The National Institute for Health Research Health Protection Research Unit in Emergency Preparedness and Response at UEA

NHS National Institute for Health Research

Ebola Virus Disease Water and Sanitation Risk management

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Handling Sanitation Waste from Ebola

Concerns over faecal transmission of Ebola

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The key question

Given the size of the epidemic and its location in densely populated localities and frequent care in the community or in community Ebola treatment centres…

- What is the possibility that the disease could spread through non-typical routes especially disposal of human body waste?

World Health Organization

unicef

Ebola Virus Disease (EVD)

Key questions and answers concerning water, sanitation and hygiene

Questions for systematic review:

- **What are the risk factors for Ebola disease transmission in the community?**
- **How much virus is in faeces, urine, other body fluids?**
- **How long does Ebola survive in sewage?**

Question for Hazard Control Analysis of Critical Points?

- **What are the handling and treatment requirements of faeces and urine during an EVD outbreak?**

Systematic reviews

- Searched 23 July 2015, no language or date limits
- Search terms (in title, abstract or key words)
  - Ebola, ebolavirus, filovirus or Marburg-virus
- Databases
  - Medline, Scopus, long list of Grey literature
- Duplicate screening and full text review, standard data extraction forms
- 5 validity questions for each syst-review:
  - Eg Test method to verify disease cause, or gap from illness to interview about risk factors < 3 months
- Numerical pooling of data where possible
  - Meta-analysis, combined risk factors, etc.

Systematic review results, July 2015

- Initial review after exclusion of most duplicates
  - 5114 scientific papers, 1905 articles grey literature
- After duplicate screening title and abstract
  - 135 papers eligible for full text review, possible info relevant to at least one of our research questions

RISK FACTORS FOR PERSON-TO-PERSON TRANSMISSION

31 reports on 29 patient groups had relevant data (pub 1978-2014), but risk ratios available in only eight reports (outbreaks in 1976-2008)

Numeric Odds, Risk or Prevalence Ratios for Filovirus Disease Acquisition demographic attributes

Risk Factor	Details	Unadjusted effect size (95% CI)	Adjusted effect size (95% CI)
Demographics and Personal attributes			
Age	Being > 18 yrs [24]	PRR* 6.8	**PRR* 3.6 (1.3-10.1)[a]**
	Being > 30 yrs old [22]	PPR 1.38 (0.64-2.97)	
	Being ≥ 30 years old [26]	OR 1.32 (0.60-2.92)	
	Being ≥ 34 years old [29]	OR 0.83 (0.35-1.95)	
	Being 41-60 yrs old [27]	OR 2.0 (0.8–4.9)	Not reported[b]
	Being ≥ 40 years old [26]	OR 0.99 (0.37-2.68)	
Sex	Being female [27]	OR 0.63 (0.28–1.43)	Not reported[b]
	Being female [22]	PPR 1.54 (0.7-3.6)	
	Being female [24]	PRR* 2.1	PRR* 1.0 (0.5-2.1)[a]
	Being female [26]	**OR 2.46 (1.03 – 5.90)**	
Occupation	Working in forest [23]	MOR 1.3 (0.4-6.0)	
	Fishing [23]	MOR 3.0 (0.04-235)	
	Fisherman [29]	OR 3.12 (0.59-16.41)	
	Healthcare worker [23]	**MOR 9.0 (1.6-91.2)**	
	Healthcare worker [26]	OR 1.52 (0.41-5.64)	
	Student [26]	OR 0.81 (0.34-1.94)	
	Housewife [26]	OR 1.23 (0.50-3.04)	
	Housewife [29]	OR 0.87 (0.24-3.09)	
	Farmer [29]	OR 1.27 (0.15 -10.81)	
	Trader [29]	OR 0.77 (0.22 -2.75)	
	Gold-panner [29]	OR 1.33 (0.56-3.17)	

Numeric Odds, Risk or Prevalence Ratios for Filovirus Disease Acquisition casual contact with (not touching) living cases

Risk Factor	Details	Unadjusted effect size	Adjusted effect size
Recurring non-intimate contact			
Commerce-related	Frequenting markets [23]	MOR 1.1 (0.3-4.5)	
Conversation with case	During incubation period [24]	PRR* 1.5	PRR* 0.7 (0.2-3.0)[a]
	During early illness [24]	PRR* 3.3	PRR* 0.7 (0.3-2.0)[a]
	During late illness [24]	PRR* 10.6	**PRR* 3.9 (1.2-12.2)[a]**
Washing clothes of a case	(point of disease onset unclear) [22]	PPR 1.68 (0.78-3.60)	PPR 1.02 (0.47-2.2)[d]
Indirect contact with case	Household or similar contact without direct physical touching [26]	**OR 6.88 (1.35-35.1)**	
Sharing same hut	Without sharing bed/sleeping mat [22]	PPR 2.16 (0.90-5.19)	**PPR 2.34 (1.13-4.8)[d]**
	Entered same room but no physical contact [25]	OR 0.06 (0.00-1.06)	
	Slept in same room [19]	OR 1.65 (0.95-2.85)	
Visiting cases	In hospital or their own home, before or after diagnosis [27]	**OR 8.7 (3.0–26.3)**	Not reported[b]
	Visit to ill (with fever and bleeding) friend (in own home) [23]	**MOR 10.6 (3.8-36.3)**	

