Supplemental Information— Fomite Model

Parameters

Each of the parameters used in the transference model is presented in this section (Table S1). The derivation of each parameter, including the data from which they were derived, is described in further detail below. In most cases, the parameter is described as a distribution of likely values. Each iteration of the Monte Carlo simulation draws a value from the distribution, simulating the uncertainty and inherent variation in the specific values.

Table S1. Transference Model Parameter Summary

Parameter	Function	Mean	Minimum	Maximum
Rate of face touching ($hour^{-1}$)	Uniform	17.8	1	34.7
Rate of household contact (day^{-1})	Negative binomial	2.4	0	+∞
Rate of community contact (day^{-1})	Negative binomial	3.8	0	+∞
Rate of surface touching (day^{-1})	Log-logistic	3.96	0	+∞
Rate of hand washing (day^{-1})	Beta	8.52	0	17.3
Rate of showering (day^{-1})	Weibull	1.09	0	+∞
Rate of animal contact ($year^{-1}$)	Pert	2.3	0.47	9.7
Likelihood of animal contact	Constant	61%	N/A	N/A
Likelihood of disobeying quarantine	Uniform	0.025	0.0005	0.05
Fraction of virus transferred after contact	Triangle	0.33	0	1
Virus removed by washing (fraction remaining)	Gamma	0.101	0	+∞
Half-life of influenza virus on skin (min)	Gamma	1.55	0	+∞
Half-life of virus on fomites (h)				
Influenza	Uniform	5.15	2.4	7.9
MERS	Uniform	25	15	35
SARS	Uniform	0.705	0.44	0.97
Human infection parameters				
Seasonal influenza ID_{50} (PFU)	Uniform	3	1	5
Seasonal influenza probit slope	Uniform	0.173	0.129	0.217
Pandemic/Avian influenza ID_{50} (PFU)	Uniform	962	286	1,637
Pandemic/Avian influenza probit slope	Uniform	0.326	0.281	0.371
SARS/MERS CoV ID_{50} (PFU)	Log-triangle	99	11	530
SARS/MERS CoV probit slope	Constant	1.34	N/A	N/A
Avian infection parameters				
Avian influenza ID_{50} in chickens (PFU)	Constant	2,500	N/A	N/A
Avian influenza ID_{50} in other poultry (PFU)	Uniform	5.5	1	10
Avian influenza probit slope	Uniform	0.250	0.129	0.371

Event Rates

As described above, much of the transference model depends on the frequency with which people commit certain acts, such as touching their face, washing their hands, or contacting other people. Each such event may or may not happen in each minute modeled, as determined by a stochastic process dependent on the rate at which the event happens.

Rate of Face Touching

Infection of an individual, whether it is the laboratorian or an individual to whom contamination was spread through contact, occurs when a person spreads contamination on his or her hand to the mucous membranes in the eye, nose, or mouth. Relatively few studies have directly examined the rate of hand-to-face touches, but two provide important data. Nicas et al. (2008) observed ten workers in an office for 3 hours and recorded hand to eye, lip, and nostril touches. The workers were informed of the intent of the study. The study reports a mean (std. dev.) of 47 (35) total touches, with 7.4 (5.7) eye touches, 24 (24) lip touches, and 16 (11) nostril touches per individual over the three hour observation period.[1] In a separate study, Ng et al. (2014) followed workers at several types of businesses, including an animal research facility and several industrial plants, and recorded the frequency of hand contacts to the mouth and perioral vicinity. Workers were aware of the observers, but were unaware of what the observers were recording.[2]

The data provided by Ng. et al., reproduced in Table S2 below, capture the various hand-to-face touching rates of each individual subject. Due to a lack of data differentiating the possibility of influenza infection through the oral, nasal, and ocular routes, all routes were treated as one and the total number of face touches per hour is used in the model. The distribution of face touches is represented by a uniform distribution from the minimum rate to the maximum rate observed among the subjects (1 to 34.7 face touches per hour); a more precise distribution could not be fit to the data due to the wide variability among the subjects (Table S3).

