

Elevator Buttons as Unrecognized Sources of Pathogen Exposure in Hospitals

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ABSTRACT

Background: Elevators are ubiquitous and frequently accessed inside hospitals, thereby potentially facilitating bacterial transmission. The objective was to estimate the prevalence of bacterial contamination on elevator buttons in large urban teaching hospitals.

Methods: A total of 120 elevator buttons and 96 toilet surfaces were swabbed over separate intervals from three separate tertiary care hospitals on weekdays and weekends in Toronto, Canada. For the elevators, swabs were taken of two interior buttons (ground floor, randomly selected floor) and two exterior buttons (“up” button from ground floor, “down” button from randomly selected floor). For the toilets, swabs were taken of the exterior entry door handle, privacy latch, toilet flusher, and interior handle of the entry door. Samples were obtained using standard bacterial collection techniques followed by plating, culture, and speciation by a technician blinded to sample source.

Participants: Passenger elevators that serviced the main hospital floor, connected to the majority of patient floors, and were frequently used. Toilets were those located nearest to the participating elevators.

Results: The contamination rate for the elevator buttons was 61% (confidence interval: 52 to 70). No significant differences in contamination rates were apparent between the location of buttons, day of the week, and panel position. Coagulase-negative staphylococci were the most common organisms cultured, whereas *Enterococcus* and

Pseudomonas species were infrequent. Elevator buttons had a significantly higher contamination rate than toilet surfaces (61% vs. 43%, $p = 0.008$).

Conclusions: Hospital elevator buttons are contaminated by bacteria. The risk of pathogen transmission might be reduced by simple countermeasures.

INTRODUCTION

Hospital acquired infections are a substantial cause of morbidity and mortality [1,2]. Even brief exposures to a hospital emergency department, for example, can increase the risk of a subsequent infection [3]. A variety of inanimate objects including white coats, computer keyboards, mobile cellular telephones, medical stethoscopes, adhesive tape, ultrasound transducers, and radiographic equipment harbor bacteria [4,5,6,7,8,9,10,11]. These studies typically identify contamination by common skin bacteria such as coagulase-negative staphylococci [5,6,8,9,10]. Surface contamination has also been implicated in the propagation of drug resistant bacteria during outbreaks of nosocomial-acquired infections [12,13]. Moreover, bacteria can persist on inanimate objects for days [14].

The risk of nosocomial infections from inanimate objects extends beyond bacteria. For example, the coronavirus responsible for the severe acute respiratory syndrome and noroviruses responsible for gastroenteritis can persist on environmental surfaces for as long as 4 and 7 days, respectively. Both pathogens were found on surfaces and other fomites of the health care institutions where outbreaks occurred [14,15,16]. Parasites including *Pediculosis capitis* responsible for human head lice and fungi including *Rhizopus microsporus* responsible for mucormycosis are additional examples of organisms that may persist on and be transmitted by inanimate objects [17,18].

We hypothesize that hospital elevator buttons may be an additional under-recognized site of microbial contamination. In a community setting at a single American

university, for example, bacteria were present on 30% of elevator buttons [19]. The corresponding frequency of contamination in hospitals has not been described. If present, such contamination creates the potential for pathogen transmission given the ubiquity of elevators in large hospitals, the necessity of using the buttons to operate the device, and the repeated contact by diverse individuals (patients, visitors, administrators, and health professionals). The objective of this study was to estimate the prevalence of bacterial contamination of elevator buttons inside large teaching hospitals.

METHODS

Study Setting

Three large urban teaching hospitals were included in the study. All were located in Toronto, Ontario, Canada and together represented a combined 1,490 acute inpatient hospital beds (range: 353 to 677). Eligible elevator groups selected for inclusion were those connected to the majority of patient floors, opened to the main floor of the hospital (defined as the street level), considered the most traveled as judged by the hospital information desk service attendant, and available for use to patients, visitors, and health care professionals. The research ethics board of Sunnybrook Health Sciences Centre approved the study. This project was supported by a Canada Research Chair in Medical Decision Sciences, the Canadian Institutes of Health Research, and the University of Toronto, Faculty of Medicine. The funding organizations had no role in the design or conduct of the study; collection, management, analysis, or interpretation of the data; and preparation, review, or approval of the manuscript.

Collection Strategy

At each hospital, four elevator buttons were swabbed daily for the presence of bacteria on ten separate days from November 5, 2012 to November 21, 2012. Specimens were collected in the mid-morning from Monday to Wednesday so that each sample could be incubated for 48 hours. To ensure a robust sampling strategy, one weekend day (Sunday) was additionally included. All samples were collected by a single individual with training in microbial collection techniques (CEK) [20,21].

Specimens

Individual elevator buttons were swabbed in a standardized fashion using a sterile single-use Copan Transystem Culture Swab and Transport System [22]. The dry swab was removed from the sterile packaging and immediately employed to swab the entire surface of one button for 2-3 seconds in a continuous motion while rotating the tip. A total of four elevator buttons were swabbed; two exterior buttons and two interior buttons. Specifically, the exterior “up” button outside the elevator on the main floor, the exterior “down” button on a randomly selected upper-level floor, the interior “number” button to travel to the same upper floor, and the interior “ground” button to return to the main floor. These four specimens were collected from each hospital each day.

