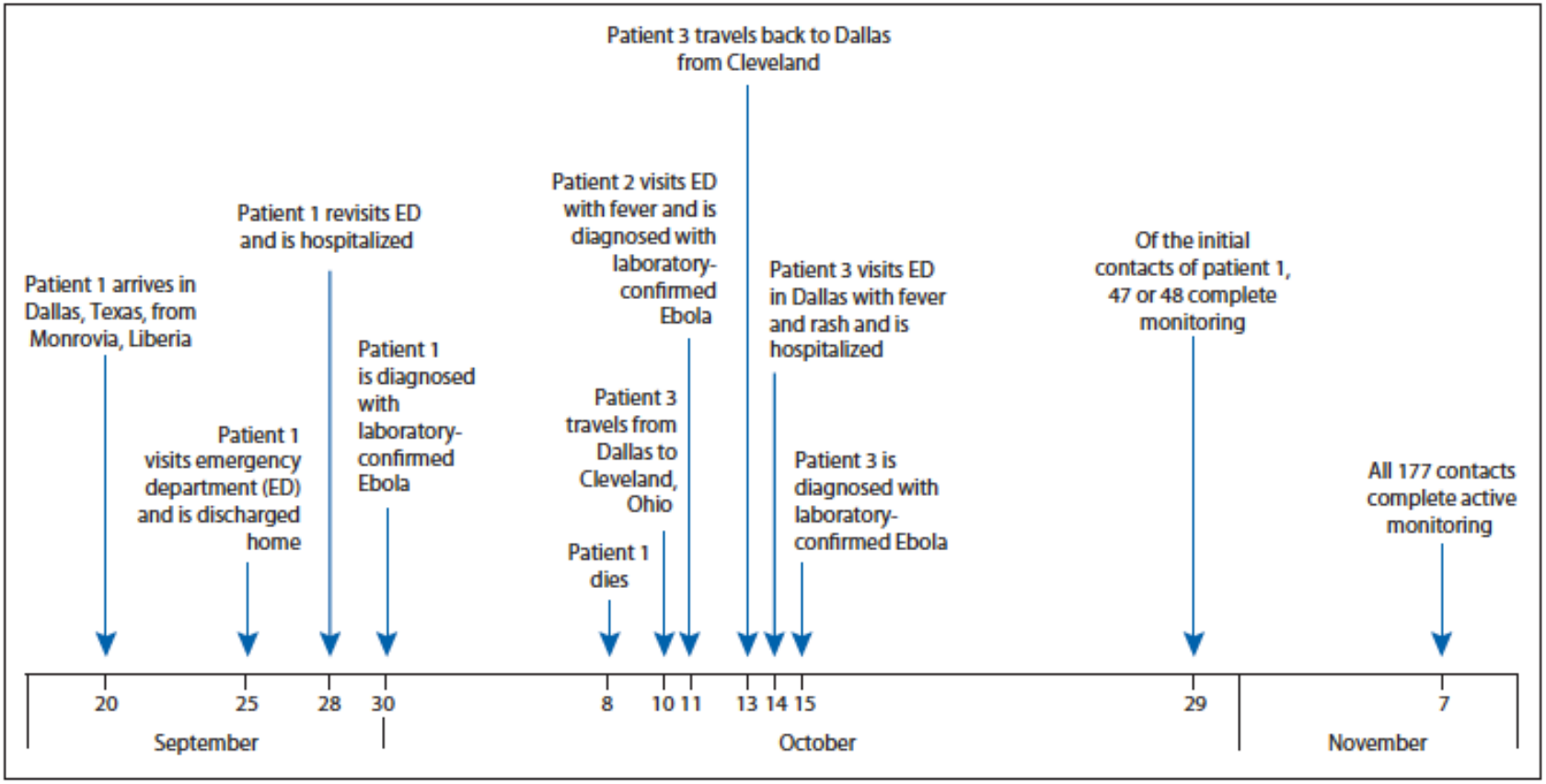
- September 30, 2014: man who traveled from Liberia to Dallas, Tx; admitted to Dallas, Tx Hospital (died on 10/08)
- October 10, 2014: Healthcare worker caring for index patient (recovered)
- October 15, 2014: 2nd Healthcare worker caring for index patient (recovered)
- October 23, 2014: Physician who worked with Doctors without Borders, NYC (recovered)

Transmission to Healthcare Personnel

- The risk is high
- Late stage illness with high viral loads and severe gastrointestinal symptoms increase the risk
- Limited experience with some invasive procedures (blood draws) can increase
- No data on risks during aerosol generating procedures

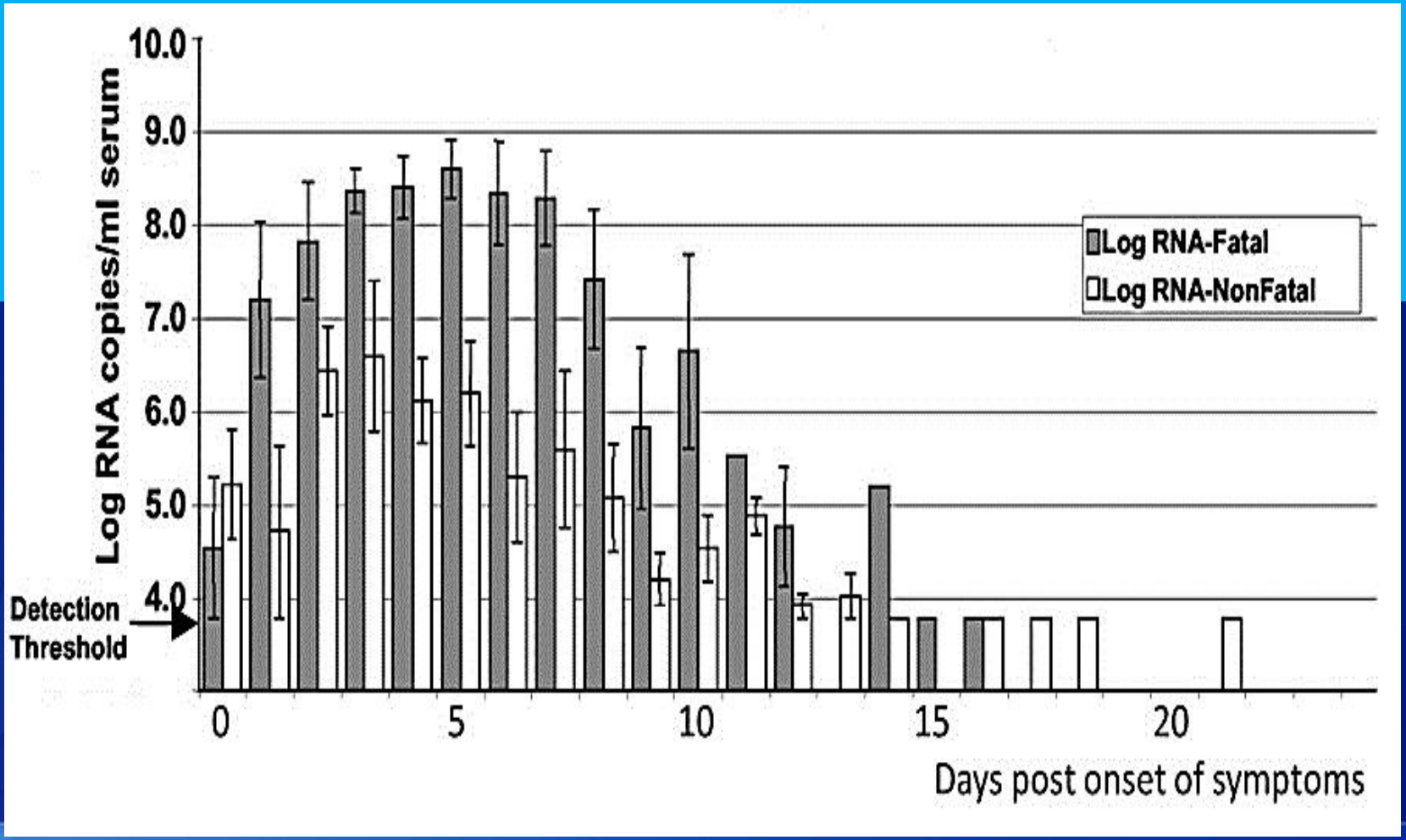
Timeline of events for Ebola patients 1, 2, 3, Dallas, TX

