Transfer Efficiency of an Enveloped Virus, Human Coronavirus 229E, from Various Hard Surface Fomites to Finger Pads of the Hand.

Charles P. Gerba PhD1; Brianna M. Leija BS1; Luisa A. Ikner PhD1; Patricia Gundy MS1; and

William A. Rutala PhD, MPH2

1Department of Environmental Science, University of Arizona, Tucson, AZ USA 85721

2Division of Infectious Diseases, University of North Carolina School of Medicine, Chapel Hill, North Carolina, USA

Word count: 1,118

Key words: coronavirus, transfer, fomites, hands, environmental surfaces, viruses

Running title: Finger-to-fomite transfer of coronavirus

Corresponding author

Charles P. Gerba

The WEST Center

University of Arizona

2959 W. Calle Agua Nueva

Tucson, AZ 85745

[gerba@ag.arizona.edu](mailto:gerba@ag.arizona.edu)

520 345 1457

**Abstract**

Respiratory viruses can be transmitted by hand-to-fomite-to-face contact, but no data currently exists on transfer of enveloped viruses. The transfer efficiency of human coronavirus from various hard surfaces was found to range from 0.46 to 49.0%. This information can be used to model the fomite transmission of enveloped viruses.

**Introduction**

The transfer efficiency of viruses from various types of fomites (i.e., inanimate objects and surfaces) to the finger pads of hands is key in the development of pathogen exposure and quantitative microbial risk assessment models.[[1]](#endnote-1) [[2]](#endnote-2) Previous studies have documented the transfer efficiencies of non-enveloped viruses from various types of fomites to finger pads.[[3]](#endnote-3) [[4]](#endnote-4) This is the first study that evaluated the transfer efficiency for enveloped viruses such as coronavirus.

**Material and Methods**

**Preparation of the Test Virus**

Human coronavirus 229E (HCoV 229E) was procured from the American Type Culture Collection (ATCC VR-740; Manassas, Virginia) and propagated using the MRC-5 cell line (ATCC CCL-171). Infected cells were freeze-thawed and clarified lysates underwent a polyethylene glycol (PEG) extraction [12% (w/v) PEG (8000 mw) and 0.5 M sodium chloride] overnight at 4 °C. The suspension was centrifuged (10,000 x g, 60 minutes), and the virus pellet resuspended in 0.01 M phosphate buffered saline (PBS; pH 7.4) to 10% of the original suspension volume. Aliquots were stored at -80 °C until use on the respective study dates. Virus stock titers were determined prior to the study by thawing and diluting (1:10) a stock vial using 0% fetal bovine sera (FBS) in minimal essential media (MEM). Dilutions were plated in replicates of six onto MRC-5 monolayers prepared in multi-well trays and incubated for seven days (35 °C) in a 5% CO2 atmosphere. Wells were scored for cytopathogenic effects~~.~~ The tissue culture infectious dose at the 50% endpoint (TCID50) per mL

**Pre- and Post-Experiment Hand Decontamination**

The subject was a healthy 75-year-old male whose hands lacked visible cracks, abrasions, cuts, or other compromising skin conditions. Permission was obtained and the protocol was approved by University of Arizona Institutional Research Board prior to conduct of the study; a human subjects review was not required. Prior to all experiments, the subject’s hands were washed using an antibacterial liquid hand soap for 45 seconds, rinsed with de-ionized (DI) water, and dried using paper towels. Each hand was then sprayed twice with 70% ethanol and rubbed over the hands and wrists for 15 seconds followed by air drying for a minimum of five minutes. After conducting fomite-to-finger viral transfer experiments, the subject’s finger pads were sprayed twice using 70% ethanol, and the entirety of each hand was wrapped within 70% ethanol-saturated paper towels for 30 seconds. The hands were then washed, rinsed, and dried as previously described.