Table S2. Face Touching Rates per Hour Among Ten Subjects

Subject	Eyes	Lips	Nostrils	Total
1	0.00	0.00	1.00	1.00
2	1.33	0.67	0.33	2.33
3	0.67	4.00	1.33	6.00
4	0.33	0.33	6.67	7.33
5	3.33	7.33	5.00	15.67
6	4.33	11.00	2.67	18.00
7	5.67	5.00	9.00	19.67
8	2.00	10.33	9.33	21.67
9	3.00	17.33	10.00	30.33
10	4.00	24.00	6.67	34.67
Mean	*2.47*	*8.00*	*5.20*	*15.67*

The data provided by Ng et al. are not as detailed, and could not be used to inform the distribution of face-touching rates. The study reported an average mouth-touching rate, which included the mouth and perioral area, of 6.3 touches per hour (median = 4) and a maximum of 26, figures which are consistent with the data reported by Nicas et al. Ng et al. did not record rates for touching of the eyes or nose.

Table S3. Parameter Description: Number of Face Touches per Hour

Function	Uniform
Minimum	1.00

[1] Nicas M, Best D (2008) A study quantifying the hand-to-face contact rate and its potential application to predicting respiratory tract infection. *Journal of occupational and environmental hygiene* 5**:** 347-352

[2] Ng MG *et al* (2014) Inadvertent ingestion exposure: hand- and object-to-mouth behavior among workers. *Journal of exposure science & environmental epidemiology*

Function	Uniform
Maximum	34.7
Mean	17.8
Standard Deviation	9.72

Rate of Person-to-Person Contact

The extent of spread of viral contamination from the laboratorian to other people is dependent on the rate at which the laboratorian makes physical contact with other people. A journal-based survey of contact frequencies was used to estimate the daily rate of contacts involving touch for adult individuals.[3] The dataset were restricted to participating individuals 20-64 years of age, with the reasoning that children and the elderly would be largely absent from containment labs. (Note that all ages of the person contacted by the participant were allowed.) While the dataset captures both interactions and physical contact events, the events used to determine contact rates for this model were restricted to physical contact events. The contacts were separated into those within the household and those that happened elsewhere, and each reporting individual's household and non-household contacts were summed separately, to allow for separate tracking of the two individual types in the branching process model of outbreak initiation that follows the transference model. The resulting individual daily contact frequencies were binned and used to fit separate population-wide negative binomial distributions (Table S4).

Table S4. Parameter Description: Number of Contacts per Day

Parameter	Household Contacts	Community Contacts
Function	Negative binomial	Negative binomial
r	2.88	0.584
p	0.547	0.133
Minimum	0	0
Mean	2.39	3.80
Standard Deviation	2.09	5.33

The primary data used to estimate these parameters consisted of surveys taken in several high-income European countries; however, the distribution for the United States is likely similar and no attempts to correct the data for the United States were undertaken. In addition, participants were instructed to only record the first contact with an individual on the day they journaled. As a result, individuals contacted many times in a single day were listed only once, resulting in distributions that may underestimate the true contact frequency.

Rate of Surface Touching

Throughout the period of time modeled, a person carrying contamination on his or her hand will be repeatedly contacting various surfaces—door handles, keyboards, keys, etc.—onto which they can spread viral material. A simplified model of such contact events was used in the Monte Carlo simulations. The number of contact events was interpreted as the number of destinations a worker goes per day. These destinations can include areas within the laboratory facility (an office, restroom, conference room, etc.) as well as destinations upon leaving the facility (a classroom, store, gym, car, or home). The rationale behind this simplification is that while a single contact event may result in loss of contaminant due to transfer, repeated contact of surfaces within a defined area over a span of time will result in both deposition of virus and re-acquisition of virus from recently contaminated surfaces. Given sufficient contact events of the same location, the amount of viral material on the hand and the surface will equilibrate, thus the

[3] Mossong J *et al* (2008) Social contacts and mixing patterns relevant to the spread of infectious diseases. *PLoS medicine* 5**:** e74

model is based on the assumption that for each defined area a contaminated person visits, half of the starting amount of virus is lost. Clearly, this assumption results in a very conservative estimate of loss of viral material due to contact, but is necessary due to the difficulty in estimating the actual number of contacts an area of a person's body may make over the course of a day. Additionally, were an estimate of total contacts to be used, the fraction remaining on the contaminated worker would very quickly be reduced to below one infectious unit, and thus every contamination event would quickly reach zero probability of infection.

The number of contact events a person may experience in a given day was determined as part of the Updated Site-Specific Risk Assessment (SSRA) of the planned National Bio and Agro-Defense Facility (NBAF) from interview data of campus Kansas State University personnel, including research employees of the Biosecurity Research Institute (BRI), faculty, and students.[4] The frequencies at which employees visited locations within and outside of the BRI and around campus were recorded, and a log-logistic distribution (α. = 5.86, β = 3.78) was fit to the data (Table S5).

