Problem Statement

In 2013, a lifecycle and cost analysis was conducted in a university setting comparing high-velocity hand dryers and paper towels as hand drying options as part of a New York State Pollution Prevention Institute (NYSP2I) Research and Development Student Competition project. The results of the lifecycle analysis (LCA) showed that the hand dryer (Dyson Airblade™) had approximately 40% less of an environmental impact than paper towels. A payback period of 4.55 years was calculated for a 40-week academic year. Sustainability has a social component in addition to the environmental and economic aspects which must be considered. Investigating the social and health aspect of high-speed hand dryers as a hand-drying option is the purpose of the project this year.

Two follow-up studies were proposed to address the social concerns of implementing high-speed hand dryers. First, signage informing patrons of the negative environmental impacts associated with paper towel usage was proposed to determine user preference and the feasibility of future implementation. Second, microbiological impacts were determined to provide evidence that the Dyson Airblade™ will either maintain or improve exposure to potentially harmful microorganisms.

Project Summary/Background

Project Description. The project was conducted using two high-traffic bathrooms and two low-traffic bathrooms. A male and a female facility at both traffic scales were used. Each contained a Dyson Airblade™ and paper towel dispensers. The Dyson Airblades™ were connected to P4400 Kill–A-Watt™ power-recording meters. These meters recorded the total power usage of the hand-drying units. Two Omron H7EC Backlit compact totalizers collected the usage data. The totalizers counted each time a hand dryer started running. In the high-traffic bathroom, the

men's facility contained two paper towel push dispensers. The female facility contained one push dispenser. The low-traffic bathrooms contained one automatic paper towel dispenser each.

A survey conducted during the 2013 study indicated user acceptance of the high-velocity hand dryer was very low, approximately 35%, compared to a paper towel. These results were reinforced in published literature by Huang et al. (2012), which showed that less than 50% of the population uses air hand dryers when given a choice. Many users also expressed the concern that the Dyson Airblade™ may not remove microorganisms from washed hands as efficiently as paper towels. The review from Huang and colleagues (2012) was mixed on the health aspect; three studies found that hot or high-velocity hand dryers removed bacteria less effectively than paper towels, one study found better performance from hand dryers, and three found no difference between the hand drying options.

Potential slogans were considered on a survey for students to determine which slogan would be most effective at communicating our results about the sustainability of Dyson Airblades™. The slogans used different units of measure from the 2013 LCA to present carbon emission savings to students. Once the slogan was selected, it was visually represented as a creative sticker.

Similar to a bacterial study performed by Fawdar and Redway (2008), analyses of growth media were performed to investigate the presence or absence of bacteria on sampled contact surfaces in restrooms. A preliminary study was conducted utilizing universal growth media [Luria-Bertani (LB) agar] plates, and it was determined that bacteria generally are present on the contact points involved in the hand-drying process. The study also evaluated bacteria present on the door handles and light switches inside the restroom facilities to determine if bacterial exposure to hands is inevitable despite the hand-drying option chosen.

Environmental impacts will be assessed in pounds of waste, energy, and CO_2 equivalents reduced per year, general health effects, and the increase or reduction in colony-forming units (CFUs) of bacteria.

Innovation. Attitudes about hand drying are known. However, to our knowledge, no studies have been conducted independent of vendors to determine whether sharing of environmental benefits in an institutional setting will change attitudes about hand drying.

To date, microbiological studies on hand drying have been confined to health care professionals in clinical settings. The target audience is university students, faculty, and staff. The project team believes the work being performed is the first attempt to measure the effects of hand drying on the types and numbers of coliform and pathogenic bacteria in an institutional setting.

Relationship to Sustainability

Our previous NYSP2I project proved through LCAs that high-velocity hand dryers are a more sustainable option than paper towels based on energy use, environmental impact, and carbon footprint. For universities to realize these benefits, the hand dryer must be utilized by the student body, faculty, and staff. Signage will expose the university community to sustainability issues and promote the utilization of high-velocity hand dryers.

