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Relative Comparisons of User Hand Cleanliness Between New Technology (no touch) Public Restrooms and Older Technology Public Restrooms

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Abstract
It is the purpose of this experiment to see if the hands of individuals exiting newer technology public restrooms are cleaner than the hands of people exiting older technology public restrooms. Our hypothesis is newer technology public restrooms (NTPR) result in a greater overall degree of hand cleanliness when compared to the older technology public restrooms (OTPR).

This paper fulfilled W. M. Sherrill's Honor Contract for Honors Science. His faculty supervisor was Professor HM Seitz of Johnson County Community College.

Keywords
bathrooms, technology, sanitation

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Introduction:

Many if not all, Americans have had the privilege of using a public restroom. Whether that public restroom is in a restaurant, gas station, department store or a hospital, much to our chagrin, each has its own degree of cleanliness. For the past several years, public restroom technologies have been changing. Many newer public restrooms now employ, to varying degrees, electronically flushing commodes and urinals, electronic water faucets, electronic soap and paper towels dispensers or no-touch heated air hand dryers. Many studies have been conducted in, preschools, high schools and colleges which illustrate the effectiveness of handwashing in slowing the spread of infections.[1-3] In addition studies have been done to examine handwashing in hospital settings. Griffith et al. from his study of hospital settings suggest that, "hand contact surfaces might be implicated in the spread of micro-organisms"[4]. He also found that "33% of the contaminants on hand contact surfaces will be of microbial origin"[5]. While technology has been changing, little has been done to empirically examine the public restroom with respect to these new technologies and their overall effect on the cleanliness of the people using those facilities. It is the purpose of this experiment to see if the hands of individuals exiting newer technology public restrooms are cleaner than the hands of people exiting older technology public restrooms. Our hypothesis is newer technology public restrooms (NTPR) result in a greater overall degree of hand cleanliness when compared to the older technology public restrooms (OTPR).

We defined older technology public restrooms as: restrooms which had standard push to flush commodes and/or urinals, standard knob or handle faucet, touch to dispense soap dispensers and pull or crank paper towel dispensers, or push to turn on air hand dryers. In addition, our older technology restrooms had exterior doors.

We defined newer technology public restrooms as follows: restrooms which incorporate new technology (e.g. automated flush mechanisms for commodes and/or urinals, automated hand-washing facilities (automated no touch water faucets, automated no touch soap dispensers) and automated no touch paper towel dispensers or automated no touch blade style air hand dryers. In addition, our newer technology restrooms had switch back private entrances with no exterior doors.

Methods:

Prior to commencement of this project a proposal was submitted to and approved by the IRB (International Review Board) of Johnson County Community College (JCCC).

Study Design

This experiment was conducted at Johnson County Community College in Overland Park, Kansas between October and November 2009. Selection for test participants was by random request. Between class periods samples were collected randomly by selecting the first 20 willing participants entering a public restroom facility. We explained to each the participant the purpose of our experiment and all of the participants asked were willing to take part in our experiment. After explanation of the experiment, we collected one specimen per participant

using a sterile polyester-tipped applicator swab (Fisherbrand 6 inch Polyester-Tipped Applicators Cat No. 23-400-122 Distributed by Fisher Scientific Company L.L.C.). One swab was used to collect specimens from both hands of each participant. This was done to insure 1) an adequate sample was collected for analysis and 2) to factor out left or right handedness. Each sample was collected by swabbing proximally from the distal end of the index finger continuing along the interior portion of the index finger towards the thumb and then continuing along the thumb distally until reaching the distal termination of the thumb. The same process was then repeated on the participants opposite hand using the same swab. All participants were then instructed to use the facilities as they normally would, however we asked that each participant to wash their hands before exiting the restroom so as to get a true representation of participant facility interaction. Upon their exit each participant was swabbed again with a sterile cotton swab following the same procedure, so as to compare entry and exit levels of bacteria present on each participant's hands. Since the participants for this experiment were chosen randomly no personal data was required from the participants. However, correlation was necessary between the participants entering and exiting samples. This correlation was done at each of the four locations by verbally giving participants a number of 1 to 5 as they were being swabbed before entering. Other than this number no other personal data was given to or collected from the participants, and no record was made of this number other than was necessary for correlation of each participant's entry and exit sample.