Randomization

A random number generator from Apple’s App Store (“Undecided”) that used the Lehmer Algorithm was employed to select a random upper floor destination at each hospital. To do so, each day one of us (CEK) activated the random number generator when approaching the elevators to determine which destination floor to select at each

hospital. As there were two potential interior button panels and two potential exterior button panels to be swabbed at each site, an additional randomization was undertaken to determine the side swabbed by activating the same random number generator application. This process was repeated every day during the study period. No failures of randomization occurred, no samples were missing, and the completion rate was 100%.

Control Comparison

For perspective, as a comparison we returned to the same hospitals at a subsequent interval to sample public toilets closest to the study elevators and used the same techniques to evaluate for bacterial contamination. Four toilet surfaces from the men's bathroom were swabbed over eight separate days from March 17, 2013 to March 27, 2013. Collections occurred daily from Sunday to Wednesday following the same time constraints for sample processing. From each toilet, swabs were taken from the exterior entry door handle, stall privacy latch, toilet flusher, and interior entry door handle. When more than a single toilet was available, a randomization was undertaken to determine which destination stall to swab. When the toilet flusher mechanism was automatic, we substituted the next nearest manually operated toilet. No failures of randomization occurred and the completion rate was 100%.

Specimen Processing

Specimens were maintained at room temperature for a maximum of two hours until the daily collection was completed, after which the samples were stored at 4°C until cultured. Each specimen was inoculated separately on Blood Agar and MacConkey Agar

followed by aerobic incubation at 37°C for up to 48 hours. Plates were examined daily for two sequential days and the organisms grown were identified to the genus level at a minimum. The organisms that were specifically assessed included *Staphylococcus aureus*, coagulase-negative staphylococci, *Streptococcal* species, *Pseudomonas* species, enterococci, diphtheroids, coliforms, or other miscellaneous organisms. Neither Gram stain nor growth quantification was undertaken. Susceptibility testing was reserved for detection of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococcus (VRE) using the polymerase chain reaction for the *nuc*, and *mec* genes for MRSA, and *vanA* and *vanB* genes for VRE [23,24]. We did not perform any advanced cultures for lack of feasibility. All samples were cultured and characterized by the same trained laboratory technician unaware of study hypothesis and swab origin.

Statistical Analysis

The primary study outcome was the prevalence of bacteria on elevator buttons. Statistical analysis used a two-tailed chi-square test to assess for significant differences in contamination rates between the interior buttons and exterior buttons as the primary comparison. Pre-specified secondary analyses compared left and right elevator panels, days of the week, and each individual hospital. Analogous statistics were replicated for the control toilets with a pre-specified secondary analysis comparing the four surfaces (exterior entry door handle, individual privacy latch, toilet flusher, and interior entry door handle). All p values were two-tailed and calculated using StatView version 5.0 from SAS Institute Incorporated with 0.05 defined as the threshold of statistical significance.

RESULTS

A total of 120 elevator buttons were swabbed during the study interval. This represented a 100% completion rate, of which 90% were collected on weekdays and 10% on weekends. Specimen collection was evenly distributed by hospital and date. The most common randomized elevator destination was the ninth floor at Hospital 1, the ninth floor at Hospital 2, and the third and fourth floors at Hospital 3. Approximately 49% of the swabbed elevator buttons were located on the left side panel. No adverse events or service disruptions occurred during the study.

A total of 73 samples from the 120 cultures showed microbiological growth. This was equivalent to a contamination rate of 61% (95% confidence interval: 52 to 70). The most common organisms cultured were coagulase-negative staphylococci, followed by *Streptococcus* species (Table 1). The distribution of coagulase-negative staphylococci was relatively even across the buttons swabbed while *Streptococcus* species and coliforms were predominately isolated from the interior elevator buttons. One elevator button grew *Pseudomonas* species, two grew *Enterococcus* species, and another grew a fungus. No *Staphylococcus aureus*, MRSA, or VRE were identified.

*** Table 1 About Here ***

We found no statistically significant difference between the interior and exterior elevator buttons in the contamination rate (60% vs. 62%, $p = 0.85$). The contamination rate varied significantly among the three hospitals (range 45% to 73%, $p = 0.034$). There

was no significant variation by day of the week (weekend vs. weekday, 60% vs. 58%, $p = 0.85$), side of the elevator swabbed (left vs. right, 58% vs. 65%, $p = 0.46$), or floor (street level vs. upper level, 57% vs. 65%, $p = 0.35$). Among the interior and exterior buttons, we found similar contamination rates between the main floor and the randomly generated upper floor (Figure 1).