FIGURE. Timeline of events for Ebola patients 1, 2, and 3 — Dallas, Texas, September 20–November 7, 2014



CDC. Ebola Virus Disease Cluster in the United States — Dallas County, Texas, 2014. MMWR 2014;63(46):1087-1088

Ebola Virus Levels in Serum



Household Transmission Data

- 1995 outbreak in Kikwit, Democratic Republic of the Congo
- 28 of 173 household contacts of 27 primary patients developed Ebola
- All 28 reported direct physical contact with a known patient
  - Other studies with similar findings
- Several studies show people who shared confined space with a patient with Ebola, but did not have direct contact, did not develop Ebola

http://www.cdc.gov/vhf/ebola/transmission/human-transmission.html

Is This Outbreak Consistent with Others?

- Clinical course of infection similar to past outbreaks
  - Incubation period
  - Duration of illness
  - Case fatality rate
- Reproductive number (R_0) similar to past outbreaks (1.38-1.81)

General Characteristics Enveloped Viruses

- Envelopes typically arise from host cell membranes; lipid bilayers
- Presence of envelope is essential for entry of the cell
- Relatively sensitive to desiccation, heat, and detergents, pH (acid pH 2.4; alkaline pH >8)
- Have limited survival outside of the host

Previous Laboratory Studies on the Persistence of Ebola Virus in/on Environmental Matrices

- Persists on glass and plastic surfaces for at least 14 days @ 4°C;
- Persists in in liquid media (tissue culture media, guinea pig plasma) for at least 50 days (Temp 4°C, in the dark)
- Viral inactivation rate (1 $\log_{10}$): 15.9 hr for EBOV; 4 $\log_{10}$ virus inactivated with in 5.9 days when dried onto (Stainless steel, glass, rubber; Temp 20-25°C in the dark.

Bibby K, Casson LW, Sacher E, Haas CN. Ebola virus persistence in the environment: State of knowledge and research needs. *Environ Sci Technol Letters* 2015; (ahead of pring)

Piercy TJ, Smither SJ, Steward JA, Eastaugh L, Lever MS. The survival of filoviruses in liquids, on solid substrates, and in dynamic aerosol. *J Appl Microbiol* 2010;109(5):1531-9

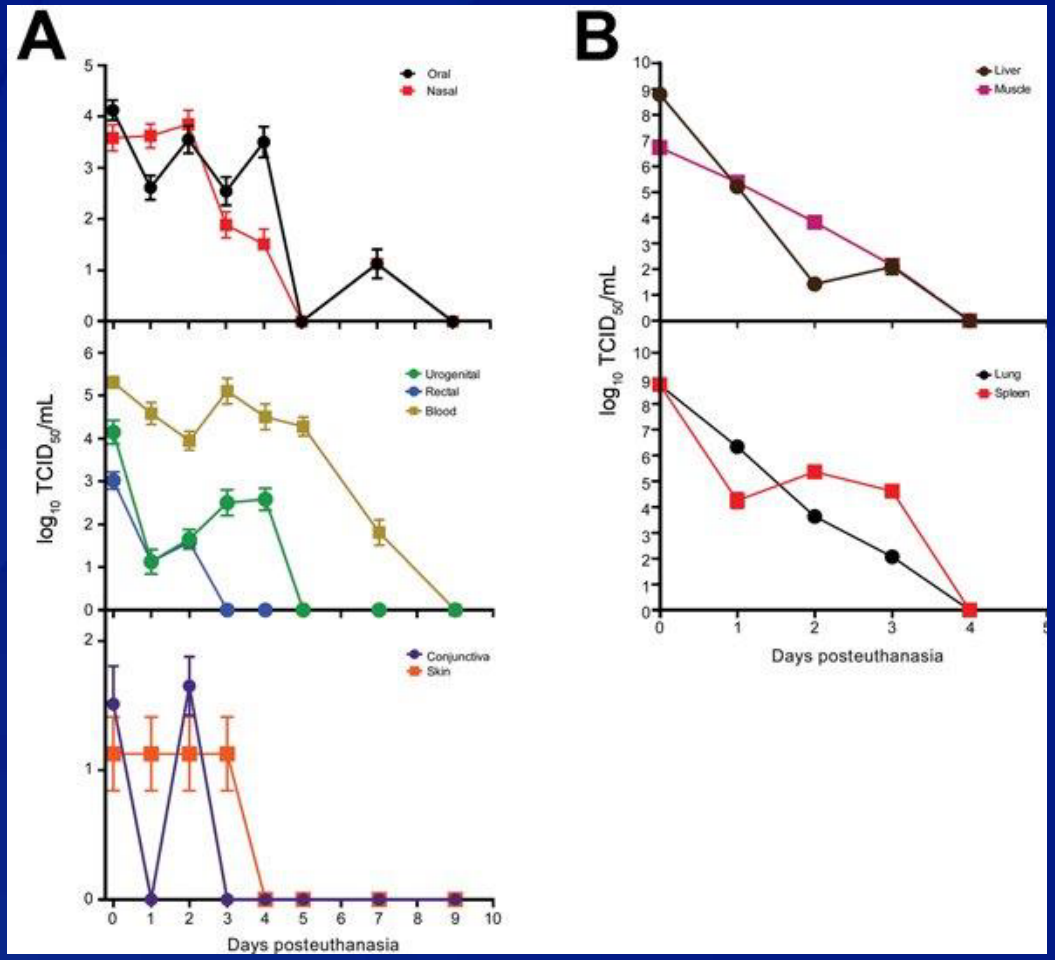
Sagripanti JL, Rom AM, Holland LE. Persistence in darkness of virulent alphaviruses Ebola virus, Lassa fever virus, deposited on solid surfaces. *Arch Virol* 2010; 155(12):2035-2039

