Bacterial transfer from a contaminated door panel surface to an artificial finger pad.

UK Health Security Agency

Emma Crabtree[a], Ailbhe Barry[a], Richard Thomas[b], Jack Vincent[b], Maurice Walker[b], Merlin Etzold[b], Tom Slatter[c] and Ginny Moore[a]

[a] Biosafety, Air and Water Microbiology Group, UKHSA, Porton Down, Salisbury, UK
[b] Defence, Science and Technology Laboratories, Porton Down, Salisbury, UK
[c] University of Loughborough, Loughborough, UK

INTRODUCTION

Fomite transfer, the transmission of infectious agents from microbe-colonised inanimate objects to a new host, is a primary route of disease spread and contaminated surfaces may play an important role in the transmission of respiratory and gastrointestinal diseases.

Surfaces can become contaminated in a variety of ways: directly e.g. via particles expelled from the nose or mouth of infected individuals when they cough or sneeze or indirectly via hands if, for example, interventions such as effective hand-washing practices are not observed after using the toilet.

Multiple factors influence the risk of fomite transmission such as frequency of cleaning/disinfection, the type of bacteria/viruses present, the minimal infective dose of the pathogen, ambient temperature and humidity and the properties of the surface material[1] (non-porous materials transmit microbes more efficiently[1].

Many high-touch surfaces, such as door handles, keyboards, and mobile phones have been shown to harbour microbes, acting as potential intermediaries in the spread of disease. Fomite transmission is particularly relevant within the healthcare setting and numerous hospital acquired infections have been linked to contaminated fomites[2]. This study aimed to determine the extent of bacterial transmission from contaminated door panels to fingertips and the impact of surface material and inoculum.

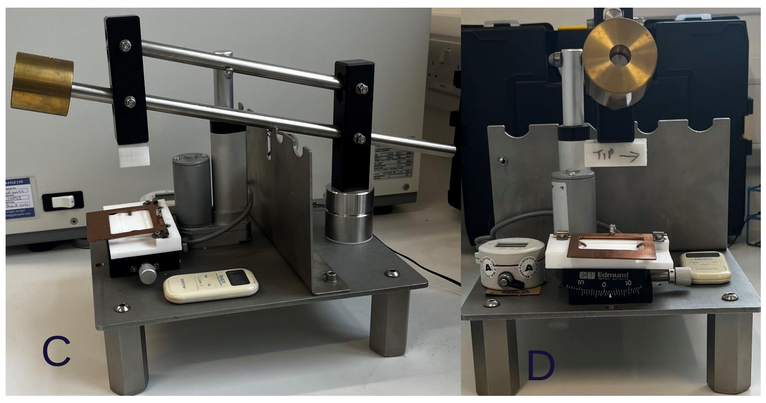

Figure 2: Contact rig. Side profile (C) and front profile (D) of contact transfer rig. AFP (*figure 1)* is attached to the magnetic holder on the arm which is operated manually by a switch resulting in a fixed 15N contact. The coupon is held in place on the stage.

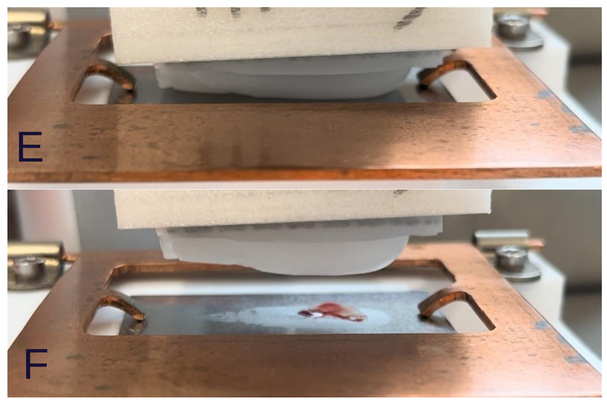

Figure 3: Contact event. Image of the contact event occurring (E) and after the contact (F) when BG suspended in blood was used.

METHODS

Artificial Finger Pads (AFP; Figure 1) were used to help standardize the contact event, specifically the recipient surface. Made using Degassed Dragon-Skin™ FX-Pro Silicon, the AFPs were modelled using the index finger of one of the research team. Four coats of artificial sebum (Verulam Scientific Ltd) were applied at the beginning of each experiment to simulate the natural secretions on a human finger.