Table S5. Parameter Description: Number of Surfaces Touched per Day

Function	Log-logistic
α	5.86
β	3.78
Minimum	0
Mean	3.96
Standard Deviation	1.30

Rate of Hand Washing

Viral contamination will be partially removed from the hands of an individual through regular hand washing over the course of the time modeled. The probability distribution for the frequency at which an individual washes his or her hands was calculated using data from three research surveys. Two of these surveys were of self-reported daily handwashing frequencies in 2006 and 2009.[5,6] The third survey compared self-reported frequencies to actual frequencies of handwashing in public restrooms, and found that adults reported washing their hands 92% of the time, but actually washed their hands 77% of the time.[7]

Table S6. Estimated daily handwashing frequency of general U.S. population.

Handwashing Frequency (day^{-1})	Percentage of Population
0	0%
0.8 - 1.7	2%
2.5 - 3.3	11%
4.2 - 5.0	18%
5.9 - 8.4	23%
9.2 - 11.7	19%
12.6 - 13.4	16%
14.2 - 15.1	9%
15.9 - 16.7	2%

[4] U.S. Department of Homeland Security. (2012) NBAF Updated Site-Specific Biosafety and Biosecurity Mitigation Risk Assessment Vol I.
[5] Sansoni B (2006) America's Clean Hands Report Card - Can't Rise Above 'C' Level.
[6] The Soap and Detergent Association (2009) 2009 National Clean Hands Report Card Survey Findings.
[7] Harris Interactive (2007) A Survey of Handwashing Behavior (Trended).

To estimate the frequency of daily handwashing, the values from the first two handwashing surveys were modified using the factor determined in the third study to account for the disparity between self-reporting and actual frequency, then weighted based on proportion of the study population. Table S6 above lists the estimated frequency and population fraction for handwashing based on these studies. These handwashing frequencies were then fit with a generalized beta distribution with a minimum of 0 and a maximum of 17.3 hand washes per day (Table S7). The generalized beta distribution was used because it has a flexible but finite maxima, minima, and average that allowed it to be closely tuned to the estimated data.

Table S7. Parameter Description: Frequency of Hand Washing per Day	
Function	**Beta**
α1	2.39
α2	2.46
Minimum	0
Maximum	17.3
Mean	8.52
Standard Deviation	3.57

Rate of Showering

As part of the National Human Activities Pattern Survey (NHAPS) database, funded by the U.S. EPA, showering and bathing frequency and duration were reported in the literature.[8] Frequency data were reported for many age groups, including both children and adults. Only the data for adults were used, based on the assumption that all laboratory workers are over the age of 18. The frequency reported in the literature is shown below in Table S8. The showering data were substantially right-skewed, with a small number of individuals apparently taking an extremely large (> 10) number of showers per day. For this reason, a Weibull distribution ($\alpha = 1.95$, $\beta = 1.23$) was fit to the data, rather than the generalized beta distribution used for handwashing, to better capture such outliers (Table S9).

Table S8. Daily Showering Trequency of Adult U.S. Population.	
Showering Frequency (day^{-1})	**Percentage of Population**
0	14.7%
1	65.5%
2	19.0%
3	0.6%
4	0.03%
5-10	0.08%
>10	0.08%

Table S9. Parameter Description: Frequency of Showering per Day	
Function	**Weibull**
α	1.95
β	1.23
Minimum	0
Mean	1.09
Standard Deviation	0.583

[8] Wilkes CR *et al* (2005) Probability Distribution for Showing and Bathing Water-Use Behavior for Various U.S. Subpopulations. *Risk Analysis* 25**:** 317-337

Animal Infection

The transference model estimates the probability of an infection in avian species arising from contact by a contaminated laboratory worker. Animal contact is modeled as a combination of two factors: whether a laboratorian ever contacts susceptible species, and the duration of time from contamination until contact with the susceptible species. The time until contact consists of two parameters: the rate at which a worker visits animal housing sites and whether or not the quarantine period imposed on laboratorians working with avian influenza is obeyed.

Likelihood of Animal Contact

With respect to frequency of contact between laboratory workers and animals, the model operates on the assumption that there are two types of workers: those that are likely to regularly come into contact with animals through their normal activities, even if at a very low rate, and those that cannot reasonably be anticipated to ever come into contact with animals. For each simulation, the laboratorian is placed into one of these two groups based on the expected proportion of the two.