Preliminary Lab Data

- EBOV 2014 spiked into simulated gastric juice immediately inactivated
- EBOV 2014 spiked into simulated gastric juice with milk (simulating light meal) not immediately inactivated but virus could not be recovered 24 hr later
- EBOV 2014 spiked into irradiated pooled stool*; immediate 3 $\log_{10}$ reduction infectious virus could not be recovered 24 hr later (ambient temperature, smooth non-porous surfaces

*pooled stool purchased from 25 healthy donors; stool matrices was itself inhibitory
DHS (unpublished data, 2015 studies are ongoing at NBBAC)

Persistence of Ebola virus in Fluids (A) and Tissues (B) from Cynomolgus Macaques



Prescott J, Bushmaker T, Fischer R, Miazgowicz K, Judson S, Munster VJ. Postmortem stability of Ebola virus. *Emerg Infect Dis.* 2015 May [*date cited*]. http://dx.doi.org/10.3201/eid2105.150041

Virus culture and RT-PCR results from 54 clinical samples collected from 26 patients with laboratory-confirmed Ebola hemorrhagic fever.

Sample type, phase of illness	Patients, no.	Samples, no.	Day after disease onset that sample was collected, range (mean)	Virus culture positive, no. (% sample type tested)	RT-PCR positive, no./total tested (%)	Latest day positive after disease onset
Saliva						
Acute	10	12	4–14 (6)	1 (8)	8/12 (67)	8
Convalescent	4	4	12–23 (16)	0 (0)	0/4 (0)	…
Skin[a]						
Acute	7	8	4–10 (7)	0 (0)	1/8 (13)	6
Convalescent	3	3	7–15 (12)	0 (0)	0/3 (0)	…
Urine						
Acute	5	7	5–22 (14)	0 (0)	0/7 (0)	…
Convalescent	4	4	8–40 (28)	0 (0)	0/4	…
Vomit						
Acute	1	1	NA (9)	0 (0)	0/1 (0)	…
Convalescent	1	1	NA (20)	0 (0)	0/1 (0)	…
Sputum						
Acute	1	1	NA (8)	0 (0)	0/1 (0)	…
Convalescent	1	1	NA (16)	0 (0)	0/1 (0)	…
Breast milk						
Acute	1	1	NA (7)	1 (100)	1/1 (100)	7
Convalescent	1	1	NA (15)	1 (100)	1/1 (100)	15
Stool,[b] acute	4	4	4–12 (8)	0 (0)	2/4 (50)	12
Sweat,[b] acute	1	1	NA (9)	0 (0)	0/1 (0)	…
Tears,[b] acute	1	1	NA (6)	0 (0)	1/1 (100)	6
Nasal blood,[b] acute	1	1	NA (10)	0 (0)	1/1 (100)	10
Body louse,[b] acute	1	1	NA (9)	0 (0)	0/1 (0)	…
Semen,[c] convalescent	1	2	40–45 (43)	1 (50)	1/2 (50)	40
Subtotal acute	23	38	4–22 (9)	2 (5)	14 (37)	12
Subtotal convalescent	8	16	7–45 (21)	2 (13)	2 (13)	40
Total	26[d]	54	4–45 (12)	4 (7)	16 (30)	…

NOTE. Samples are classified as either acute phase (serum ELISA antigen positive and/or RT-PCR positive) or convalescent phase (previously serum ELISA antigen positive or RT-PCR positive but now reverted to negative, often with the appearance of ELISA IgG antibody). Clinical samples were classified as acute or convalescent phase on the basis of the results of the most closely matched serum sample by date, which was a mean difference of 1.2 days (range, 0–13 days) and 7.3 days (range, 0–29 days) for acute- and convalescent-phase samples, respectively. NA, not applicable.

[a] Samples were swabbed from the hand (10) or forehead (1). The sole positive sample was from a hand.
[b] No convalescent-phase samples were available for this sample type.
[c] No acute-phase sample was available for this sample type.
[d] Both acute- and convalescent-phase samples were collected from some patients.

Live virus detected in:
Saliva
Breast Milk
Semen

Samples RT-PCR +:
Saliva (67% acute)
Skin (13%)
Breast Milk
Stool (50% acute)
Tears
Blood
Semen

Bausch D G et al. J Infect Dis. 2007;196:S142-S147

The Journal of Infectious Diseases

Virus culture and RT-PCR results from 33 environmental samples.

Sample	Color	Virus culture result	RT-PCR result
Outside of ward			
Changing room wall	Clear	–	–
Changing room desk	Clear	–	–
Exterior surface of door of isolation ward	Clear	–	–
Inside ward, suspected side			
Nurse's newly placed glove	Clear	–	–
Bed frame	Clear	–	–
Instrument tray for ward rounds	Clear	–	–
Inside ward, probable side			
Air (tube opened and capped, negative control 1)	Clear	–	–
Sterile swab (negative control 2)	Clear	–	–
Intravenous fluid support pole	Clear	–	–
Light switch	Clear	–	–
Floor	Clear	–	–
Handle of 0.05% bleach solution dispenser	Clear	–	–
Nurse's clean apron	Clear	–	–
Nurse's clean glove	Clear	–	–
Clean stethoscope	Clear	–	–
Stethoscope after use	Clear	–	–
Stethoscope after use and rinsing with 0.05% bleach solution	Clear	–	–
Bed frame	Clear	–	–
Bedside chair (2 different samples)	Clear	–	–
Food bowl	Clear	–	–
Spit bowl	Clear	–	–
Skin (hand) of patient attendants (3 different samples)	Clear	–	–
Clean glove of patient attendant	Clear	–	–
Corpse decontaminated with 0.5% bleach solution	Clear	–	–
Body bag decontaminated with 0.5% bleach solution (2 different samples)	Clear	–	–
Clean mattress	Clear	–	–
Intravenous tubing	Clear		–
Doctor's blood-stained glove (positive control 1)	Pink	–	+
Bloody intravenous insertion site (positive control 2)	Red	–	+
Total (% of all samples)	…	0 (0)	2 (7)

Bausch D G et al. J Infect Dis. 2007;196:S142-S147

The Journal of Infectious Diseases

Lab based studies and field investigations

LESSONS LEARNED FROM THE GLOBAL AIDS EPIDEMIC

déjà vu

- Similar experience to other enveloped virus of concern almost 30 years ago
- Human Immunodeficiency virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS)
- In the early 1980's to early to mid '90s no available therapy; universally fatal

Persistence Studies with HIV

- HIV inoculated into sterile drinking water, sewage, and ocean water found up to 11 days after inoculation; virus infectivity was not assessed
- HIV Stable for 12 hr in wastewater at 25°C, with 2-3 $\log_{10}$ reduction within 24 hr (spiking concentration above the highest titers seen clinically) or what would be typically in wastewater

Casson LW, Sorber CA, Palmer RH, Enrico A, Gupta P. HIV survivability in wastewater. *Water Environ Res* 1992; 64:213-215.

