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Groves, J., Church, H.R. orcid.org/0000-0003-0455-9576, Holland, D. et al. (1 more author) (2017) Reducing the risk of mouth to mouth transmission of pathogens via reusable, machine-read, parking tickets. An observational cohort study. Journal of Hospital Infection, 97 (4). pp. 430-432. ISSN 0195-6701

https://doi.org/10.1016/j.jhin.2017.05.027

Reducing the Risk of Mouth to Mouth Transmission of Pathogens Via Parking Ticket Machines. An observational cohort study

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Competing interests: All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

The study was not externally funded.

Abstract

Like many others, our hospital staff carpark is accessed using ticket-reading machines. During our study we initially observed 598 staff members entering the carpark, 21.6% of whom put their reusable parking ticket in their mouth. Using UV dye we successfully demonstrated card-to-card cross-contamination, however swabs of the ticket machine only yielded non-pathogenic coagulase negative *Staphylococcus* and a *Bacillus* species.

After placing a poster on the ticket-reading machine highlighting this potential infection risk, a further 1366 observations resulted in a statistically significant and persistent decline in the proportion of staff putting their carpark tickets in their mouths ($p<0.001$).

Introduction

During respiratory and enteric viral infections, large quantities of virus are present in bodily secretions. Subsequent transmission can be classified as direct, droplet, airborne or indirect. (1) The latter includes an intermediary such as unwashed hands or an inanimate object known as a fomite. A recent study into fomite-mediated influenza transmission showed that frequently touched small surfaces (such as door handles) exceeded that of the more apparent droplet-contaminated routes (coughing, sneezing). (2)

Whilst queuing for the hospital staff carpark, one of the authors noted that some members of staff held their parking tickets in their mouths. At the barrier, the ticket was fed into the machine, which read the ticket using a series of rollers, before being subsequently returned to the user. Some drivers then put the ticket back into their mouth. This observation led the author to question the potential role of such behaviours as a possible route of infection transmission between carpark users.

A literature search on the topic returned only 3 papers. These suggested that microbiological contamination of ATM key pads in Nigeria was significant. (2,3,4) A web only elicited a reference to a chewing gum company who had observed that drivers entering carparks put tickets in their mouths and produced a mint flavoured ticket as an advertising campaign (5).

We hypothesise that multiple-use parking tickets and the ticket machine have the potential to act as fomites and promote infection transmission.

The research questions for this study were:

1. What proportion of staff put their parking tickets into their mouths before and after using a ticket machine controlling entry to a carpark?
2. If putting parking tickets in the mouth is prevalent, would an educational intervention reduce it?
    a. If so, by how much?
    b. Is this reduction maintained over the observation period?
3. Can the parking ticket act as a fomite?
4. Can bacteria or viruses be isolated from the parking machines?

Methods

The Chesterfield Hospital Local Research Committee reviewed the study protocol and deemed ethical committee approval was not required. The study was not externally funded.

Hospital staff were observed entering a carpark as they arrived at work on six mornings (2 pre-, and 4 post-intervention). The staff were blind to the study. The observers recorded whether a driver put their carpark entry ticket in their mouth before, after or both before and after using the ticket machine. For statistical analysis purposes, both pre-intervention observations were combined into a single variable. The first two post interventions observations were on consecutive days, and were treated analytically as a single observation. The fifth and sixth observation points were individual days.

The hospital Infection Control Team attached posters highlighting the risk to the ticket machines for seven days prior to first set of post-intervention observations and they remained on display for duration of the study.

Pre-post intervention observations were compared using unadjusted Chi-squared tests and Chi-squared tests for trend. Statistical analysis was performed using SPSS version 24 (IBM).

A non-toxic dye visible only under ultraviolet light (Deb UV glow cream and Deb UV glow powder, Deb Group, Denby, Derbyshire UK) was used to demonstrate the ticket machines' capacity to act as a fomite. A carpark ticket was coated with dye and fed into the machine. A second and third ticket, uncoated with dye, were subsequently fed into the machine to check for cross contamination. A control ticket carried by the operator excluded contamination from sources other than the machine.

Swabs were taken from the ticket slot for bacterial and viruses (influenza A and B were prevalent in the local population at the time).

Results

Table 1 displays the raw data for total pre- and post-intervention observations. Table 2 displays the sequential data results across the post-intervention observation period.

Table I. Raw data for pre and post-intervention observations of carpark users' behaviours.

	Number of cars entering car park	Number (percentage) of individuals putting tickets in mouth (before and/or after ticket machine)	Number (percentage) of individuals putting tickets in mouth before AND after ticket machine
Pre-Intervention	598	129 (21.6%)	61 (10.2%)
Post-intervention (Total)	1366	120 (8.8%)**	43 (3.1%)**

***Statistically significant reduction compared to pre-intervention data, p<0.001*

Table II. Raw data for individual post-intervention data collection observations of carpark users' behaviours.