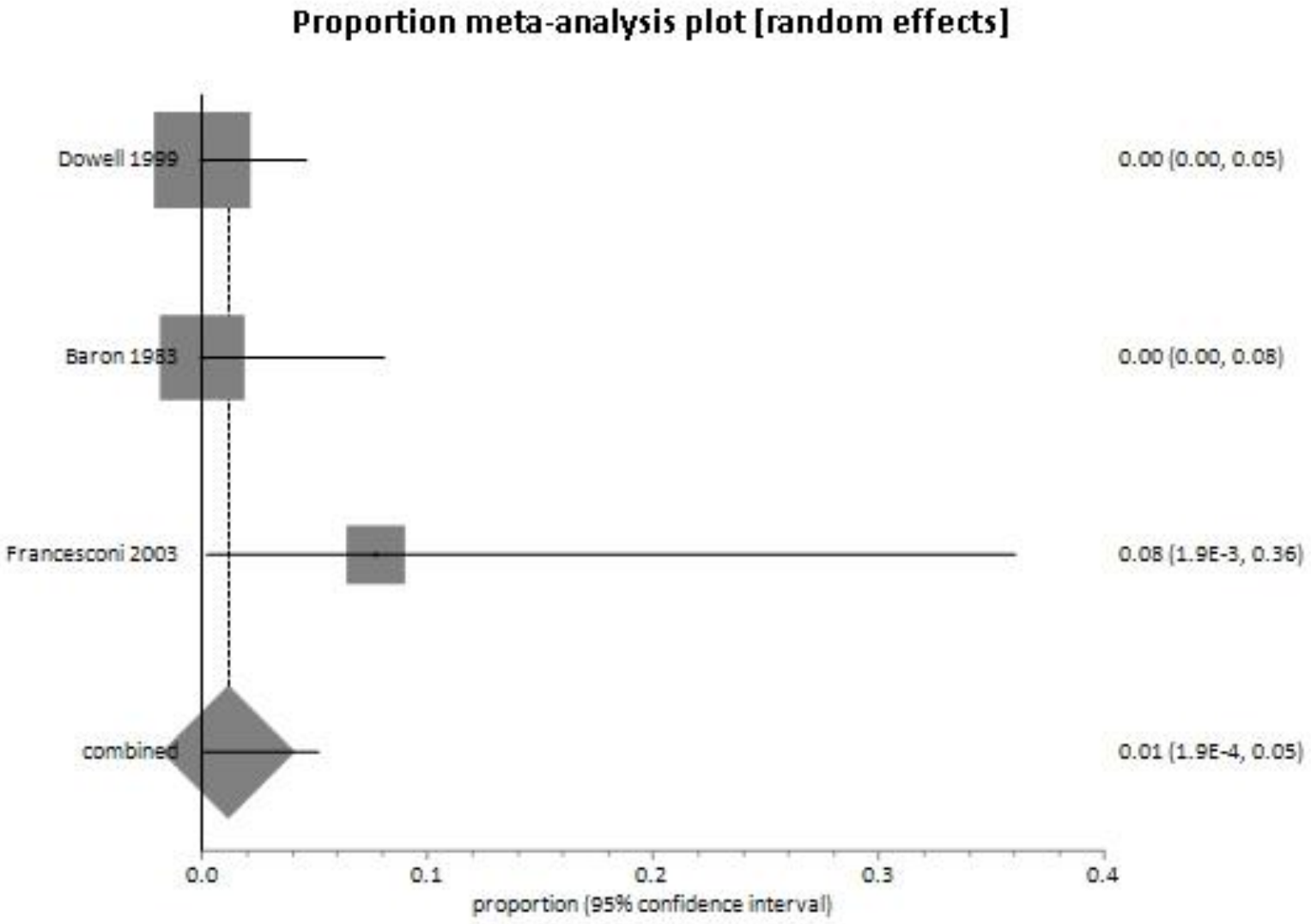
Numeric Odds, Risk or Prevalence Ratios for Filovirus Disease Acquisition direct contact with (touching) living cases

Risk Factor	Details	Unadjusted effect size	Adjusted effect size
Direct physical contact - touching	During incubation period [24]	PRR* 2.9	PRR* 0.8 (0.4-1.8)[a]
	During early illness [24]	PRR* 12.5	
	During late illness [24]	PRR* 12.5	
	With person who had fever or bleeding, at work or in the market [23]	**MOR 24.0 (3.2-1065)**	
	Contact with body or body fluids of a suspected case [26]	**OR 11.0 (2.6-46.1)**	
	Touched case [19]	OR 1.45 (0.73-2.87)	
	Touching during illness [22]	PPR 3.53 (0.52-24.11)	PPR 1.56 (0.2-13.0)[c]
	Touching but no nursing care [25]	OR 0.40 (0.11-1.45)	
Contact with body fluids	Contact with body fluids [22]	**PPR 5.30 (2.14-13.14)**	**PPR 4.61 (1.7-12.3)[c]**
	Direct contact with individuals potentially infected with MHF or their bodily fluids or direct contact during funeral [26]	**OR 12.0 (3.6-39.6)**	
	Body fluid contact in early illness [24]	PRR* 6.1	
	Body fluid contact in late illness [24]	PRR* 5.9	
Caring for patient	Nursing a patient [25]	**OR 8.9 (3.1-25.4)**	
	Cared for case [19]	OR 0.99 (0.56-1.76)	
	Early care at home, not until death [22]	**PPR 6 (1.3-27.1)**	**p for trend for these 3 <0.001**
	At hospital until death [22]	**PPR 8.57 (1.9-37.7)**	
	In home until death [22]	**PPR 13.33 (3.2-55.6)**	
	Aided patient in childbirth [19]	**OR 2.46 (1.02-5.92)**	