Slade JS, Pike EB, Eglin RP, Colbourne JS, Kurtz JB. The survival of human immunodeficiency virus in water, sewage, and sea water. *Water Sci Tech* 1989;21:55—9

Enveloped Viruses In Sewage, or Wastewater Effluents

- Analysis of sewer effluent using an infectivity assay did not detect HIV[2]
- Detect HIV in wastewater from Belle Glade (2 samples) an 1 sample from Pontiac, MI by PCR[1,3]

[1]Ansari SA, Farrah SR, Chaudhury GR. Presence of human immunodeficiency virus nucleic acids in wastewater and their detection by polymerase chain reaction. Appl Environ Microbiol 1992;58(12):3984-90 (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC183215)

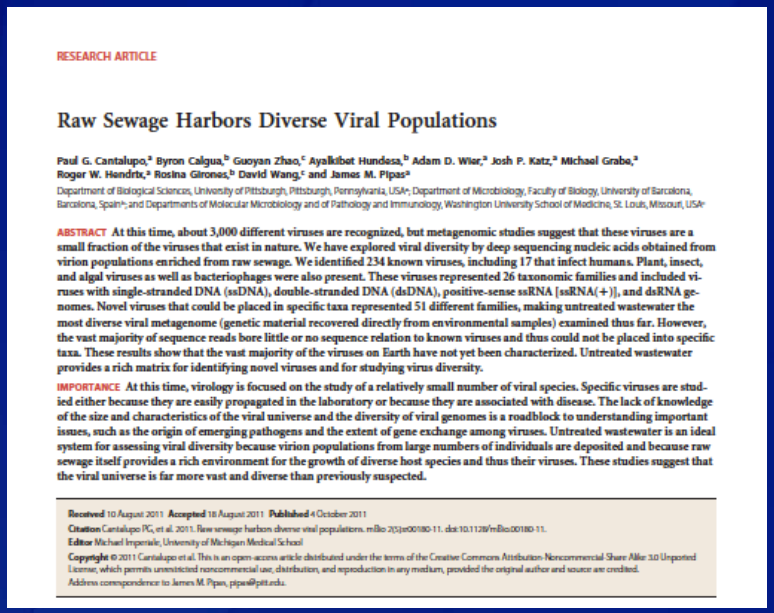
[2]Palmer CJ, Lee MH, Bonilla GF, Javier BJ, Siwak EB, Tsai YL. Analysis of sewage effluent for human immunodeficiency virus (HIV) using infectivity assay and reverse transcriptase polymerase chain reaction. Can J Microbiol 1995;41(9):809-15.

[3]Preston DR, Farrah SR, Bilton G, Chaudhury GR. Detection of nucleic acids homologous to human immunodeficiency virus in wastewater. *J Virol Methods* 1991;33(3):383-90

Detection and Recovery of Enveloped Viruses from Sewage or Waste Water

- Coronaviruses including SARs CoV have been detected in sanitary plumbing systems by RT-PCR, however infectious virus has never been recovered from sewage samples
- HIV has been detected by RT-PCR, but no studies provided evidence for the presence of infectious virus using culture based methods
- Influenza virus has been detected using q-RT-PCR
- Herpes virus was found to persist in liquid manure but infectious titers rapidly decline

Most Current Research uses Metagenomic Approaches



RESEARCH ARTICLE

Raw Sewage Harbors Diverse Viral Populations

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ABSTRACT At this time, about 3,000 different viruses are recognized, but metagenomic studies suggest that these viruses are a small fraction of the viruses that exist in nature. We have explored viral diversity by deep sequencing nucleic acids obtained from virion populations enriched from raw sewage. We identified 234 known viruses, including 17 that infect humans. Plant, insect, and algal viruses as well as bacteriophages were also present. These viruses represented 26 taxonomic families and included viruses with single-stranded DNA (ssDNA), double-stranded DNA (dsDNA), positive-sense ssRNA [ssRNA(+)], and dsRNA genomes. Novel viruses that could be placed in specific taxa represented 51 different families, making untreated wastewater the most diverse viral metagenome (genetic material recovered directly from environmental samples) examined thus far. However, the vast majority of sequence reads bore little or no sequence relation to known viruses and thus could not be placed into specific taxa. These results show that the vast majority of the viruses on Earth have not yet been characterized. Untreated wastewater provides a rich matrix for identifying novel viruses and for studying virus diversity.

IMPORTANCE At this time, virology is focused on the study of a relatively small number of viral species. Specific viruses are studied either because they are easily propagated in the laboratory or because they are associated with disease. The lack of knowledge of the size and characteristics of the viral universe and the diversity of viral genomes is a roadblock to understanding important issues, such as the origin of emerging pathogens and the extent of gene exchange among viruses. Untreated wastewater is an ideal system for assessing viral diversity because virion populations from large numbers of individuals are deposited and because raw sewage itself provides a rich environment for the growth of diverse host species and thus their viruses. These studies suggest that the viral universe is far more vast and diverse than previously suspected.

Received 10 August 2011 **Accepted** 18 August 2011 **Published** 4 October 2011

Citation Cantalupo PG, et al. 2011. Raw sewage harbors diverse viral populations. mBio 2(5):e00180-11. doi:10.1128/mBio.00180-11.

Editor Michael Imperiale, University of Michigan Medical School

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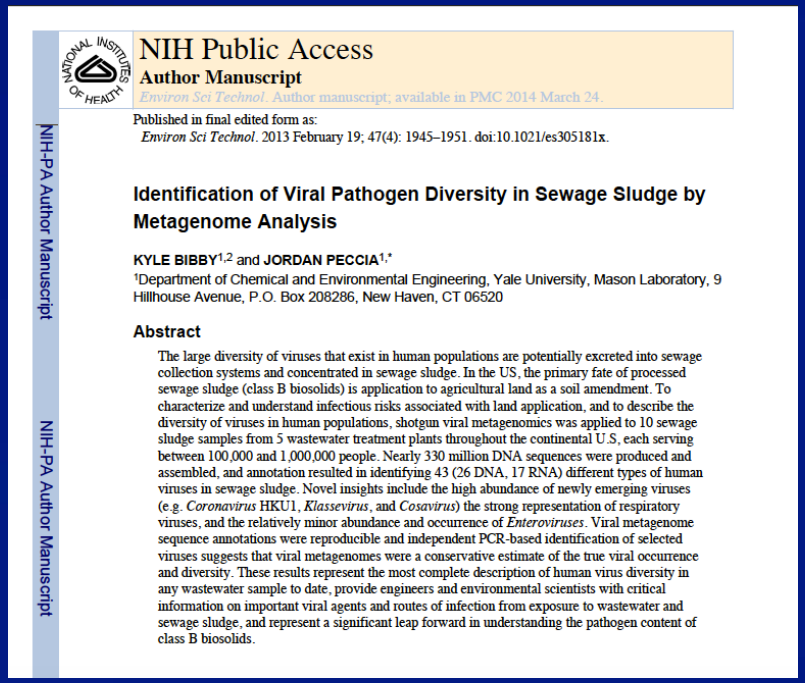