**Test Carrier Preparation and Inoculation with HCoV 229E**

On the test dates, a vial of stock virus was thawed and amended with FBS ~~fetal bovine serum~~ to achieve an organic load of 5% (v/v). Cleaned, sanitized test carriers (Table 1) were inoculated with 10 L of virus, which was spread over an area of 1-cm2 using a bent pipette tip. The carriers were dried under controlled conditions [(22 ± 1 oC; 40% ± 5% relative humidity (RH)] for ~30 minutes with the Petri dish lids on. A triplicate set of carriers was immediately harvested to determine levels of infectious virus per carrier just prior to the transfer experiments. Carriers were rinsed with 1 mL of 0% FBS MEM with antibiotics three to five times and treated with a sterile cell scraper to further facilitate virus detachment. Dilutions and plating onto MRC-5 cell monolayers followed as previously described.

**Fomite-to Finger pad Transfer Experiments**

The remaining carriers underwent fomite-to finger pad transfers within 15 minutes after drying. The study was conducted ~~at~~ under controlled conditions (22 ± 1 oC 55% ± 5% RH). One transfer trial consisted of six transfer events using the index, middle, and ring fingers of both hands for each surface type. The transfer protocol was conducted according to Lopez et al.4 by placing the finger pad directly onto the contaminated carrier, achieving full contact with the 1-cm2 inoculum zone for 10 seconds at 1.0 kg/cm2 of average pressure (range, 900 g/cm2 to 1,200 g/cm2).

**Finger sampling**

HCoV 229E was initially recovered from contaminated finger pads using the nylon swab method described by Rusin et al.[[5]](#endnote-5); however, low viral recoveries were achieved. An alternative method was then employed during which the contaminated finger pads were washed in 1 mL of 0% FBS MEM with antibiotics within a sterile Petri dish. The finger pads were rubbed into the liquid for 10 seconds to facilitate viral removal, and the suspensions were diluted (1:10) using 0% FBS MEM with antibiotics. Dilutions and plating onto confluent MRC-5 host cell monolayers followed as previously described.

**Results**

The swab method for sampling HCoV 229E transferred to the finger pads yielded lower numbers than directly rubbing the fingers into 1 mL of 0% MEM with antibiotics (Table 2). Overall, the highest numbers of HCoV 229E were transferred from glazed porcelain (49.07%) to the finger pads compared to stainless steel (<1%), which demonstrated the lowest mean transfer efficiency of HCoV 229E (Table 2).

**Discussion**

Fomite-to-finger pad transfer data has been published for non-enveloped viruses; however, it cannot be extrapolated to enveloped viruses due to differences in viral structure and methodologies. The transfer efficiencies presented herein for HCoV 229E are similar to non-enveloped viruses, although they may be greater for glazed porcelain. The reason for greater fomite-to-finger transfer from glass and glazed porcelain is unknown but may be attributable to the microscopically smoother surface of these fomites compared to others (e.g., stainless steel) or the hydrophobicity of the surfaces. Lopez et al. (2013) demonstrated a 7.1% transfer of MS-2 from ceramic tiles, and both MS-2 and PRD-1 phages were transferred from glass at efficiencies of 19.3% and 33.47%, respectively.5 Ansari et al.3 measured a mean transfer efficiency of rotavirus from stainless steel of 16.8%.

Respiratory viruses such as influenza, rhinoviruses, and respiratory syncytial virus, and coronavirus can be transmitted, in part, by inoculation of the nose, mouth, or eyes via contaminated hands. Thus, fomites may play a role in the transmission of these viruses including coronavirus. For this reason, infection prevention measures recommended to preclude the transmission from an environmental surface or object by hands to the nose, mouth or eyes include disinfection of surfaces and hand hygiene.3-5 In the case of rhinoviruses and respiratory syncytial virus, inoculation of the nose, mouth or eyes may be the major route of transmission.[[6]](#endnote-6) [[7]](#endnote-7) While transmission of influenza via fomites depends on touching frequency and other factors in indoor environments.[[8]](#endnote-8) Human coronavirus 229E can be transmitted by placement on the nose in humans [[9]](#endnote-9) and transmission of SARS-CoV-2 has been demonstrated by intranasal inoculation.10 The role of fomites in the transmission of coronavirus SARS-CoV-2 is not currently known. However, this study has demonstrated the potential for coronaviruses (such as SARS-CoV-2) to be transferred from various fomites to the fingers.