*** Figure 1 About Here ***

Of the 96 toilet specimens, 75% were collected on weekdays and 25% on weekends. A total of 41 showed microbiological growth, equivalent to a contamination rate of 43% (95% confidence interval: 33 to 53). Toilet surfaces had a significantly lower contamination rate than elevator buttons (61% vs. 43%, $p = 0.008$). The contamination rate of toilets varied modestly among the four surfaces (range 29% to 54%, $p = 0.474$). We observed no significant variation by day of the week (weekend vs. weekday, 38% vs. 44%, $p = 0.551$). The three hospitals showed modest variability (range 25% to 53%, $p = 0.063$). Coagulase-negative staphylococci were the most frequently cultured organisms and the distribution of bacterial species was approximately even across the washroom surfaces. Four surfaces grew a fungus and one grew a *Pseudomonas* species.

DISCUSSION

We found that elevator buttons in three large urban hospitals were contaminated with bacteria typical of skin commensal organisms. When compared to prior research documenting prevalence rates of 30% at an American university [19], elevators in large teaching hospitals were more likely to be contaminated. Interior buttons were less contaminated than exterior buttons with the main floor button being the most heavily colonized, although these observed differences were not statistically significant. Individual hospitals varied somewhat, yet no hospital had a prevalence equal to community rates (Figure 1). Elevator buttons compared unfavorably to toilet surfaces, which had higher contamination rates than previously observed [25].

The majority of contaminating bacteria were of relatively low pathogenicity and we observed no MRSA or VRE. However, both *Pseudomonas* and fungi were cultured. Transmission of these pathogenic organisms could result in serious infections, especially in elderly or immunocompromised patients who often frequent hospitals. Although we observed a lower prevalence of contamination of elevator buttons when compared to computer keyboards [5] and ultrasound transducers [10], individuals are at a potential risk of cross contamination from elevator buttons because of the frequent use by diverse persons. In addition, an individual is more likely to come into contact with an elevator button or toilet than other inanimate objects in a hospital.

Our study has several limitations that merit emphasis. Sample collection occurred during the influenza season when patients and visitors may have been prompted toward

more hand sanitizer use. In addition, cold autumn weather may have increased the use of gloves that block the transmission of hand organisms. Sampling hospitals from a single geographic area may limit generalization and replication outside might be valuable. Swabbing the elevator buttons mostly on weekdays and in the mornings might have introduced additional bias if, for example, environmental cleaning varied. Additional bias might have occurred as a result of collecting toilet and elevator button specimens from two different seasons. Only specific bacteria were assessed thereby missing the possibility of contamination by other pathogens such as *Clostridium difficile*, viral respiratory pathogens, and enteric viruses. Smaller inocula of microorganisms may not have been detected because broth enhancement cultures were not used [20]. Together, these limitations may cause our study to underestimate contamination rates.

While many inanimate objects in a hospital harbor bacteria, elevator buttons represent a frequently encountered fomite because of their ubiquity and necessity of use. The enclosed environment and ongoing usage also tends to make disinfecting elevator buttons a challenge. Alcohol based hand sanitizers are effective for removing surface bacteria [26] and their strategic placement inside and outside elevators might attenuate some of the potential risk of pathogen transmission. Additional countermeasures include enlarging the buttons to allow for elbow activation or the adoption of touchless proximity sensors for button activation. A fourth approach to mitigate risk could be public education toward hand hygiene to improve rates of hand disinfection. This could be targeted to individuals exiting the elevators and visitors who tend to exhibit poor hand hygiene

practice [27]. Ultimately, an awareness of risk might spur greater attention throughout a hospital.

Author contributions: Two authors (CEK and DAR) had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors were involved in the study design, analysis and interpretation of the data and critical revision of the manuscript for intellectual content. Kandel was responsible for data acquisition and wrote the first draft of the manuscript. Redelmeier was responsible for statistical analysis and is the guarantor for the manuscript. Redelmeier and Simor were responsible for obtaining funding and study supervision.

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Table 1. Bacteria species cultured from elevator buttons and toilets.

Organism	Elevators (n = 120)	Toilets (n = 96)
Staphylococcus*	67 (56%)	35 (36%)
Streptococcus	11 (9%)	7 (7%)
Coliforms	10 (8%)	2 (2%)
Enterococcus	2 (2%)	0 (0%)
Pseudomonas	1 (1%)	1 (1%)
Miscellaneous†	2 (2%)	4 (4%)

Footnotes:

Data are count (% of total samples). The summation of the individual percentages for each column does not add up to the overall prevalence as each surface may have polymicrobial contamination.

*. Coagulase-negative staphylococci in all cases

†. Includes other gram negative bacilli and fungi

Figure 1. Contamination rates of elevator buttons (top panel) and toilets (bottom panel).

Footnotes:

Bargraphs of bacterial samples with positive growth from different surface locations. Top panel for elevators, bottom panel for toilets. Each individual bar has the corresponding 95% confidence intervals denoted by the solid line. From the bottom panel, interior refers to the inside handle of the entry toilet door while exterior refers to the outer handle.