Published in final edited form as:
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Identification of Viral Pathogen Diversity in Sewage Sludge by Metagenome Analysis

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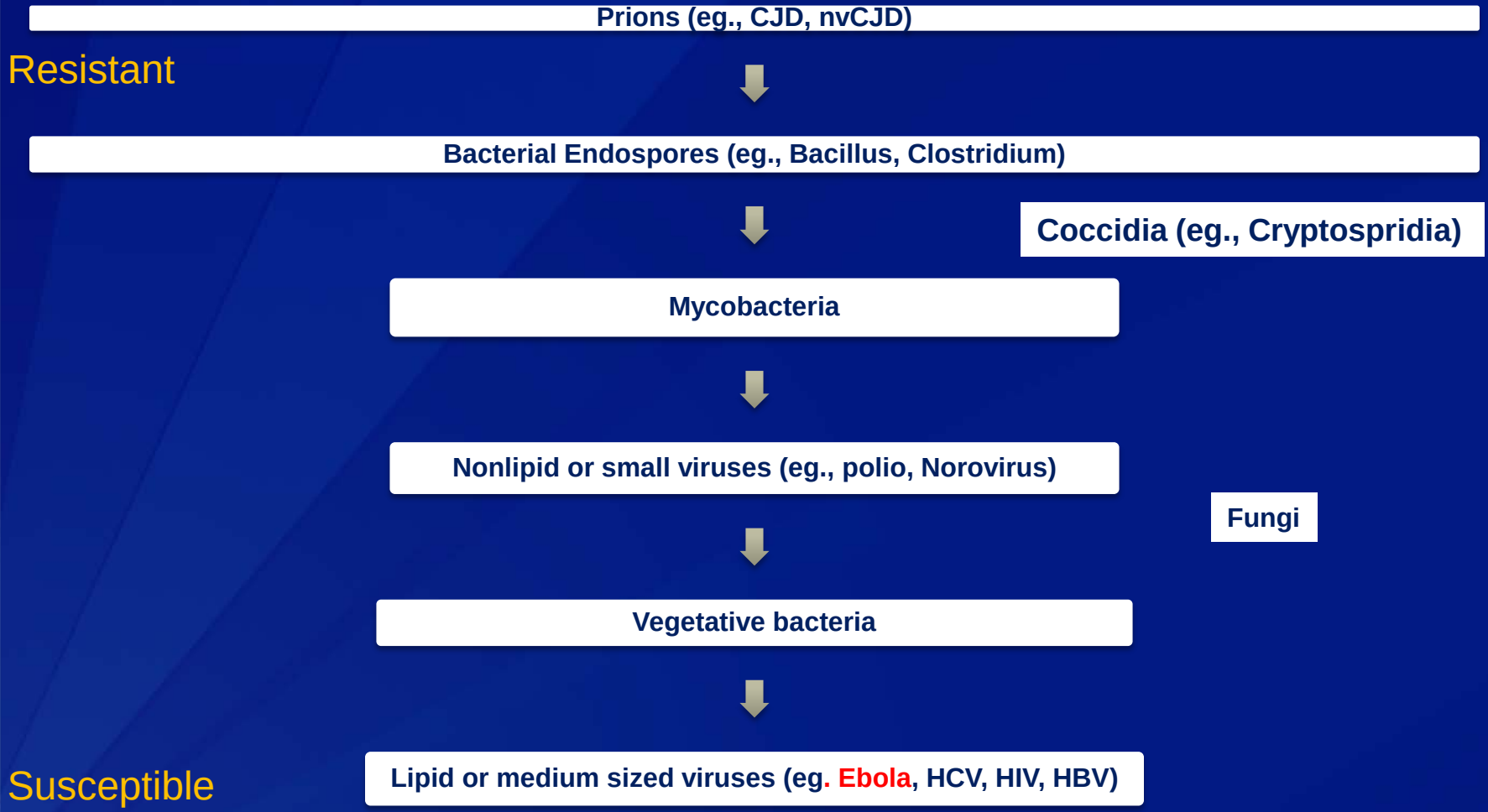
Abstract

The large diversity of viruses that exist in human populations are potentially excreted into sewage collection systems and concentrated in sewage sludge. In the US, the primary fate of processed sewage sludge (class B biosolids) is application to agricultural land as a soil amendment. To characterize and understand infectious risks associated with land application, and to describe the diversity of viruses in human populations, shotgun viral metagenomics was applied to 10 sewage sludge samples from 5 wastewater treatment plants throughout the continental U.S, each serving between 100,000 and 1,000,000 people. Nearly 330 million DNA sequences were produced and assembled, and annotation resulted in identifying 43 (26 DNA, 17 RNA) different types of human viruses in sewage sludge. Novel insights include the high abundance of newly emerging viruses (e.g. *Coronavirus* HKU1, *Klassevirus*, and *Cosavirus*) the strong representation of respiratory viruses, and the relatively minor abundance and occurrence of *Enteroviruses*. Viral metagenome sequence annotations were reproducible and independent PCR-based identification of selected viruses suggests that viral metagenomes were a conservative estimate of the true viral occurrence and diversity. These results represent the most complete description of human virus diversity in any wastewater sample to date, provide engineers and environmental scientists with critical information on important viral agents and routes of infection from exposure to wastewater and sewage sludge, and represent a significant leap forward in understanding the pathogen content of class B biosolids.