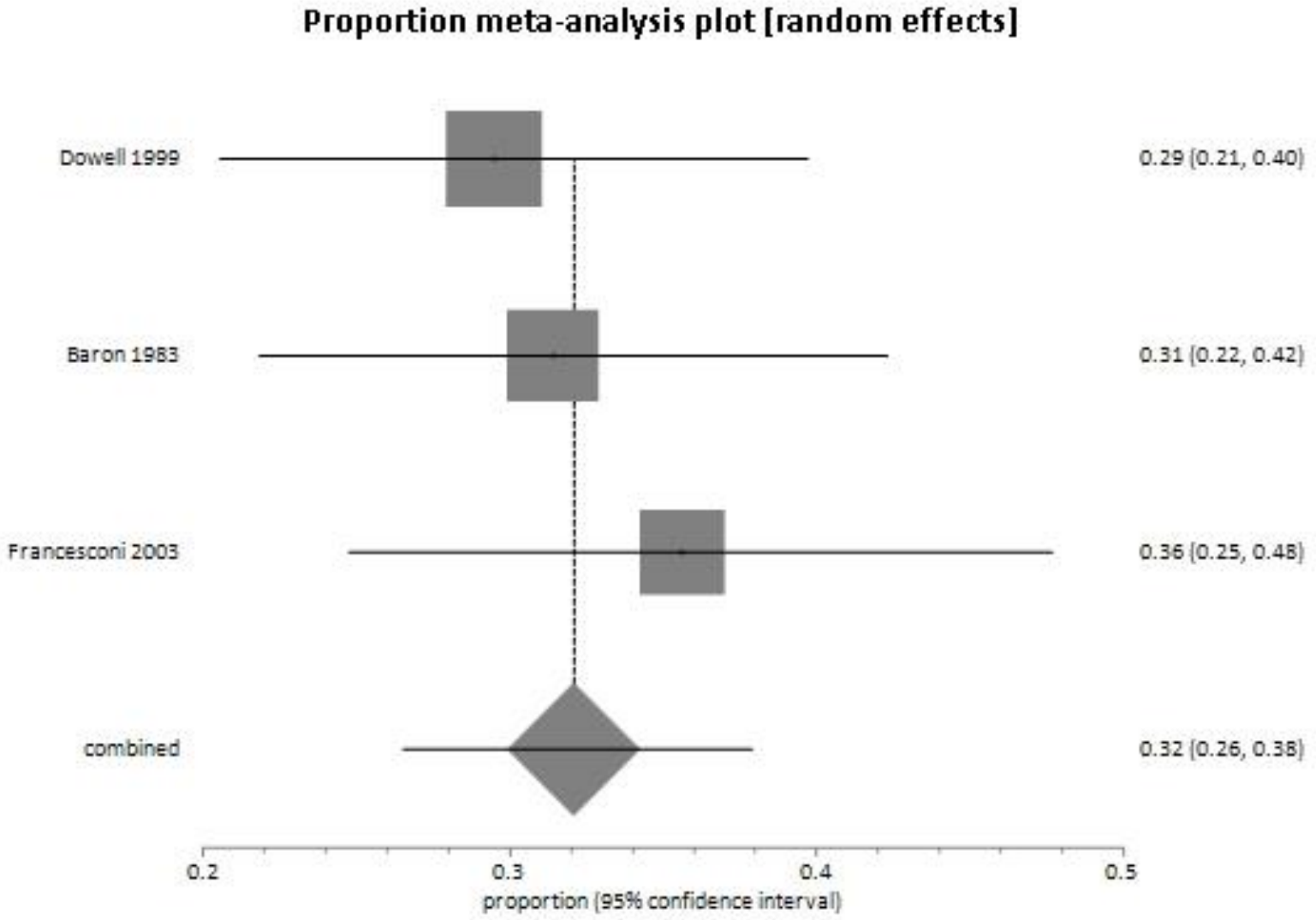
Numeric Odds, Risk or Prevalence Ratios for Filovirus Disease Acquisition activities associated with cadavers or funerals

Risk Factor	Details	Unadjusted effect size	Adjusted effect size
Viewed body	Without touching [24]	PRR* 4.8	PRR* 1.6 (0.5-4.9)[a]
Attended	Special (pre-funeral) rituals [23]	MOR 0.8 (0.2-3.2)	
	Funeral itself [23]	**MOR 3.0 (1.2-7.6)**	
	Funeral itself [19]	OR 0.86 (0.41-1.79)	
Communal meal	As part of funeral event [22]	**PPR 2.84 (1.35-5.98)**	PPR 1.5 (0.98-2.28)[d]
Touched body	Before or during funeral [22]	PPR 1.95 (0.91-4.17)	PPR 1.84 (0.95-3.55)[c]
	Before or during ceremony [24]	PRR* 4.9	**PRR* 2.1 (1.1-4.2)[a]**
	Ritual Handwashing [22]	**PPR 2.25 (1.08-4.72)**	PPR 1.16 (0.54-2.49)[d]
	Washing and dressing body [27]	**OR 7.4 (2.9–19.3)**	**OR 3.83 (1.78-8.23)[b]**
	Direct contact with corpse, its body fluids or soiled items [26]	**OR 38.5 (4.2-352.1)**	
	Prepared for burial [23]	**MOR 13.1 (1.4-631)**	
	Prepared cadaver [19]	OR 1.07 (0.63-1.82)	

The good news – attack rates **without** direct contact (household members)



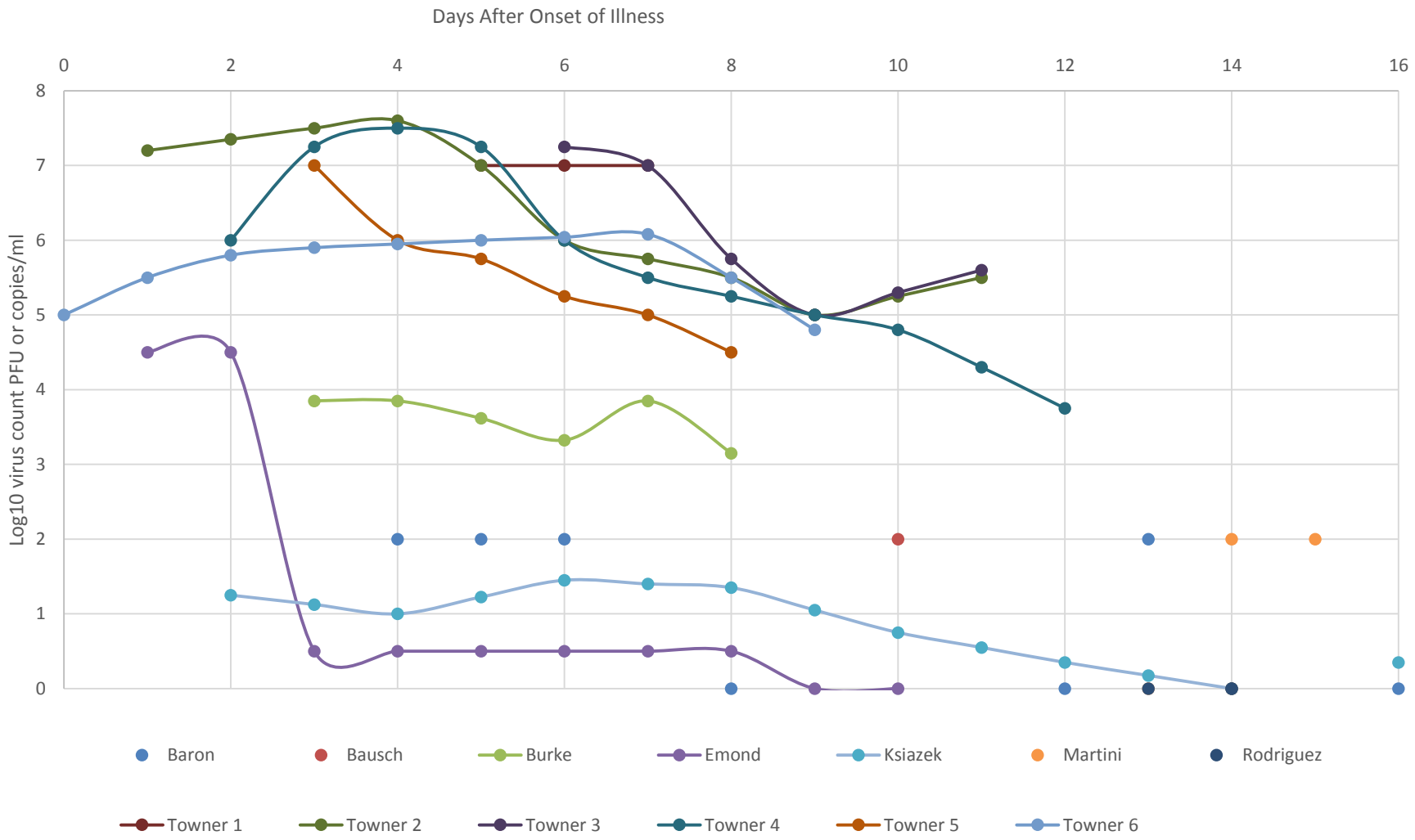
The good news – attack rates **with** direct contact (household members)