The 20 participants tested were 10 females and 10 males. After explaining our experiment, 10 labeled swabs were collected from 5 female and 5 male participants outside of a newer technology public restroom immediately prior to entering. Ten swabs were again collected and correlated with the same participants upon their exit from the newer technology public restroom. The same was in turn completed for the older technology public restroom. After explaining our experiment, 10 labeled swabs were collected from 5 female and 5 male participants outside of an older technology public restroom immediately prior to entering. Ten swabs were again collected and correlated with the same participants upon their exit from the older technology public restroom. In addition to these collected specimens, 2 sterile swabs were labeled as controls to rule out the eventuality of possible contamination of swabs or media

Culture Conditions

These samples (along with the 2 controls) were then each placed aseptically into 5 ml of sterile Tryptic Soy Broth (TSB), a non-selective media and incubated at 37°C for 48 hours. A non-selective media was chosen to insure maximum bacterial growth from each sample.
After 48 hours of incubation at 37°C turbidity was observed in several of the samples however, controls remained unchanged. The swabs were then aseptically removed from each of the samples and autoclaved. Each of the samples were mixed to insure uniformity and then diluted according to the Standard Plate Count Method. Briefly, the dilution was done as follows: 0.05ml of sample was diluted into 4.95ml of TSB. Then 0.05mL was then taken from the first dilution and put into an additional 4.95ml of TSB resulting in a final dilution factor of 10^{-4}. Next, 0.1ml of the final dilution from each sample was plated respectively on 3 agar plates {1-Eosin Methylene Blue (EMB), 1-Manitol Salt Agar (MSA), 1-Nutrient Agar (NA) purchased from Remel, Lenexa, Kansas}and spread evenly across the media using a sterile spreader bar. Then the plates were incubated at 37°C for 48 hours. The 2 control plates showed no growth on any of the 3 plates (EMB, MSA, NA). Of the 120 plates 78 were enumerated using the standard plate count and the data recorded. However, 42 of the plates were found to be TMTC (too many to count).

The samples for these plates were then further diluted 0.05ml to 4.95ml of TSB giving a final dilution factor of 10^{-5}. These samples were plated again at 0.1ml on each of 3 plates (EMB, MSA, NA) and again spread evenly across the media using a sterile spreader bar. Then the plates were incubated at 37°C for 48 hours.
These 42 plates were then enumerated using the standard plate count and the data recorded.

Statistical Analysis

Statistical Error Bars were calculated using the following formula: Std. Error = $\frac{\text{Std. Deviation}}{\sqrt{\#\text{ of sample}}}$
The total number of samples equaled 10 (male = 5 / female = 5). Statistical calculations were made using Standard Deviation and Standard Error formulas in Microsoft Excel 2007.

Results

Before going into a discussion of the experimental data, it must be pointed out that there was a slight difference in the handling technique used for the swabbed samples gathered from participants using the older technology public restrooms and from participants using the newer technology restrooms. While it does not appear the handling differences contributed to a variation in our overall findings, a repeat of this experiment would suggest all swabbed samples be handled in identical fashion so as to eliminate an unnecessary potential variable. In this experiment the swabbed samples gathered from participants using the newer technology public restrooms were transferred within one hour to TSB media and then placed in directly into the incubator. Likewise, the swabbed samples gathered from participants using the older technology public restroom were transferred within one hour to TSB media. However, rather than being placed directly into the incubator, they were then refrigerated for 36 hours prior to being placed in the incubator. As suggested this may have introduced a slight variable.

A comparison of experimental the data as seen in figures 1 and 2 reveals an overall reduction in the number of bacteria present on the hands of participants leaving newer technology public restrooms. While data collected does not show a statistically significant reduction in the overall bacterial counts on the hands of participants using the newer technology public restrooms when compared to participants using older technology public restrooms, the data does suggest a strong trend that supports our hypothesis. Figure 1 shows a reduction in bacterial CFU/ml for participants using newer technology public restrooms while Figure 2 shows that bacterial CFU/ml actually increased for participants using older technology public restrooms.