Cantalupo PG, Calgua B, Zhao G, Hundesa A, Wier AD, Katz JP, Grabe M, Hendrix RW, Girones R, Wang D, Pipas JM. Raw sewage harbors diverse viral populations. *MBio* 2011 Oct 4;2(5). pii: e00180-11 (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3187576/)

Bibby K, Peccia J. Identification of viral pathogen diversity in sewage sludge by metagenome analysis. *Environ Sci Technol*. 2013; 47(4): 1945–1951 (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3963146/)

Microbial Resistance to Physical and Chemical Methods for Inactivation



Adapted from: Rutala WA, Weber DA, Healthcare Infection Control Practices Advisory Committee. Guideline for Disinfection and Sterilization in Healthcare Facilities, 2008 (http://www.cdc.gov/hicpac/Disinfection_Sterilization/toc.html)

Factors that Impact Ebola Infectivity

- 3% Acetic acid, pH 2.5 (15 minutes)[1]
- 60°C; 5 $\log_{10}$ Inactivation in 22 minutes (hold for an hour for an extra margin of safety) [1]
- Boiling, 5 min
- Sunlight
- Germicidal ultraviolet irradiation[2]
- Detergents, Nanoemulsion[3]
- β-propionolactone[4]

1. Mitchell SW, McCormick JB. *J Clin Microbiol* 1984;20(3):486-9.
2. Sagripanti JL, Lytle CD. *Arch Virol* 2011;156:489-494
3. Chupernova AA, et al. *Acta Tropica* 2003;87:315-320
4. Van der Groen G, Elliott LH. *Ann Soc Belg Méd Trop* 1982; 62:49-54

Does Disinfection Work

- **No direct data with Ebola virus**
- **CDC and EPA/Office of Pesticides/Antimicrobics Division using the hierarchy of resistance to disinfectants have a general agreement to use products the label claims against a non-enveloped virus (eg, adenovirus, poliovirus, rotavirus, norovirus, etc.)**
- **EPA List L Disinfectants for Use Against the Ebola Virus: http://www.epa.gov/oppad001/list-l-ebola-virus.html**
  - Hospital grade disinfectants (eg., alcohol, halogens, quaternary ammonium compounds, peracetic acid, peroxides, phenolics)
  - List L is not all inclusive
- **Processes in place to address enteric viruses would inactivate *Ebolavirus* and other members of the Filoviridae**

Recommendations From WHO, 2014

- **Waste, such as feces, urine and vomit, and liquid waste from washing, can be disposed of in the sanitary sewer or pit latrine.**
- **No further treatment is necessary**

WHO. 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 (http://www.who.int/csr/resources/publications/ebola/filovirus_infection_control/en/)

Interim Guidance for Environmental Infection Control in Hospitals for Ebola Virus

5 Is it safe for Ebola patients to use the bathroom?

Yes. Sanitary sewers may be used for the safe disposal of patient waste (WHO, 2014). Additionally, sewage handling processes in the United States are designed to inactivate infectious agents.

Consistent with other recommendations by CDC with using sanitary sewers for Disposal of other potentially infectious body fluids

http://www.cdc.gov/vhf/ebola/hcp/environmental-infection-control-in-hospitals.html

CDC A-Z INDEX

Ebola (Ebola Virus Disease)

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- **Guidance for Handing Untreated Sewage**
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- Treatment
- Healthcare Workers +

Interim Guidance for Managers and Workers Handling Untreated Sewage from Individuals with Ebola in the United States

November 20, 2014

Who this is for: Workers who handle untreated sewage that comes from hospitals, medical facilities, and other facilities with confirmed individuals with Ebola.

What this is for: To provide recommendations for workers on the types of personal protective equipment (PPE) to be used and proper hygiene for the safe handling of untreated sewage that may contain Ebola virus.

How to use: Use this document to reduce the workers' risk of exposure to infectious agents including Ebola virus when working with untreated sewage.

Key Points:

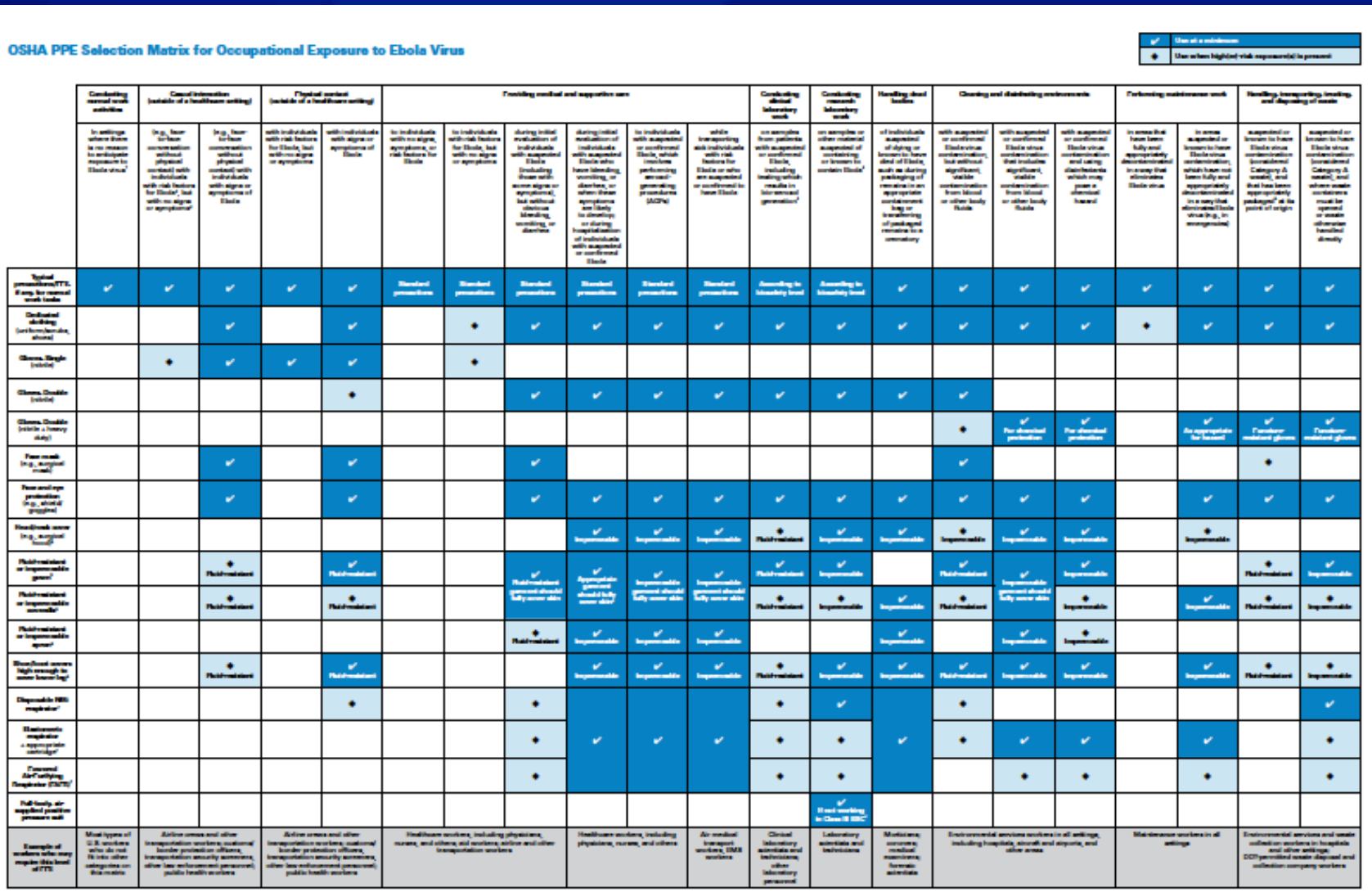
- Ebola virus is more fragile than many enteric viruses that cause diarrheal disease or hepatitis.
- The envelope that covers Ebola makes it more susceptible to environmental stresses and to chemical germicides than non-enveloped viruses, such as hepatitis A, poliovirus, and norovirus.
- To protect workers against Ebola
  - Educate them on