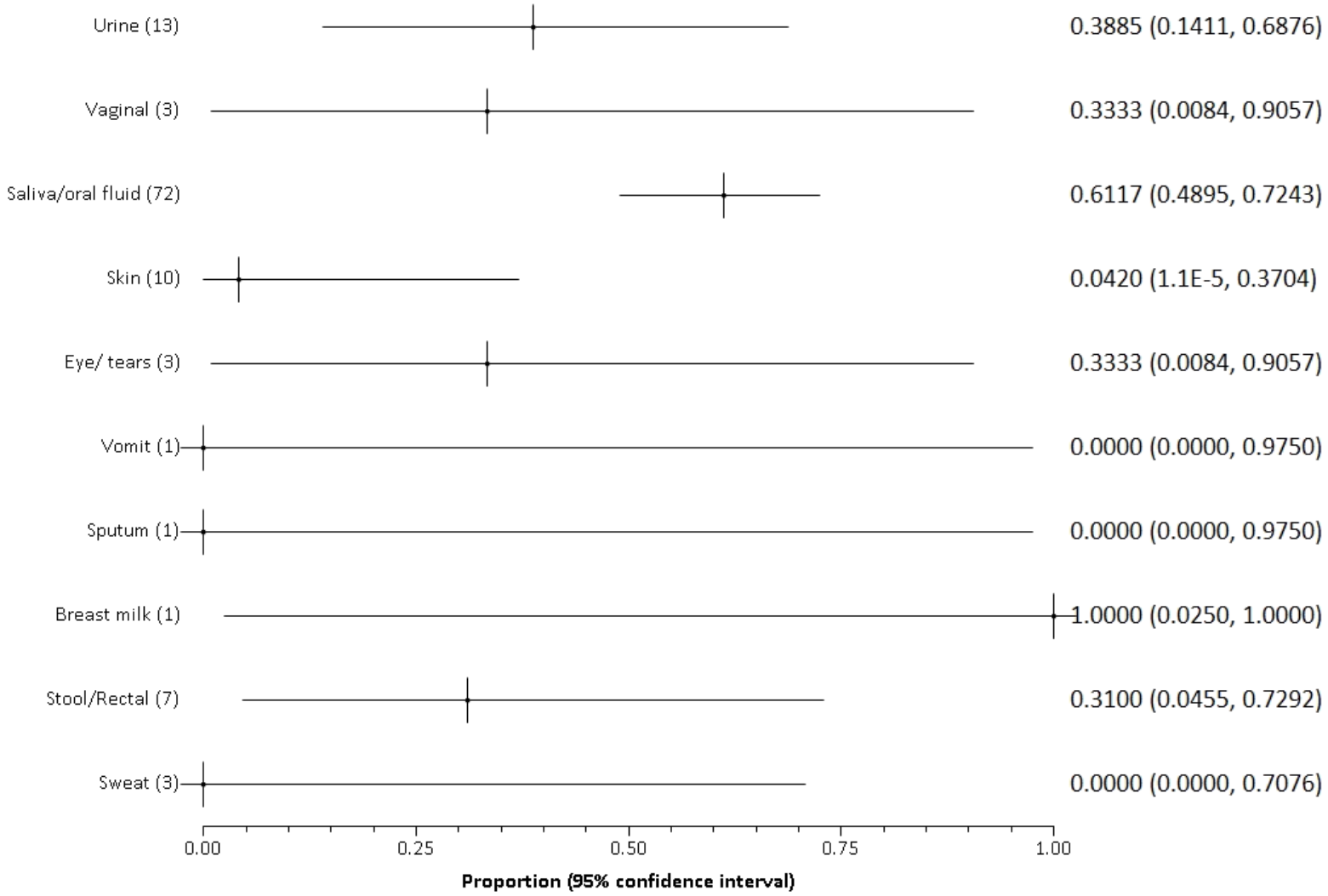
VIRAL LOAD STUDIES IN HUMAN BODY FLUIDS

33 reports had eligible data in systematic review (1976-2015)