While it is true that gram positive bacterial counts were reduced by older technology public restrooms as shown in figure 4. This is offset by a much greater number of gram negative bacteria acquired during the use of the same older technology public restrooms as seen in figure 3.

The data also suggests in fig. 4 that while there was a reduction in gram positive bacteria on the hands of participants using both older and newer technology public restrooms. There was a much smaller reduction in overall bacterial counts realized by participants using older technology public restrooms. This again suggests newer (no touch) technology in public restrooms benefits in greater bacterial reduction percentages.

By comparing fig. 5 and fig. 6, it can be seen that while both male and female participants both showed an increase of gram negative bacteria after using older technology public restrooms, the greater percentage of increase in gram negative bacteria is seen in fig. 5. In addition, a comparison of fig. 7 and fig. 8 shows when using older technology public restrooms male participants' hands showed less reduction in gram positive bacteria than the female participants' hands after using older technology public restrooms.

Statistical Charting of Results

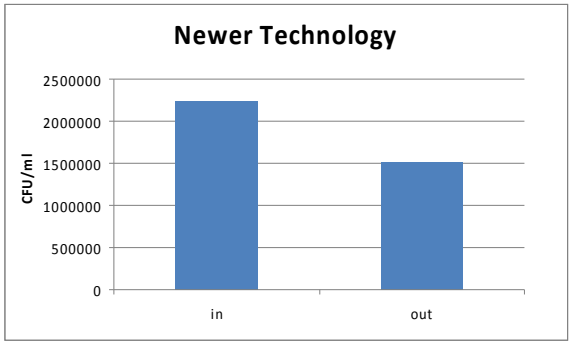

Figure 1

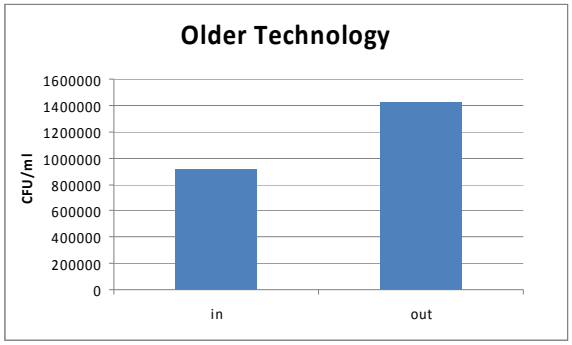

Figure 2

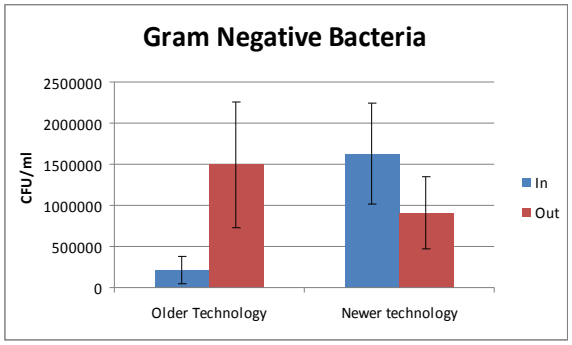

Figure 3

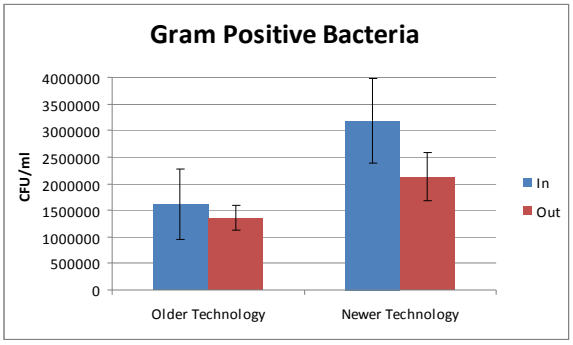

Figure 4

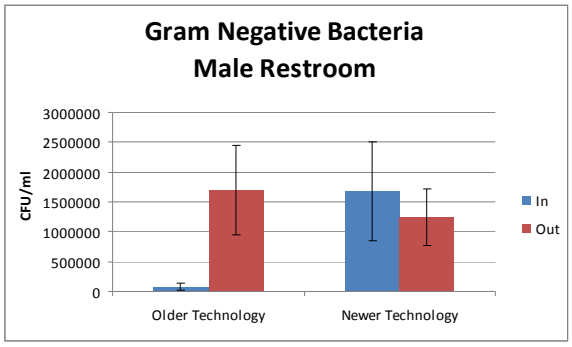

Figure 5

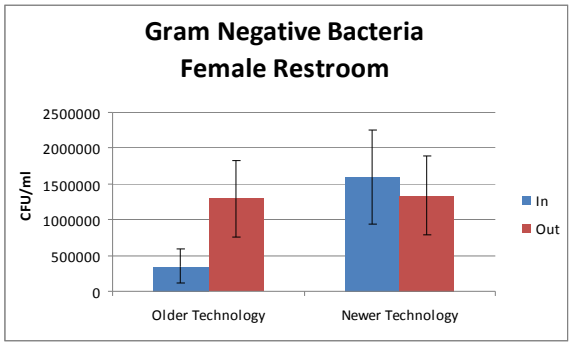

Figure 6

Statistical Charting of Results Continued

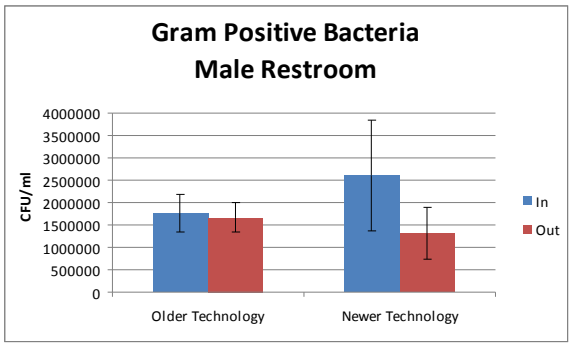

Figure 8

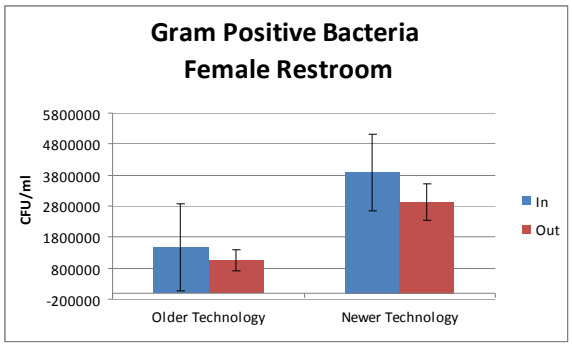

Figure 7

Discussion

While the experimentation data collected does support our hypothesis that newer technology public restrooms (NTPR) result in a greater overall degree of hand cleanliness when compared to the older technology public restrooms (OTPR) this data was not as statistically significant as we had expected.