Post-Intervention (Broken down into data collection stage)	Number of cars entering car park	Number (percentage) of individuals putting tickets in mouth (before and/or after ticket machine)	Number (percentage) of individuals putting tickets in mouth before AND after ticket machine
Post- Intervention 1 (+8 and 9 Days)	667	80 (12.0%)	33 (5%)
Post Intervention 2 + 22 Days	370	27 (7.3%)$^{\otimes}$	9(2.4%)$^{\otimes}$
Post Intervention 3 +43 Days	329	13 (4.0%)$^{\otimes}$	1 (0.3%)$^{\otimes}$

$^{\otimes}$ *Statistically significant trend reduction across three data collection points, p<0.001*

21.6% of carpark users put their tickets in their mouths.

The overall impact of the intervention was measured using Chi-squared tests to compare pre-intervention and total post-intervention data. The percentage of drivers putting their tickets in their mouths *before AND/OR after* the ticket machine fell by 12.8%. This relationship was statistically significant (X^2 (1, N = 1964) = 61.43, p<0.001). The odds ratio demonstrates that post-intervention, carpark users were 65.0% less likely to put their ticket in their mouths (95% CI 54.1-73.3%). Similarly, a statistically significant reduction of 7.1% was also observed regarding the subset of people specifically putting their ticket in their mouth *before AND after* the barrier, (X^2 (1, N = 1964) = 41.25, p<0.001).

To conclude whether the presence of the intervention poster remained effective we performed a Chi-squared test for Trend. Both data sets (ticket in mouth before AND/OR after machine and placing ticket in the mouth before AND after machine) showed a statistically significant reduction. (X^2 for trend (2, N = 1366) = 19.02, p<0.001) and X^2 for trend (2, N = 1366) = 16.39, p<0.001, respectively).

Swabs from the ticket machine slot yielded bacterial growth of a coagulase negative *Staphylococcus* and a *Bacillus* species. The viral swab tested negative for respiratory viruses. The control ticket revealed no contamination from other sources.

Dye, coated onto the surface of a ticket and fed into the machine, contaminated the next two clean tickets fed into the machine. The control ticket was uncontaminated.

Figure 1: Dye transferred onto clean ticket. Figure shows the first ticket inserted and retrieved from the machine following the insertion of a contaminated ticket, front & rear view.

Discussion

We have demonstrated that a significant proportion of carpark users put machine read tickets into their mouths and that this behaviour can be modified by placing a poster on the machines. In addition, our results suggest that the poster not only maintained its effect in deterring carpark users to put their ticket in their mouths, but continued to improve this behaviour throughout the observation period.

The ultraviolet dye coated tickets demonstrate that ticket machines requiring the driver to retain and reuse tickets may act as fomites. Although we only isolated non-pathogenic organisms during the study these did include skin flora. This suggests that it would be possible to isolate the more pathogenic *Staphylococcus aureus* (or even MRSA), should a colonized individual use the machine. The failure to detect viruses was perhaps not surprising as the sensitivity of the test used when intended is only 50 to 70%.

Why do individuals, particularly health care workers, behave in this fashion? The behaviour is likely to be controlled subconsciously: Locating the ticket while queueing and then holding it in the mouth frees both hands for driving and operating the window. This avoids a delay at the barrier albeit it by a small amount. This speeds access and, perhaps more importantly, prevents irritation of the next driver in the queue.

It is gratifying to see that the behaviour, once confronted, can be substantially reduced. The poster is now displayed on ticket machines in all staff carparks.

Study Limitations

Sampling on different days may have surveyed two different populations. Healthcare has a significant shift working component and change of staff will have occurred. The observers may have been seen and altered carpark users' behaviour. This study measured a short-term outcome and therefore longer-term behavioural change, in the absence of a local aid memoir is questionable: If the poster is taken down, does behaviour immediately revert to that of the pre-intervention?

Although the microbiological results for the ticket slot samples were positive for coagulase negative *Staphylococcus* and a *Bacillus* species, these were not grown from the swabs of the tickets themselves and the risk therefore remains theoretical

Further Work

Despite the success of the poster, risk prone behaviour persisted. Other interventions highlighting the risk, such as infection control seminars or even making tickets that have an unpleasant taste,

may reduce the incidence further. The gold standard though is likely to be use of contact-free, carpark access.

Conclusion

This study demonstrates that hospital carpark machines may act as fomites and present a risk of cross infection between carpark users. The intervention in this study provides evidence that a simple, cost-effective educational intervention can significantly reduce this risk.

It is likely that the practice of putting parking tickets in one's mouth is prevalent not only in other healthcare premises, but in other industries and therefore and these results are generalisable to similar machines that read multiple-use tickets. Further work in this area is needed to investigate means of reducing infection risk between staff members or identify alternative designs of healthcare premises which reduce this to zero.

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Acknowledgements:

Michael Collins, Senior BMS in Microbiology; Clare Dawson, Deputy Library Services Manager.

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