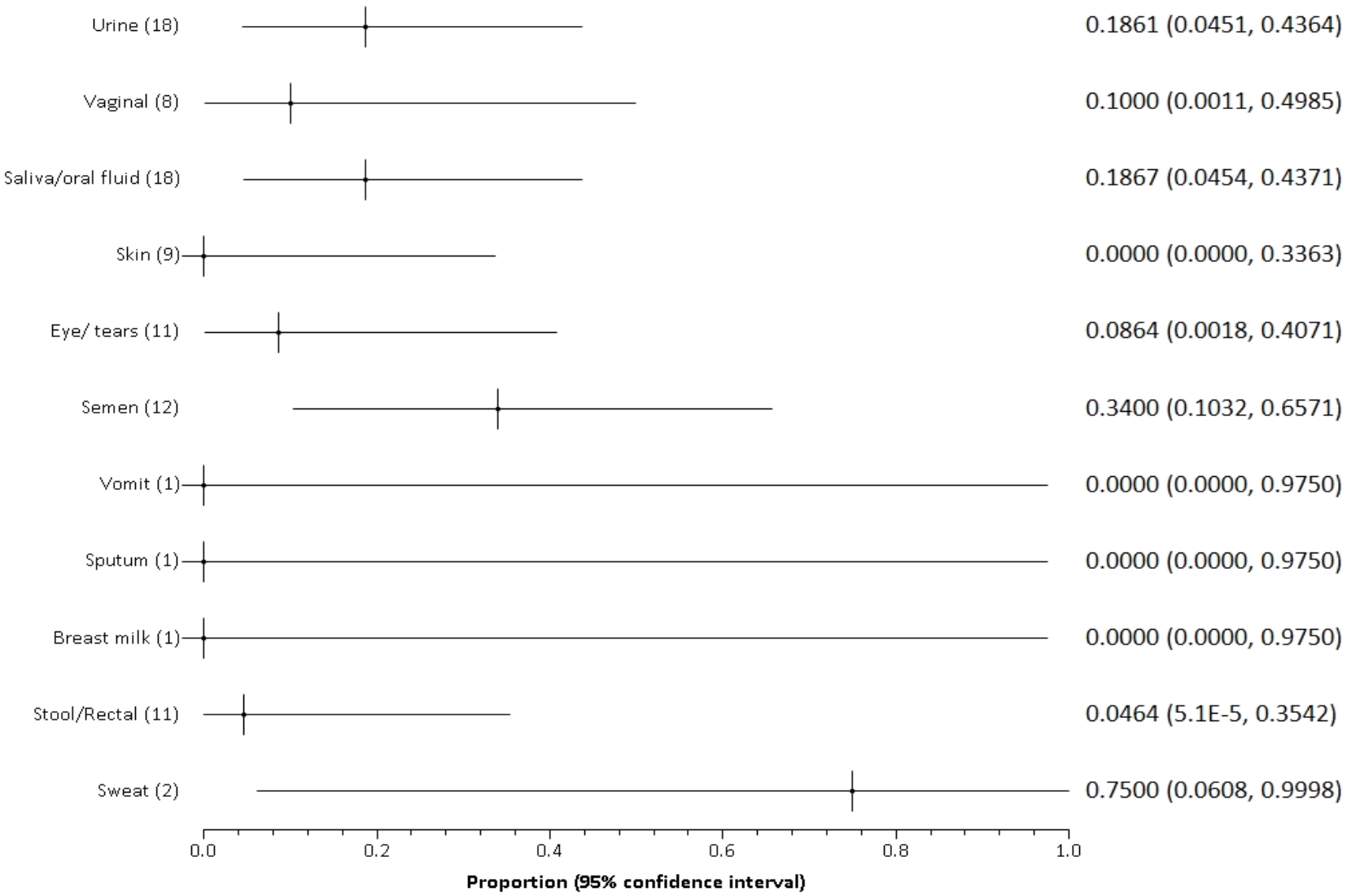
Viral load in blood on days after onset of illness (data before 2014)



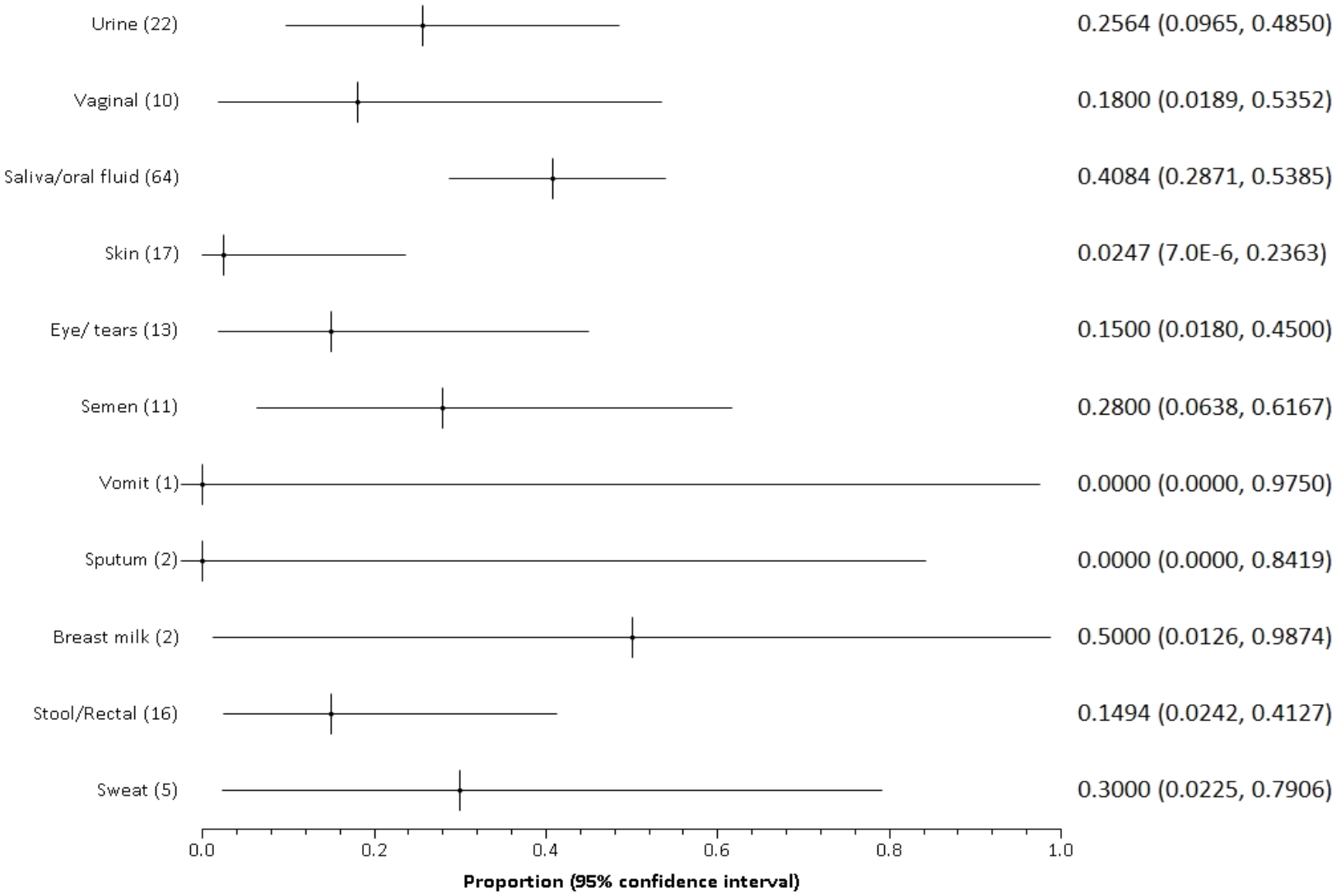
Proportion of body fluids positive for filovirus by PCR early samples (<17d)