While not directly relevant to this experiment, this research as it applies to JCCC, the particular test environment of this experiment, was raised. Why do the hands of participants entering the newer technology public restrooms have higher CFU/ml counts than participants entering older technology restrooms?

Another interesting aspect of the data found suggests that while the male participants' hands had higher levels of CFU/ml in 3 of 4 instances it was actually the male participants who showed the greatest level in CFU/ml reductions and therefore benefited most from the newer technology public restrooms.

Suggestions for further research

While our experiment demonstrated that newer technology restrooms do contribute a greater degree of overall hand cleanliness, we proposed to undertake that further study to more clearly determine the effect of the variable introduced by the use of an exterior door on a public restroom and its effects hand cleanliness. We also intend to study further the effects of stall doors with regards to the differences seen in benefits between males and females in the use of newer technology public restrooms.

As noted above further research is needed with regards to the JCCC environment so as to determine why the entry levels of CFU/ml on the hands of participants using the newer technology public restrooms are higher than those using the older technology public restrooms.

Our hypothesis was correct. Newer technology public restrooms do contribute to a greater degree of overall hand cleanliness when compared to older technology public restrooms. We acknowledge a multiplicity of variables in comparing the differences of or newer and older public restroom technologies. We also acknowledge the differing hand-washing techniques of individuals and their degree of hand-washing. However, the purpose of this experiment was to

determine the overall effects of restroom technology on hand cleanliness and therefore the data we collected suggests a clear trend. Having a newer technology public restroom significantly contributes to overall hand cleanliness to those who are using it.

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