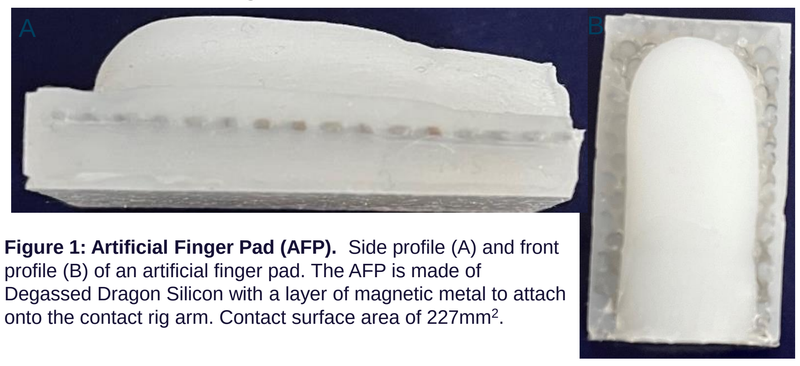

Figure 1: Artificial Finger Pad (AFP). Side profile (A) and front profile (B) of an artificial finger pad. The AFP is made of Degassed Dragon Silicon with a layer of magnetic metal to attach onto the contact rig arm. Contact surface area of 227mm^2.

A contact rig (Figure 2) incorporating a mechanical arm (to which a sterile AFP was magnetically attached) was operated via a switch[3]. This facilitated contact (15N for 1-second) between the AFP and test surface (material coupon (12.5cm^2); Figure 3). Test materials included stainless steel (SS), plain aluminium (PA) and satin aluminium (SA) door push-panels (Figure 4). Prior to each contact event, the material coupon was inoculated with 5µl (~2.25 x 10^7 CFU) *Bacillus atrophaeus* (BG), a stable, spore-forming bacteria. Spores remaining on the coupon and those transferred to the AFP were recovered by vortexing in 10ml diluent (Figure 5) before a 24-hour 37^{o}C incubation on TSA (Tryptic Soya Agar).

BG was also suspended in various organic and inorganic solutions: saline, PBS, nutrient broth, a low-nutrient medium (0.001g/ml tryptone), defibrinated horse blood and artificial saliva (Sigma-Aldrich). Water was used as a control. Stainless steel coupons were inoculated with each bacterial suspension and left to dry for 0, 5, 10, 14, 18, 22, 26, and 30 minutes. At each timepoint, the coupons were contacted with an AFP and BG recovered as above.

RESULTS

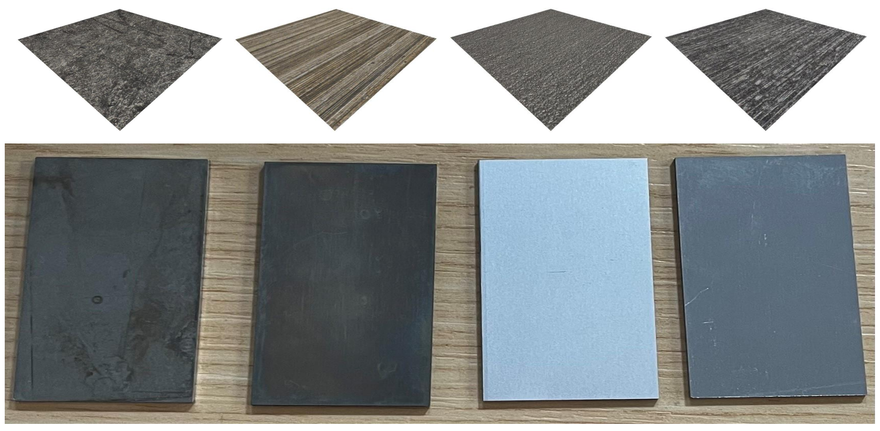

Figure 4: Test materials with corresponding Alicona™ surface images. Stainless steel (control surface), and coupons (12.5 cm^2) laser cut from stainless steel, plain aluminium and satin aluminium commercially available door push-panels.

Figure 5: AFP and SS coupon following a contact event. Photograph of an AFP in a Falcon™ tube with 10ml recovery diluent after contact with a stainless-steel control coupon contaminated with BG suspended in defibrinated horse blood.