The proportion of laboratory workers that do contact animals to those that do not was determined as part of the NBAF Updated SSRA from interview data of research employees of the BRI at Kansas State University.[9] Researchers at this facility handle high-consequence agricultural pathogens (although primarily plant and livestock pathogens), and as such have similar restrictions on contact with susceptible animal species as would researchers working on avian influenza. Researchers working in containment laboratories were asked how often they visited facilities that contain species susceptible to the pathogens they handled, including farms, campus animal facilities, veterinarian offices, and state and county fairs. Sixty-one percent of containment laboratory workers specified that they contacted animals at some point.

Rate of Animal Contact

For those laboratory workers that do contact susceptible animal species, the duration of time from breach of containment to animal contact is determined from an average rate of animal contact events per year. A distribution was fit to the interview data described in the previous section to describe how many days per year a worker will likely visit a farm containing susceptible species. A Pert distribution was used to describe the range of values, with a minimum of 0.47 visits per year, a mode of 0.94, and a maximum of 9.7 (Table S10). (A Pert distribution is a variant of the beta distribution that allows for significant skewing of the function rather than maintaining symmetry).

Given that the specific population of workers is undefined for the current risk assessment, it is difficult to estimate what characteristics the workers will display as far as contact with susceptible species. While many differences may exist between the workers of any given gain-of-function laboratory and those surveyed here, the population surveyed here offers several advantages as a basis for this and the previously described parameter. Because the workers are dealing with high-consequence agricultural pathogens, they will have had similar training on appropriate procedures for limiting the potential for spreading virus. Additionally, the population surveyed is from a large agricultural research college located in a largely rural area, in close proximity to livestock and other agriculture; the risk posed by such a scenario is likely to be higher than many of the potential settings for gain-of-function research and thus any predictions based on these parameters will be conservative.

[9] U.S. Department of Homeland Security. (2012) NBAF Updated Site-Specific Biosafety and Biosecurity Mitigation Risk Assessment Vol I.

Table S10. Parameter Description: Number of Animal Contacts per Year	
Function	**Pert**
Minimum	0.477
Mode	0.937
Maximum	9.65
Mean	2.31
Standard Deviation	1.39

Likelihood of Violating Quarantine

Laboratory workers handling avian influenza are instructed to avoid contact with avian species for five days after working in the laboratory. The transference model assumes a rules-based error rate of 5×10^{-2} to 5×10^{-4} for failure to maintain quarantine, as is used in the event tree models and described in Appendix 13.1; the range is represented in the model as a uniform distribution (Table S11).

Table S11. Parameter Description: Likelihood of Violating Quarantine	
Function	**Uniform**
Minimum	0.0005
Maximum	0.05
Mean	0.025
Standard Deviation	0.014

Virus Reduction Factors

Several events in the transference model cause a loss of viable virus material available for causing infection, including transfer to another person, removal by hand washing or showering, and natural degradation of the virus. Each of these factors is described below.

Fraction of Virus Transferred

A fraction of the amount of virus present on the laboratory worker will be transferred from the site of contamination every time the worker contacts another person. Published data from contact transfer studies were used to determine the fraction of viral material transferred in each such contact event. Data from 18

different studies of virus transfer during contact were analyzed.[10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25] Together the studies quantified the transfer of 12 different viruses between skin and eight other surfaces, including skin-to-skin. Most studies examined the transfer from hands or fingers to other materials, while eight of them also reported the reverse. The fractions of virus samples transferred were calculated if not directly reported and grouped according to material. One-way ANOVA testing determined that the mean fractions transferred were not statistically significant between groups ($p = 0.186$). Thus, all data were used to fit a distribution; the fraction of virus transferred in each contact event was defined as a triangular distribution with a minimum and mode of 0 and a maximum of 1 (Table S12).