http://www.cdc.gov/vhf/ebola/prevention/handling-sewage.html

How do We Protect Sewage Workers

- **Use Appropriate PPE to protect against contact with human wastes**
  - Goggles or face shield: to protect eyes from splashes of untreated sewage
  - Face mask (e.g., surgical mask): to protect nose and mouth from splashes of human waste. If undertaking cleaning processes that generate aerosols, a NIOSH-approved N95 respirator should be used.
  - Impermeable or fluid-resistant coveralls: to keep untreated sewage off clothing
  - Waterproof gloves (such as rubber) to prevent exposure of hands to untreated sewage
  - Rubber boots: to prevent exposure of feet to untreated sewage

OSHA PPE Matrix



OSHA PPE Selection Matrix for Occupational Exposure to Ebola Virus

✔ Use at a minimum

◆ Use when high(er)-risk exposure(s) is present

	Conducting normal work activities	Casual interaction (outside of a healthcare setting)		Flight at contact (outside of a healthcare setting)		Providing medical and supportive care						Conducting clinical laboratory work	Conducting research laboratory work	Handling dead bodies	Cleaning and disinfecting environments			Performing maintenance work	Handling, transporting, treating, and disposing of waste	
	In settings where there is no reason to anticipate exposure to Ebola virus[1]	(e.g., face-to-face conversation without physical contact with individuals with risk factors for Ebola[2], but with no signs or symptoms[3])	(e.g., face-to-face conversation without physical contact with individuals with signs or symptoms of Ebola	with individuals with risk factors for Ebola, but with no signs or symptoms	with individuals with signs or symptoms of Ebola	to individuals with no signs, symptoms, or risk factors for Ebola	to individuals with risk factors for Ebola, but with no signs or symptoms	during initial evaluation of individuals with suspected Ebola (including those with some signs or symptoms), but without obvious bleeding, vomiting, or diarrhea	during initial evaluation of individuals with suspected Ebola who have bleeding, vomiting, or diarrhea, or when these symptoms are likely to develop; or during hospitalization of individuals with suspected or confirmed Ebola	to individuals with suspected or confirmed Ebola, which involves performing aerosol-generating procedures (AGPs)	while transporting sick individuals with risk factors for Ebola or who are suspected or confirmed to have Ebola	on samples from patients with suspected or confirmed Ebola, including testing which results in laboratory generation[4]	on samples or other material suspected of containing, or known to contain Ebola[5]	of individuals suspected of dying or known to have died of Ebola, such as during packaging of remains in an appropriate containment bag or transferring of packaged remains to a mortuary	with suspected or confirmed Ebola virus contamination, but without significant, visible contamination from blood or other body fluids	with suspected or confirmed Ebola virus contamination that includes significant, visible contamination from blood or other body fluids	with suspected or confirmed Ebola virus contamination and using disinfectants which may pose a chemical hazard	in areas that have been fully and appropriately decontaminated in a way that eliminates Ebola virus	in areas suspected or known to have Ebola virus contamination, which have not been fully and appropriately decontaminated in a way that eliminates Ebola virus (e.g., in emergencies)	suspected or known to have Ebola virus contamination (considered Category A waste)[6], and that has been appropriately packaged[7] at the point of origin	suspected or known to have Ebola virus contamination (considered Category A waste)[6], and where waste containers must be opened or waste otherwise handled directly
Typical precautions/PPE, if any, for normal work tasks	✔	✔	✔	✔	✔	Standard precautions	Standard precautions	Standard precautions	Standard precautions	Standard precautions	Standard precautions	According to biosafety level	According to biosafety level	✔	✔	✔	✔	✔	✔	✔	✔
Dedicated clothing (uniform, coveralls, shoes)			✔		✔		◆	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	◆	✔	✔	✔
Gloves, Single (nitrile)		◆	✔	✔	✔		◆															
Gloves, Double (nitrile)					◆			✔	✔	✔	✔	✔	✔	✔	✔							
Gloves, Double (nitrile + heavy duty)															◆	✔ For chemical protection	✔ For chemical protection		✔ As appropriate for hazard	✔ Puncture-resistant gloves	✔ Puncture-resistant gloves
Face mask (e.g., surgical mask)			✔		✔			✔							✔					◆	
Face and eye protection (e.g., shield or goggles)			✔		✔			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
Headhook cover (e.g., surgical hood)									✔ Impermeable	✔ Impermeable	✔ Impermeable	◆ Fluid-resistant	✔ Impermeable	✔ Impermeable	◆ Impermeable	✔ Impermeable	✔ Impermeable		◆ Impermeable		
Fluid-resistant or impermeable gown[8]			◆ Fluid-resistant		✔ Fluid-resistant			✔ Fluid-resistant gown should fully cover skin	✔ Appropriate gown should fully cover skin[9]	✔ Impermeable gown should fully cover skin	✔ Impermeable gown should fully cover skin	✔ Fluid-resistant	✔ Impermeable		✔ Fluid-resistant	✔ Impermeable gown should fully cover skin	✔ Impermeable			◆ Fluid-resistant	✔ Impermeable
Fluid-resistant or impermeable coveralls[8]			◆ Fluid-resistant		◆ Fluid-resistant			◆ Fluid-resistant	✔ Impermeable	✔ Impermeable	✔ Impermeable	◆ Fluid-resistant	◆ Impermeable	✔ Impermeable	◆ Fluid-resistant		◆ Impermeable		✔ Impermeable	◆ Fluid-resistant	◆ Impermeable
Fluid-resistant or impermeable apron[8]								◆ Fluid-resistant	✔ Impermeable	✔ Impermeable	✔ Impermeable			✔ Impermeable		✔ Impermeable	◆ Impermeable				
Shoe/boot covers (high enough to cover boot/leg)			◆ Fluid-resistant		✔ Fluid-resistant				✔ Impermeable	✔ Impermeable	✔ Impermeable	◆ Fluid-resistant	✔ Impermeable	✔ Impermeable	✔ Fluid-resistant	✔ Impermeable	✔ Impermeable		✔ Impermeable	◆ Fluid-resistant	◆ Impermeable
Disposable N95 respirator[10]					◆			◆	✔	✔	✔	◆	✔	✔	◆						✔
Elastomeric respirator + appropriate cartridges[10]								◆				◆	◆		◆	✔	✔		✔		◆
Powered Air-Purifying Respirator (PAPR)[10]								◆				◆	◆			◆	◆		◆		◆
Full-body, air-supplied positive-pressure suit													✔ If not working in Class III BSC[11]								
Examples of workers who may require this level of PPE	Most types of U.S. workers who do not fit into other categories on this matrix	Airline crews and other transportation workers; customs/ border protection officers; transportation security screeners; other law enforcement personnel; public health workers		Airline crews and other transportation workers; customs/ border protection officers; transportation security screeners; other law enforcement personnel; public health workers		Healthcare workers, including physicians, nurses, and others; airline and other transportation workers			Healthcare workers, including physicians, nurses, and others		Air medical transport workers; EMS workers	Clinical laboratory scientists and technicians; other laboratory personnel	Laboratory scientists and technicians	Morticians; coroners; medical examiners; forensic scientists	Environmental services workers in all settings, including hospitals, aircraft and airports, and other areas			Maintenance workers in all settings		Environmental services and waste collection workers in hospitals and other settings; DOT-permitted waste disposal and collection company workers	