The bacteria study addresses another aspect of social acceptance and therefore another barrier to the realization of the sustainability benefits. Economic sustainability also is promoted when money is saved as paper towel use decreases.

Materials and Methods

Signage

Potential slogans for signs were presented on a survey for bathroom patrons to determine which slogan would effectively communicate the negative environmental aspects of using paper

towels. The slogans used different units of measure from the 2013 LCA to present carbon emission savings to bathroom patrons. Carbon emissions were converted to relatable units using the EPA's Greenhouse Gas Equivalencies Calculator. The surveys were gender specific to allow the most effective slogan to be implemented in each bathroom. The selected slogan for each gender was then graphically designed for eventual implementation in the high-traffic bathroom.

Bacteria Study

Preparing Media. Media facilitates the growth of bacteria present in samples taken. To prepare the growth media, 25 g of LB powder and 15 g of agar were added to 1 L of deionized. This solution was placed on a stir plate and mixed thoroughly until all solids were dissolved. Once thoroughly mixed, the jar was marked with autoclave tape and autoclaved for 15 minutes. The autoclave sterilizes the media and ensures that no bacteria were introduced to the LB agar. Following autoclaving, the LB agar was allowed to cool until it was safe to handle but still well above room temperature to ensure it remained in a liquid state for distribution into petri dishes.

Two team members working within a biosafety cabinet used pipettes to transfer the media into petri dishes. After the LB agar was allowed to solidify, the completed plates were flipped upside down and left in the biosafety hood overnight with a UV light on for final disinfection. The plates were refrigerated at 4°C for future use. LB agar plates were made as needed for various sampling dates.

Sampling. Sampling was conducted in the male and female bathrooms on the first floor of a low-traffic bathroom, and two different sets of restrooms in a high-traffic building. Plates were labeled with the sampling contact points, sampling locations, dates, media, and initials of the people who prepared them.

The sampling procedure involved 3 people for each collection. A propane torch was used as an open flame nearby the sampling locations to prevent any ambient bacteria in the air from contaminating the cotton swap or the LB agar. A sterile cotton swap was extracted from its package and immediately used to swipe the contact point. The swab was swiped in a zigzag pattern across the LB agar media. Used swaps were placed in a bag, which was later autoclaved prior to disposal.

The points of contact sampled in each of the high-traffic bathrooms included the front and back inner portions of the Dyson Airblade™, door handle, light switch, paper towel, and paper towel lever. The inner area of the Airblade™ was sampled, because this was thought to be the area most likely to be touched when a person is drying their hands. Both paper towel dispensers in the male were tested. One dispenser was located near the sinks and the other was on the wall towards the exit. Although two samples were taken at each location, only the first samples are reported. Results from the second samples are likely skewed, because bacteria had already been removed from the surfaces after the initial swabs were taken.

Sampling in the low-traffic bathroom was conducted on two dates with one sample taken for each contact point for each date. The men's bathroom door in the low-traffic restroom opened outward, so the rectangular metal push plate that was swiped. The paper towel dispensers were automatic so no paper towel lever was analyzed. During the first sampling date, the contact points sampled were the metal door plate (men's), door handle (women's), light switch, and the front and back inner portions of the Dyson Airblade™. Paper towel samples were excluded due to an insufficient number of LB agar plates. On the second sampling date, the paper towel dispenser sensor was sampled in the case of people accidentally making contact with it. Paper towels and the other points of contact tested on the first date also were included. Only the second

more complete sampling period will be reported. Based on the study design, it is necessary to have data comparing the Dyson Airblade™ hand dryer to paper towel dispensers in the same bathroom and on the same date.

Finally, additional samples were taken from paper towel handles in a second set of high-traffic bathrooms to provide a quality control check for the original samples obtained from the high-traffic restrooms.

Incubation. All samples were transferred to the lab for incubation. Dishes were placed with the lids up in an incubator set to 39°C. The first high-traffic restroom samples taken were originally placed in the incubator upside-down for the first 15 hours, but they were turned over for the remaining time of incubation due to the formation of condensation. The dishes were left at constant temperature for 23.5 hours, with pictures taken at 15 hours and 23.5 hours to evaluate bacterial growth. After incubation, the plates were stored at room temperature for another 22 hours prior to analyzing bacterial growth.