Table S12. Parameter Description: Fraction of Virus Transferred After Contact

Function	Triangle
Minimum	0
Mode	0
Maximum	1
Mean	0.33
Standard Deviation	0.24

Virus removed by washing

Over the course of the model, a contaminated individual will likely wash his or her hands multiple times as well as take a shower. Each washing event removes a significant fraction of the viral material. Three studies demonstrating the efficacy of hand washing at removing virus were used to determine the range of virus removal due to washing. Experiments with rotavirus, hepatitis A virus, and poliovirus all showed approximately one log reduction from washing hands with soap (range 81.4% to 98.4%, mean

[10] Ansari SA *et al* (1988) Rotavirus survival on human hands and transfer of infectious virus to animate and nonporous inanimate surfaces. *Journal of clinical microbiology* 26**:** 1513-1518

[11] Bean B *et al* (1982) Survival of influenza viruses on environmental surfaces. *The Journal of infectious diseases* 146**:** 47-51

[12] Bidawid S *et al* (2000) Contamination of foods by food handlers: experiments on hepatitis A virus transfer to food and its interruption. *Applied and environmental microbiology* 66**:** 2759-2763

[13] Gwaltney JM, Jr. *et al* (1978) Hand-to-hand transmission of rhinovirus colds. *Annals of internal medicine* 88**:** 463-467

[14] Hall CB *et al* (1980) Possible transmission by fomites of respiratory syncytial virus. *The Journal of infectious diseases* 141**:** 98-102

[15] Hall CB, Douglas RG, Jr. (1981) Modes of transmission of respiratory syncytial virus. *The Journal of pediatrics* 99**:** 100-103

[16] Julian TR *et al* (2009) A model of exposure to rotavirus from nondietary ingestion iterated by simulated intermittent contacts. *Risk analysis : an official publication of the Society for Risk Analysis* 29**:** 617-632

[17] Julian TR *et al* (2010) Virus transfer between fingerpads and fomites. *Journal of applied microbiology* 109**:** 1868-1874

[18] Kampf G, Kramer A (2004) Epidemiologic background of hand hygiene and evaluation of the most important agents for scrubs and rubs. *Clinical microbiology reviews* 17**:** 863-893, Table Sof contents

[19] Lopez GU *et al* (2013) Transfer efficiency of bacteria and viruses from porous and nonporous fomites to fingers under different relative humidity conditions. *Applied and environmental microbiology* 79**:** 5728-5734

[20] Mbithi JN *et al* (1992) Survival of hepatitis A virus on human hands and its transfer on contact with animate and inanimate surfaces. *Journal of clinical microbiology* 30**:** 757-763

[21] Pancic F *et al* (1980) Role of infectious secretions in the transmission of rhinovirus. Ibid. 12**:** 567-571

[22] Reed SE (1975) An investigation of the possible transmission of Rhinovirus colds through indirect contact. *The Journal of hygiene* 75**:** 249-258

[23] Rusin P *et al* (2002) Comparative surface-to-hand and fingertip-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage. *Journal of applied microbiology* 93**:** 585-592

[24] Sattar SA *et al* (1993) Chemical disinfection to interrupt transfer of rhinovirus type 14 from environmental surfaces to hands. *Applied and environmental microbiology* 59**:** 1579-1585

[25] Winther B *et al* (2007) Environmental contamination with rhinovirus and transfer to fingers of healthy individuals by daily life activity. *Journal of medical virology* 79**:** 1606-1610

90.9%).[26,27,28] A gamma distribution ($\alpha = 2.35$, $\beta = 0.0429$) was fit to the data from the three studies to describe the expected range of fraction of virus remaining after washing (Table S13). Because data specific to showering, as opposed to hand washing, were not available, the model operates on the assumption that both actions are equally effective at removing virus.

Table S13. Parameter Description: Fraction of Virus Remaining After Washing	
Function	**Gamma**
Minimum	0
α	2.35
β	0.0429
Mean	0.101
Standard Deviation	0.0659

Half-life of Virus on Skin

Viruses are relatively unsTable Sin the environment, especially on a person's skin, and degrade quickly in an exponential fashion. The rate of virus degradation is highly dependent on the specific virus, therefore studies examining environmental persistence of each virus modeled (influenza, SARS CoV, and MERS CoV) were used to develop separate decay rates.

Influenza Half-life

Several studies have examined the survivability of influenza virus on fomites, but only one provides data on virus stability on hands or fingers. Thomas et al. (2014) demonstrates that influenza virus is short lived on fingertips in mucus. Eighteen fingers were inoculated with a 2 µl droplet of either H3N2 at 1.8×10^7 $TCID_{50}$/ml or H1N1 at 1×10^5 $TCID_{50}$/ml and sampled for remaining viable virus at various time points. After 30 minutes, only two out of 18 fingers remained positive for each of the two viruses tested.[29] Assuming a threshold of detection of 4 $TCID_{50}$, estimates of half-lives could be made for each finger based on the time at which the samples returned negative. Data from the two virus types were combined and a Gamma distribution ($\alpha = 1.01$, $\beta = 1.54$) fit to describe the range of expected half-lives (Table S14).