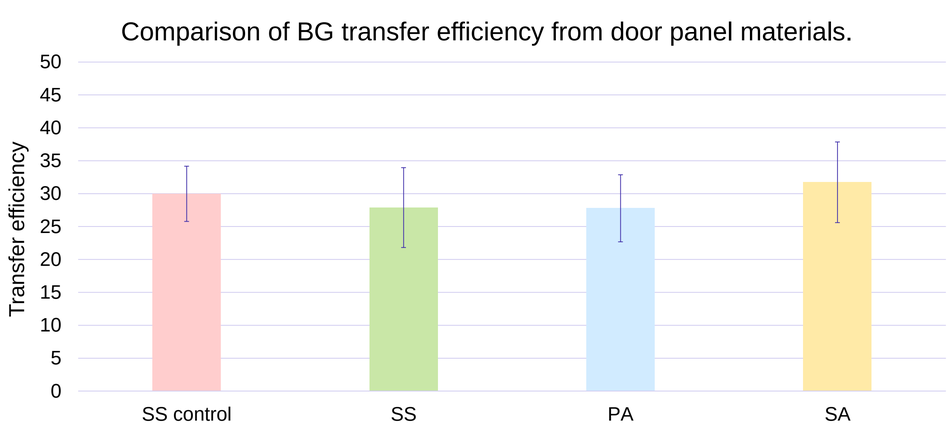

Figure 6: Transfer efficiencies from different metal coupons. Mean transfer efficiency of BG following contact between a sterile AFP and different test materials. Error bars show standard deviations. N = 10 contact events per material. A stainless-steel control was used alongside coupons of stainless steel (SS), plain aluminium (PA) and satin aluminium (SA) laser cut from commercially available door push-panels.

Transfer efficiency (TE) was calculated as a percentage: (BG CFU recovered from the recipient / CFU of the recipient + donor) *100.

<u>Impact of surface material.</u>

- When the contact event occurred **immediately** following surface inoculation (Time 0), surface material had no statistically significant effect (p=0.3) on transfer efficiency (TE; Figure 6).
- Mean (n=10) transfer from the stainless-steel control surface to AFP was 31.4% ± 12.0 (Figure 4). This was significantly lower (p = 0.00029) than the mean transfer (n=10) from AFP to the surface (65.7% ± 15.9), highlighting the importance of effective handwashing techniques and effective surface cleaning and disinfection.

<u>Impact of inoculum</u>

- Immediately following inoculation, the mean transfer efficiency of BG when suspended in blood was 43.1%. This reduced to 0.21% 30 mins after surface contamination (Figure 7). In contrast, mean transfer efficiency of BG, when suspended in artificial saliva increased from 22.6% (Time 0) to 33.6% (30 min)
- The transfer efficiency of BG was not influenced by nutrient concentration. When suspended in nutrient broth, TE was observed to decrease >18 mins after surface contamination (Figure 8). A similar trend was observed when BG was suspended in a low nutrient medium
- When BG was suspended in solutions with similar properties (saline and PBS), transfer efficiencies were also similar (Figure 9).
- Whilst differences were observed, suspending medium had no statistically significant effect upon transfer efficiency.

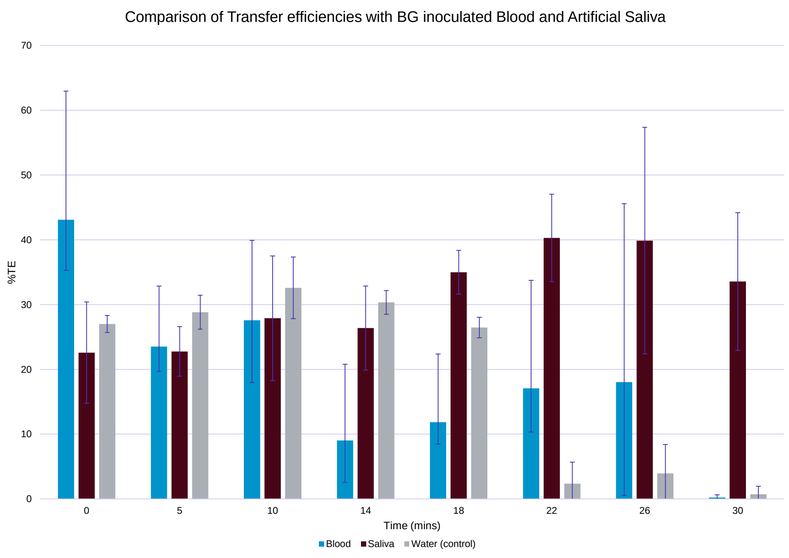

Figure 7: Mean (n=3) transfer of BG when suspended in blood and artificial saliva. Error bars represent the standard deviation. Transfer efficiency was assessed over time (i.e. as time from surface contamination increased).