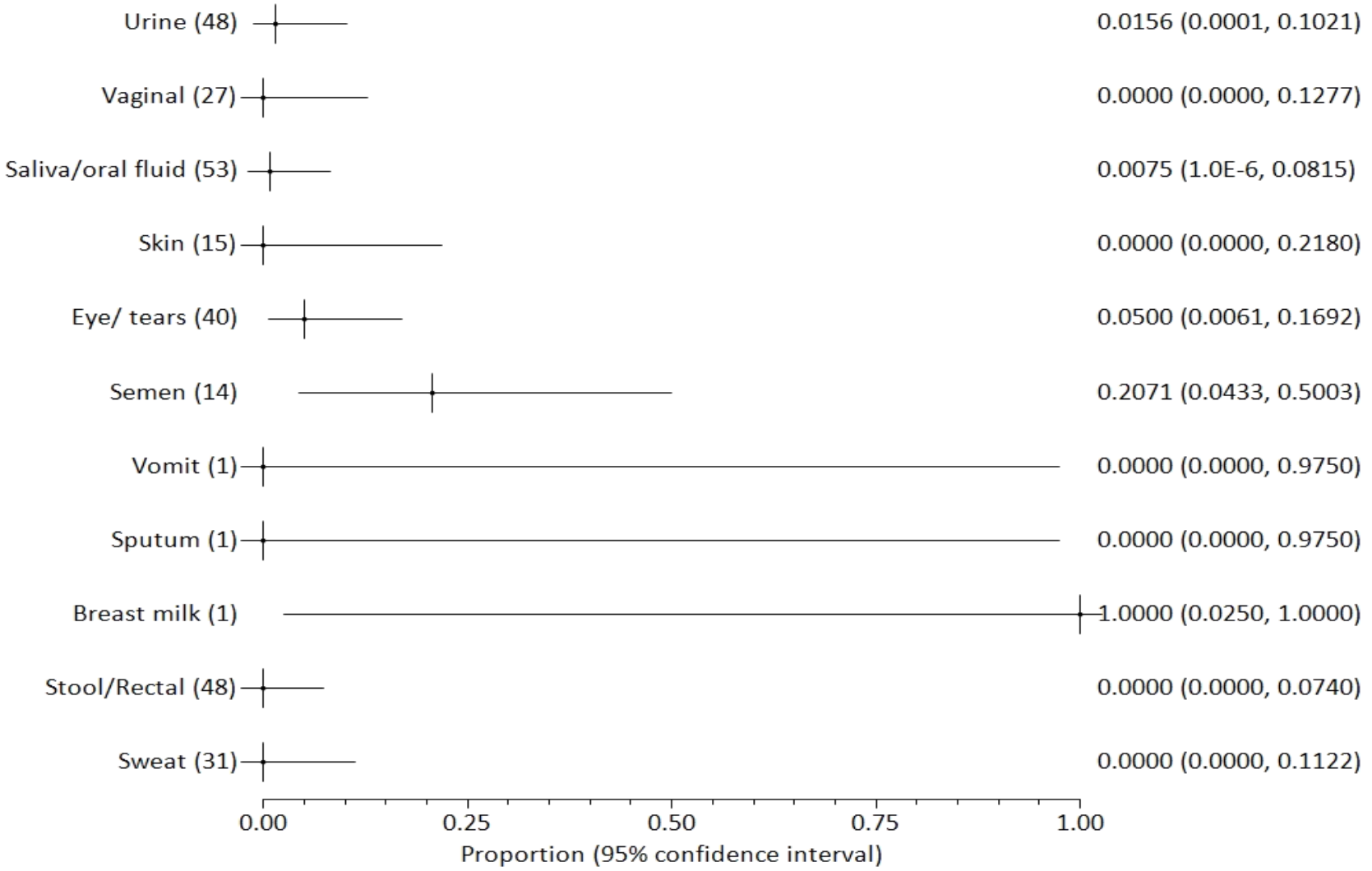
Proportion of body fluids positive for filovirus by PCR late samples (day 17-110)



Proportion of body fluids positive for filovirus by pooled PCR until day 110 (No. patients)



Proportion of body fluids positive for filovirus by Culture Only, thru day 110



SURVIVAL IN FAECES, STOOL, SEWAGE?

Until mid 2015 there were no data, so had to go on other facts we knew, like….