Table S14. Parameter Description: Half-life of Influenza Virus on Fingers (min)	
Function	**Gamma**
Minimum	0
α	1.01
β	1.54
Mean	1.55
Standard Deviation	1.54

Bean et al. (1982) demonstrated that influenza virus H1N1 survives for several hours on surfaces and common objects, including a stainless steel counter top, plastic dishpan, cotton handkerchief, and

[26] Ansari SA *et al* (1989) In vivo protocol for testing efficacy of hand-washing agents against viruses and bacteria: experiments with rotavirus and Escherichia coli. *Applied and environmental microbiology* 55**:** 3113-3118

[27] Mbithi JN *et al* (1993) Comparative in vivo efficiencies of hand-washing agents against hepatitis A virus (HM-175) and poliovirus type 1 (Sabin). Ibid. 59**:** 3463-3469

[28] Bellamy K *et al* (1993) A test for the assessment of 'hygienic' hand disinfection using rotavirus. *The Journal of hospital infection* 24**:** 201-210

[29] Thomas Y *et al* (2014) Survival of influenza virus on human fingers. *Clinical microbiology and infection : the official publication of the European Society of Clinical Microbiology and Infectious Diseases* 20**:** O58-64

magazine page.[30] The half-lives of the virus derived from these data ranged from 3.5 to 7.9 hours. Sakaguchi et al. tested survival of influenza PR8 on a variety of surfaces including a rubber glove, a surgical mask, Tyvek, and finished wood.[31] The half-lives derived from these data were all from 2.4 to 2.7 hours. After assessing all fomite-based half-lives together a uniform distribution was chosen to describe the range of possible half-lives in the model (Table S15). Because the transference model does not track virus fate after sitting on surfaces, these data were not directly used in determining influenza environmental survival; however, they are necessary for estimating the stability of the corona viruses on hands, as described in the following section.

Table S15. Parameter Description: Half-life of Influenza Virus on Fomites (h)	
Function	**Uniform**
Minimum	2.4
Maximum	7.9
Mean	5.15
Standard Deviation	1.59

SARS CoV and MERS CoV Half-life

Compared to influenza virus, the coronaviruses SARS and MERS have very little data on environmental persistence. Data on virus survival on hands or fingers is not available for either virus. However, some data were found that could be used to determine the half-lives of these viruses on fomites. As demonstrated above, the stability of a virus on skin versus other surfaces can be very different. Therefore, to estimate the half-lives of SARS and MERS CoVs, half-lives on fomites were estimated for each of the viruses and scaled using the ratio of half-lives on skin and fomites of influenza virus.

Chan et al. (2011) tested survival of SARS CoV on polystyrene at several different temperatures and levels of humidity.[32] Exponential decay models were fit to the data, resulting in a wide range of half-lives, from two to 35 hours. The shortest half-life estimates were from data collected at 38°C, an unreasonably high temperature. A uniform distribution based on the remaining values (15 – 35 h) was used to describe the range of half-lives for SARS CoV on fomites (Table S16).

Table S16. Parameter Description: Half-life of SARS CoV on Fomites (h)	
Function	**Uniform**
Minimum	15
Maximum	35
Mean	25
Standard Deviation	5.77

Van Doremalen et al. (2013) tested stability of MERS CoV on plastic and steel, and reported estimated half-lives from trials at different temperatures and humidity levels.[33] The half-lives ranged from 0.44 to 0.97 hours; a uniform distribution was used to describe this range in the model (Table S17).

[30] Bean B *et al* (1982) Survival of influenza viruses on environmental surfaces. *The Journal of infectious diseases* 146**:** 47-51

[31] Sakaguchi H *et al* (2010) Maintenance of influenza virus infectivity on the surfaces of personal protective equipment and clothing used in healthcare settings. *Environmental health and preventive medicine* 15**:** 344-349

[32] Chan KH *et al* (2011) The Effects of Temperature and Relative Humidity on the Viability of the SARS Coronavirus. *Advances in virology* 2011**:** 734690

[33] van Doremalen N *et al* (2013) Stability of Middle East respiratory syndrome coronavirus (MERS-CoV) under different environmental conditions. *Euro surveillance : bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin* 18

Table S17. Parameter Description: Half-life of MERS CoV on Fomites (h)	
Function	**Uniform**
Minimum	0.44
Maximum	0.97
Mean	0.705
Standard Deviation	0.153