Analyzing Bacterial Growth. Plates removed from the incubator at various intervals were examined to detect the presence of bacteria. Plates were counted 45.5 hours after samples were first put in the incubator. The purpose of counting colonies is to estimate bacteria cell numbers. While CFUs do not quantify the amount of bacteria on a surface, they do qualitatively compare the abundance of bacteria on different surfaces relative to each other. Visible colonies were defined as small and opaque formations with discrete round morphologies. Larger colonies with blurry edges were assumed to be fungi or mold species and were not included in the CFU counts.

Results, Evaluation and Demonstration

Signage Results. Survey results indicated that participants identifying as female were influenced most by comparing the carbon emissions saved from using the Dyson Airblade™ to the uptake

of carbon from 130 trees. Users who classified themselves as male indicated that relating hand dryer carbon savings to car trips (5 trips from New York City to Los Angeles) would be most effective in a bathroom. The signs have yet to be implemented in a high-traffic bathroom due to issues involving data collection of baseline energy readings.

Figure 1 shows representative overall results for the signage survey. The survey question asked was: "Please choose the statement that would convince you to use the Dyson Airblade™ hand dryer over paper towels. Using this Dyson Airblade™ hand dryer for a school year...." Users were asked to pick their top three preferences. Cost savings and global climate change impacts were generally the least persuasive motivations.

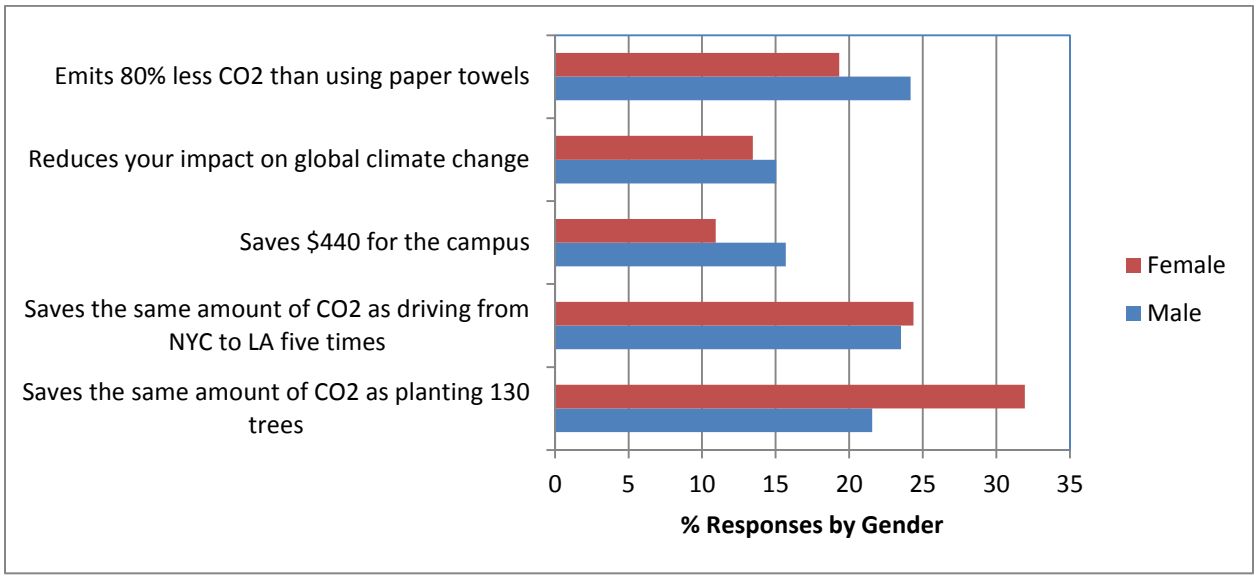

Figure 1: Signage Survey Results

Bacteria Study Results. Tables 1 and 2 display the bacteria counts for each high-traffic bathroom sample taken for the men's and women's bathrooms, respectively.