https://www.osha.gov/Publications/OSHA3761.pdf

Basic Hygiene Practices

- Wash skin with soap and water immediately after handling sewage, or any materials that have been in contact with sewage.
- Avoid touching face, mouth, eyes, nose, or open sores and cuts while handling sewage, or any materials that have been in contact with sewage.
- Wash your hands with soap and water before eating or drinking after you have handled sewage.
- Remove soiled work clothes and do not take home to launder. Launder clothing at work or use a uniform service.
- Eat in designated areas away from untreated sewage.
- Do not smoke or chew tobacco or gum while handling human waste or sewage, or any materials that have been in contact with sewage.
- Cover open sores, cuts, and wounds with clean, dry bandages.

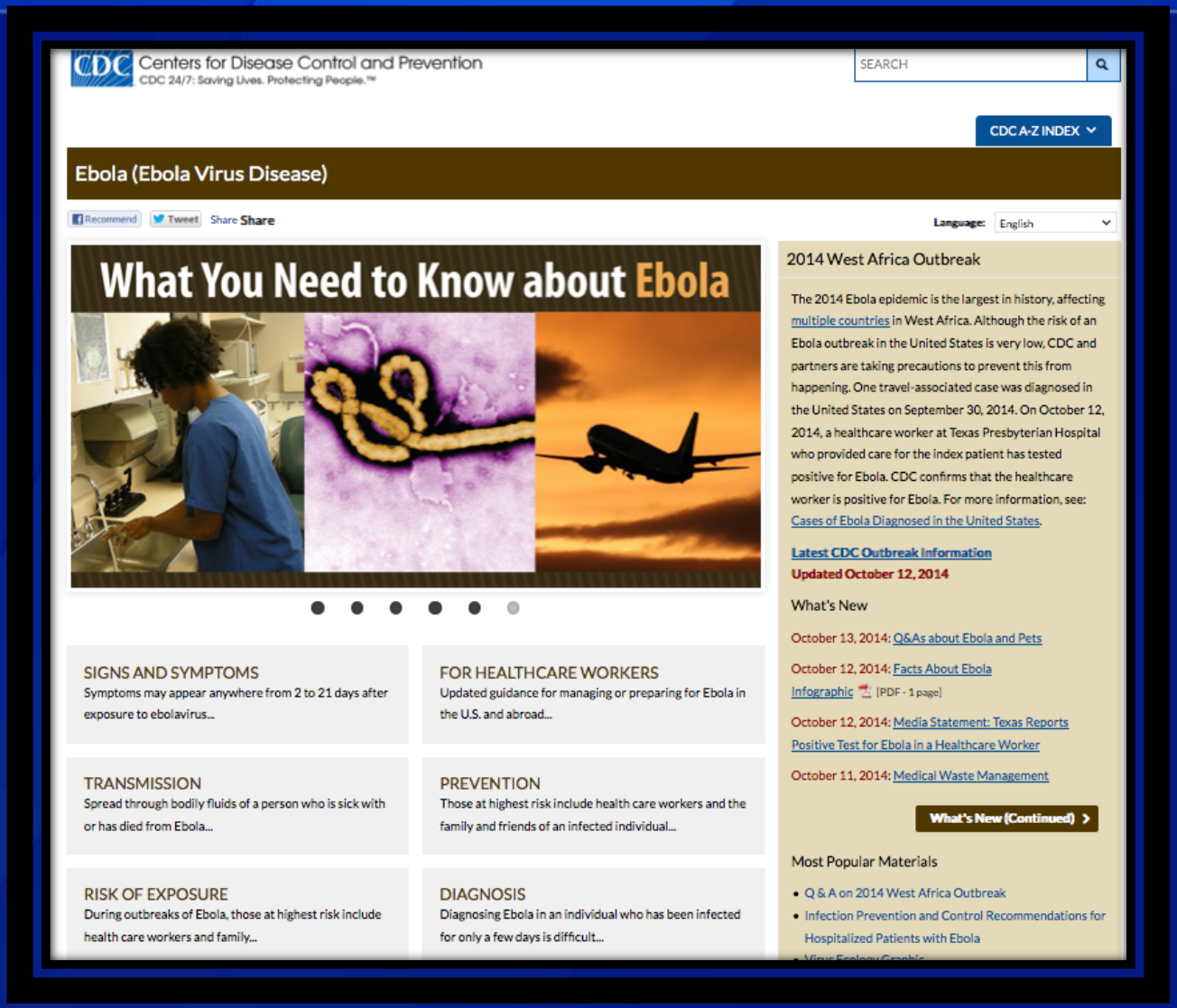
Why are There no Formal Recommendations For Treating Waste

- Ebola is an enveloped virus
- ≤ 10% of patients are excreting virus in their feces (WHO)
- Some preliminary data suggests infectious virus does not persist long
- No increased exposure to HBV, HCV, HIV, Influenza through sewage
- Unlike enteric viruses (non-enveloped) recovery of infectious enveloped viruses from sewage, wastewater, sludge or biosolids has not been very successful

Treatment of Patient Wastes Prior to Discharge

- **Some utilities are requiring pre-treatment**
  - One hospital has used bleach
  - One has used a quaternary ammonium compound
- **Disinfection of waste**
  - No data on efficacy
  - Bleach may be a patient safety risk because of chemical fumes
- **Some utilities required no discharge: Use of camping toilet with solidifier**
  - Disposal with other solid Ebola-Associated waste

Lowe JJ, et al. Nebraska Biocontainment Unit perspective on disposal of Ebola medical waste. *AJIC* 2014; Article in Press (http://www.ajicjournal.org/pb/assets/raw/Health%20Advance/journals/ymic/YMIC_3269.pdf)



For questions regarding environmental infection control, disinfection, waste Management: eocevent181@cdc.gov

http://www.cdc.gov/vhf/ebola/index.html