**Table 1. Fomites/surface types tested**

|  |  |  |
| --- | --- | --- |
| **Fomite/Surface Type** | **Description** | **Manufacturer or Source** |
| Stainless steel | Gauge 304 | AK Steel Corporation |
| Glass | Slides | VWR, Mississauga, Ontario, |
| Glazed porcelain | Porcelain | Home Depot, Atlanta, GA |
| Laminate | Vinyl floor tile | Home Depot, Atlanta, GA |
| Formica | Countertop tiles | Home Depot, Atlanta, GA |

**Table 2. Fomite-to-finger pad transfer efficiencies of human coronavirus 229E**

|  |  |  |  |
| --- | --- | --- | --- |
| **Fomite/Surface Type** | **Mean Pre-Transfer Surface Viral Titer**  **Log10 ± S.D. (n=3)** | **Transfer Replicates**  **(n)** | **Mean Transfer Efficiency % ± S.D.** |
| Stainless steela | 4.78 ± 0.19 | 6 | 0.008 ± 0.003 |
| Stainless steelb | 4.94 ± 0.25 | 6 | 0.46 ± 0.57 |
| Glassb | 4.17 ± 0.17 | 6 | 37.24 ± 82.34 |
| Glazed porcelainb | 4.72 ± 0.10 | 6 | 49.07 ± 16.70 |
| Laminateb | 4.28 ± 0.10 | 6 | 6.55 ± 5.48 |
| Formicab | 4.44 ± 0.10 | 6 | 25.38 ± 28.4 |

aSwab method

bWash method

Financial Support. This study was supported in part from a grant to the University of Arizona from Allied Biosciences and Disinfection Gift Trust Fund at the University of North Carolina.

Disclosures. Dr. Rutala is a consultant to Professional Disposables International (PDI).

**References**

1. Nicas M, Best D. A study quantifying the hand-to-face contact rate and its potential application to predicting respiratory tract infection. *J Occup Environ Hyg* 2008; 5:347–352.
2. Haas, CN, Rose JB, Gerba CP. *Quantitative Microbial Risk Assessment*. 2nd ed. New York, NY: John Wiley; 2014.

Ansari SA, Sattar SA, Springthorpe VS, Wells GA, Tostowaryk W. Rotavirus survival on human hands and transfer of infectious virus to animate and nonporous inanimate surfaces. *J Clin Microbiol* 1988; 26:1513–1518.

Lopez GU, Gerba CP, Tamimi AH, Kitajima M, Maxwell SK and Rose JB. Transfer efficiency of bacteria and viruses from porous and nonporous fomites to fingers under different relative humidity. *Appl Environ Microbiol* 2013; 79:5728-5734.

Rusin, P, Maxwell S, Gerba, CP. Comparative surface-to-hand and ginger-to-mouth transfer efficiency of gram-positive bacteria, gram-negative bacteria, and phage. *J Appl Microbiol* 2002; 93: 585-592.

Gwaltney J. Rhinoviruses. In: Evans AS, Kaslow, RA. *Viral Infections of Humans*. Plenum, New York, NY. 2012: 815-838.

McInosh, K. Respiratory syncytial virus. In: Evans, AS, Kaslow, RA. *Viral Infections of Humans*. Plenum, New York, NY. 1997: 691-711.

Zhao J, Eisenberg JE, Spicknall IH, Li S, Koopman JS. Model analysis of fomite mediated influenza transmission. PLOS ONE <https://doi.org/10.1371/journal.pone.0051984>. Published 2012. Accessed February 6, 2021

Bradburne, AF, Bynoe, ML, Tyrrell DAJ. Effects of a “new” human respiratory virus in volunteers. *Br Med*. 1967;J.3:767-769.

Richard, M, Oko A, de Meulder et al. SARS-CoV-2 is transmitted via contact and via the air between ferrets. *Nature Comm.* 2020;11:3496 |doi.org/10.1038/s41467-020-17367-2.

1. [↑](#endnote-ref-1)
2. [↑](#endnote-ref-2)
3. [↑](#endnote-ref-3)
4. [↑](#endnote-ref-4)
5. [↑](#endnote-ref-5)
6. [↑](#endnote-ref-6)
7. [↑](#endnote-ref-7)
8. [↑](#endnote-ref-8)
9. [↑](#endnote-ref-9)