- Ebola virus is an enveloped virus
- Apparently not adapted to faecal transmission
- Community latrines are the main type of transmission site

Time for one log decline

Virus	Temp	Substrate	T90	%
TGEV/MHV[C]	25	Settled (water) sewage	10.5d	
TGEV/MHV[C]	25	Stool	4.7d	45%
Sars CoV[L]	RT	Viral Transport Medium	42.0h	
Sars CoV[L]	RT	Stool	2.7h	6%
Sars CoV[L]	RT	Diarrhoeal stool	24.0h	57%

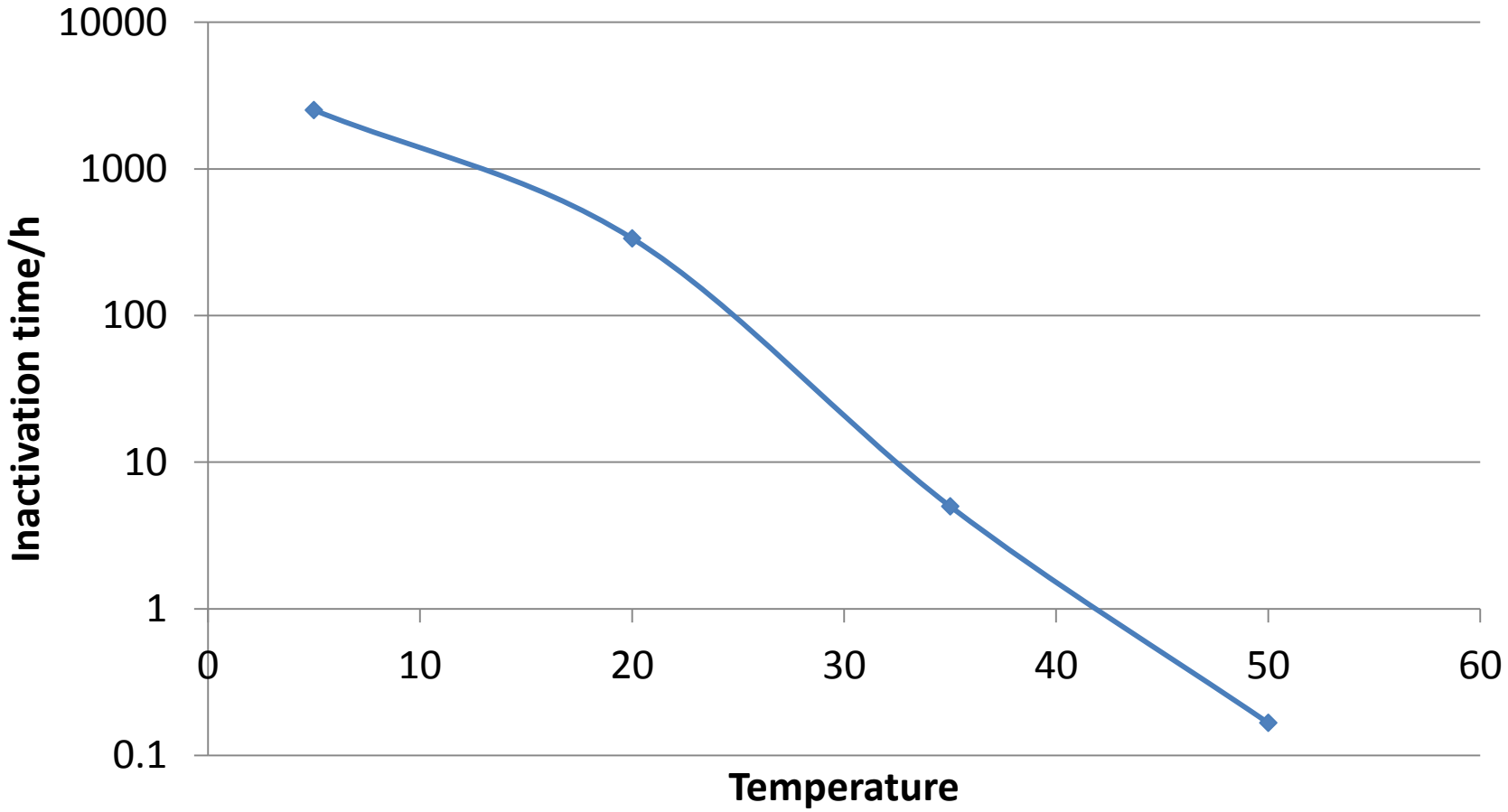
C = Casanova et al 2009. Survival of surrogate coronaviruses in water. *Water Res*. 43(7): 893-8

L = Lai et al 2005, Survival of Severe Acute Respiratory Syndrome Coronavirus *Clin Inf Dis*

Time for one log decline

Virus	Temp	Substrate	T90	Impact of stool (% adj.)
Ebola	20	Viral media	9.6d	
TGEV/MHV	25	Watery sewage	10.5d	
TGEV/MHV	25	Stool	4.7d	45%
SARS CoV	RT	Viral medium	42.0h	
SARS CoV	RT	Stool	2.7h	6%
SARS CoV	RT	Diarrhoeal stool	24.0h	57%

Inactivation of Aujeszky's disease virus in pig slurry, die-off at 28^{o} about 80 hrs, 4x faster than at 20^{o} (336 hrs)



So for Ebola virus in pit latrines

	Medium	Most likely T90	Upper estimate T90
T90 at 20^{o}C	Tissue culture	9.6d	
T90 at 20^{o}C	Stool	23h (10%)	4.8d (50%)
T90 in pit latrine at 28^{o}C	Pit latrine	6h (25%)	29h (25%)

Recent research

Bibby et al 2015

- Spiked sterilised and diluted mixed origin sewage with Ebola virus (Makona, triplicate expt)
- Observed 90% decline (T_{90}) after 2.1 days
- Concluded that 2.1 days was upper bound for T_{90} in field, due to exptl. conditions
- LoD = 0.75 $\log_{10}$, still detected until day 8