Table 1: Bacteria Counts on Contact Points in the Men's High-Traffic Restroom

Sample	Bacteria Counts (CFU)
Door Handle	2
Light Switch	0
Dyson - Front	20
Dyson - Back	21
Paper Towel Handle - Wall	31
Paper Towel Handle - Sink	108
Paper Towel - Wall	0
Paper Towel - Sink	0

Table 2: Bacteria Counts on Contact Points in the Women's High-Traffic Restroom

Sample	Bacteria Counts (CFU)
Door Handle	2
Light Switch	0
Dyson - Front	1
Dyson - Back	9
Paper Towel Handle	139
Paper Towel	4

Table 3 illustrates the bacteria counts on the paper towel handle samples from the second set of high-traffic men's and women's bathrooms.

Table 3: Bacteria Counts on Contact Points in Second Set of High-Traffic Restrooms

Sample	Bacteria Counts (CFU)
Men's Paper Towel Handle	142
Women's Paper Towel Handle - Sink	91
Women's Paper Towel Handle - Wall	222

Table 4 depicts the bacteria counts on the low-traffic restroom samples from the men's and women's bathrooms, respectively.

Table 4: Bacteria Counts on Contact Points in the Men's and Women's Low-Traffic Restroom

Sample	Men's Bacteria Counts (CFU)	Women's Bacteria Counts (CFU)
Door Handle	0	0
Light Switch	0	0
Dyson - Front	5	1
Dyson - Back	1	0
Paper Towel Sensor	8	0
Paper Towel	2	0

Bacteria Study Evaluation. Based on the results obtained from the high-traffic samples, there are far fewer bacteria present on the high-speed hand dryers contact points than the paper towel dispensers. It is clear that high-speed hand dryers are more socially sustainable than paper towel dispensers, because they reduce the transport of bacteria to human hands. The number of bacteria on the door handle and light switch samples are consistently small. Thus, turning off a light or opening the door may not introduce bacteria back-transferred to human hands after the drying processes.

The transferability of these results was verified by sampling contact points in a low-traffic bathroom in addition to the original high-traffic restroom. It is therefore apparent that high-velocity hand dryer generally represent a small source of bacteria transferred during the drying processes when compared to paper towels, especially when paper towels are dispensed using a manual handle.

Demonstration. The results of this study will be presented at the NYSP2I exhibition event as a research poster. Members of the team will present the event. Additionally, plates will be on display for viewing, as well as signage prototypes.

Conclusions

Previously, an LCA and cost analysis was conducted on the high-velocity hand dryers. The current study examined the social, health and safety aspect of sustainability. This component was represented by performing a bacteria study on the paper towel dispensers, door handles, light switches, and high-velocity hand dryers. The initial hypothesis for the bacteria study was that the high-velocity hand dryers would have fewer bacteria colonies than the paper towel dispensers. The results from the high-traffic and low-traffic restroom samplings showed that the high-velocity hand dryer surfaces have fewer bacteria than the paper towel dispensers.

The signage component of the study involved investigating signs in the bathrooms to increase usage of the high-speed hand dryers. Users were more motivated by comparison of CO_2 savings to tree uptake and transportation sources.

The Sustainable Hand Drying project addresses all three pillars of sustainability (environmental, economic, and social) with the main goals to promote sustainable practices at our university and inform students and faculty about the benefits of choosing high-velocity hand dryers over paper towels.

Feasibility. This project supports the implementation of high-velocity hand dryers in a university setting. It answers critical questions about how to promote hand dryer usage in terms of social and health aspects.

Future Work. This project has described the relative abundance and presence or absence of bacteria on different contact points in high- and low-traffic restrooms. To further evaluate the health risks each surface with bacteria poses on humans, this project will be expanded to determine if bacteria on each sample are pathogenic or nonpathogenic bacteria species. The next phase in the signage study will be implementation of the signs and to record the change in usage of the high-velocity hand dryers.

References

Fawdar, S. and K. Redway. “A comparative study of hand drying methods: Paper towel, warm air dryer, jet air dryer.” University of Westminster, November 2008.

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