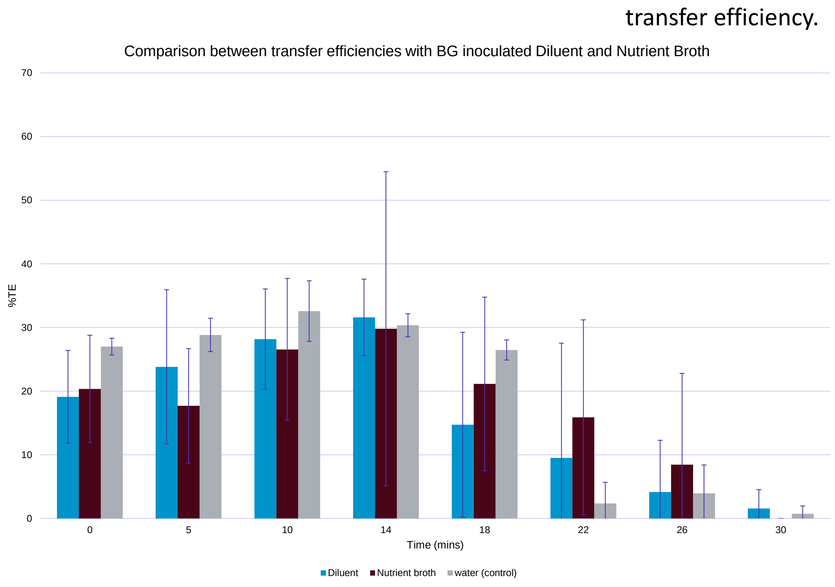

Figure 8: Mean (n=3) transfer of BG when suspended in a low- and high nutrient (NB) medium. Error bars represent the standard deviation. Transfer efficiency was assessed over time (i.e. as time from surface contamination increased).

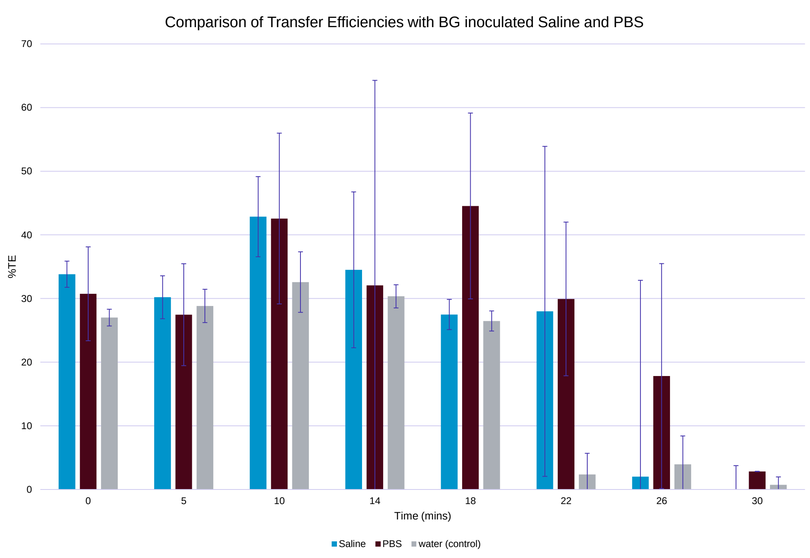

Figure 9: Mean (n=3) transfer of BG when suspended in saline and PBS. Error bars represent the standard deviation. Transfer efficiency when contact was assessed over time (i.e. as time from surface contamination increased)..

CONCLUSIONS

- The contact rig used in this study allowed standardised 15N contact events to occur. However, variability was introduced elsewhere within the study protocol (e.g. sample processing) and whilst differences in TE were observed (Figs 7-9), variation within the data meant these differences were not statistically significant. Future work will incorporate a greater number of biological and technical repeats.
- The mean TE between AFP and different surface materials was based on 10 replicate samples. Variability was reduced (Figure 4) and no statistically significant differences were observed suggesting that the transfer of spores from a recently contaminated door push-panel to hands would be similar regardless of surface material.
- The time for the inoculum to visibly dry differed with suspending medium. BG is environmentally stable and the reduction in observed TE, which, in general occurred > 20 minutes after surface inoculation, likely resulted from increased surface adsorption rather than losses in viability. Artificial saliva may not adsorb as readily to surfaces.

REFERENCES

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