T_{90}

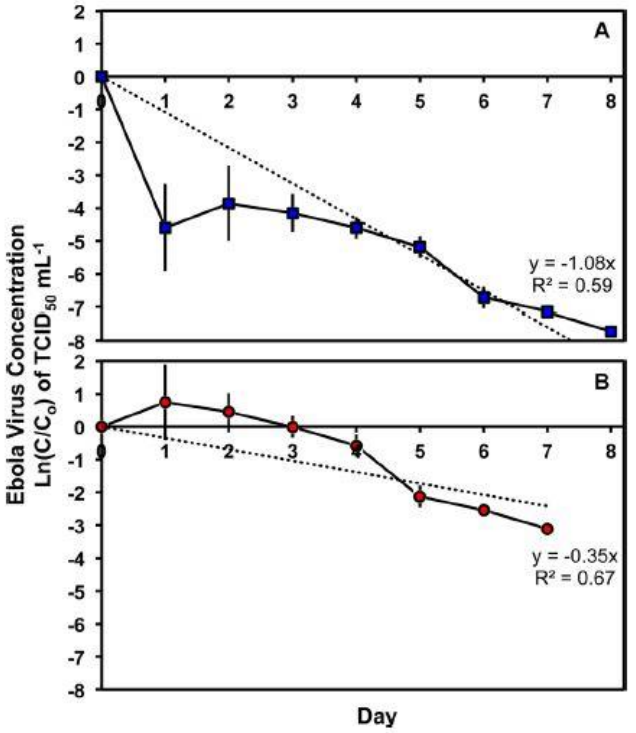


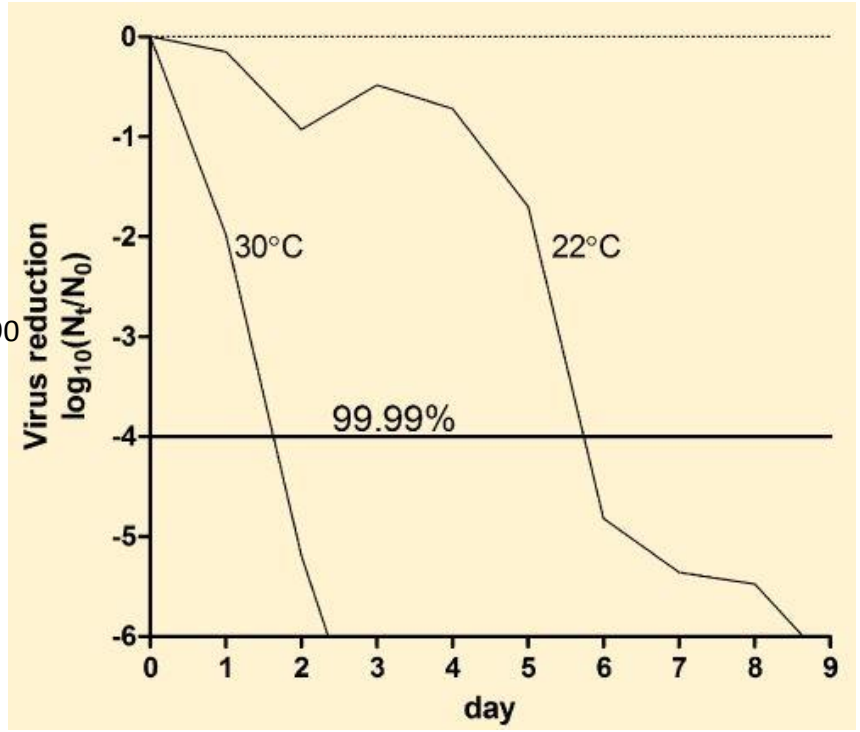
Figure 1. Persistence of an initial Ebola virus concentration of 10^6 $TCID_{50}$ mL^{-1} in domestic wastewater (untreated sewage) (A) including the time zero time point and (B) excluding the time zero time point to mitigate potential aggregation effects. Linear trendlines are shown. Fit inactivation constants (k) were determined to be −1.08 when including time zero and −0.35 when excluding time zero. Error bars are ±1 standard deviation.

Recent research

Casanova & Weaver 2015

- Spiked pasteurised urban sewage with phage surrogate for Ebola virus, held at 22^{o} or 30^{o} C
- T90 reached at 1 day (30^{o}) to 4.5 days (22^{o})
- 7 $\log_{10}$ inactivation after 3 days at 30^{o}, and 5.22 $\log_{10}$ decay after ~ 6 days (22^{o})
- Limit of detection reached at 4 days (30^{o}) or 10 days (22^{o})

T_{90}



Sewage/Faecal transmission

- Risk close to patient probably moderate
  - Handling faeces
  - Faecal smearing of environment/latrines
- Risk distant to patient probably low to very low
  - Dilution
  - Probable rapid decay in faeces at ambient temperatures
  - Risk to drinking water likely to be low -

Table 1. Hazard Analysis of Critical Control Point (HACCP) assessment for the disposal of waste potentially contaminated with Ebola Virus Disease viral material.

Edmunds et al (under review) *WHO Bulletin*.

Risk Environment	Type of risk, associated with…	… Blood-contaminated materials	…Other body fluid contamination	Recommendations
1. Latrine use	Contamination of environment	High	Medium	Suspected and confirmed cases use isolated and segregated latrines and keep secure for 7 days[1,2] after last use by suspected case. Secure from surface water inflow via external channels or concrete surroundings, and ensure adequate quality of construction to limit risk of collapse and contamination of groundwater sources[3]. First, clean surfaces using a single-use cloth with water and detergent which should then be incinerated. Following cleaning, wipe 0.5% chlorine solution[2,4-7] on all surfaces, including door handles, toilet seat, floor, walls[7]. Wash hands with soap and water after using latrine.
6. Emptying of latrine	Contamination of handler	Variable	Variable (age of waste, latrine construction)	Wait a minimum of seven days after last use by a known case before desludging[6,10]. If not possible to wait seven days, wear full PPE*[11-13].
12. Discharge and treatment of wastewater through sewer	Contact with virus by general public through open sewers, or with workers at treatment plant	Low	Low	Public health education of community representatives and construction of physical barriers[15]. Ensure appropriate conditions of carriage (in many places effluent streams are used by neighbours)[3] by following sanitation safety planning guidelines[3,16].

On the balance of evidence

- Risk of widespread rapid transmission via indirect casual contact in communities is very low
  - Requires close person contact to spread the infection
- Risk from contact with sewage is very low
  - With the possible exception when very close to the patient
  - Disinfection of faeces may be pointless
- Risk of transmission through drinking water is low

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NHS
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