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# Innovative Approach to Measure Effectiveness of Handwashing Education in School-Age Children by Extension Educators

Katie Hoffman
*University of Idaho Extension*, khoffman@uidaho.edu

Surine Greenway
*University of Idaho Extension*, surineg@uidaho.edu

Julie Buck
*University of Idaho Extension*, jhbuck@uidaho.edu

Grace Wittman
*University of Idaho Extension*, gwittman@uidaho.edu

Jang Ho Kim
*University of Idaho Extension*, janghok@uidaho.edu



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# Innovative Approach to Measure Effectiveness of Handwashing Education in School-Age Children by Extension Educators

**Katie Hoffman**
**Surine Greenway**
**Julie Buck**
**Grace Wittman**
**Jang Ho Kim**
*University of Idaho*

*University of Idaho Extension educators developed an innovative approach to analyze the effectiveness of handwashing lessons taught to school-age children. A protocol was designed to determine if there was a significant decrease in bacterial Colony Forming Units (CFUs) before and after implementing an educational handwashing lesson. The protocol allowed Extension educators with limited to no research experience to validate their handwashing lessons with scientific research. A 79% reduction in Mean CFU counts pre- and post-handwashing was found, excluding an outlier. The results support the effectiveness of Extension handwashing lessons using a novel quantitative approach.*

*Keywords:* handwashing effectiveness protocol, school-age children

According to the Centers for Disease Control and Prevention (CDC, 2020), hands can transmit many infectious diseases. The germs can spread quickly if individuals do not wash their hands with soap and clean running water. Although people worldwide wash their hands with water, many do not use proper handwashing methods, which include using soap (CDC, 2020).

In a 2018 observational study of 2,249 adults, handwashing occurred only 31% of the necessary times during food preparation (Cates et al., 2018). Furthermore, among the handwashing attempts completed, all steps of proper handwashing were only followed 4% of the time. A study conducted by Bowen et al. (2012) analyzed the association between encouraging intensive handwashing in children and a reduction in illness. They found that handwashing promotion could improve child well-being and societal productivity. Additionally, cleaner hands may contribute to youth's reduced absence from school due to illness (Nandrup-Bus, 2009).

Extension educators have documented the impact of handwashing education programs since 2002 (Buck et al., 2018; Craig, 2002; Fenton et al., 2010; Oregon State University Extension Service, 2016). The body of existing research on Extension handwashing education has shown that interventions can increase knowledge and behavior change related to handwashing

Direct correspondence to Surine Greenway at surineg@uidaho.edu


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frequency. In addition, handwashing research has documented that individuals increase handwashing frequency, knowledge, and behavior change after lessons (Buck et al., 2018; Fenton et al., 2010; Hoffman et al., 2020; Oregon State University Extension Service, 2016). These authors also state that Extension educators have completed qualitative evaluations on handwashing lessons using fluorescent lotion to demonstrate handwashing effectiveness.

## Purpose

The purpose of this study was to assess the effectiveness of Extension handwashing lessons taught to school-age children (K-5th grades) in classrooms across the state.

Extension educators have yet to evaluate if handwashing lessons effectively teach all proper handwashing steps, as demonstrated by a reduced microbial presence on students' hands. Therefore, this team researched the connection between handwashing lessons taught by educators and effective proper handwashing methods.

Extension handwashing lesson effectiveness was defined by a reduction in the microbial load on students' hands. The microbial load, which is the number of colony forming units (CFUs), was measured by comparing pre- and post-hand samples. This study's quantitative method has not been previously utilized by Extension to measure handwashing lessons' effectiveness.

## Method

University of Idaho Extension faculty designed a protocol to ensure all educators at each site followed the same lesson when teaching students. Handwashing lessons were taught to more than 300 elementary students, grades K-5, in 13 classrooms and four communities in Idaho. To determine the lessons' effectiveness, a team of University of Idaho Extension educators developed a protocol to measure microbial count easily and accurately on students' hands. The team of Extension educators used a swab analysis technique to collect microbial presence on students' hands before and after the lesson was provided. Family and Consumer Sciences (FCS) Extension educators in Idaho do not commonly have the scientific research background, equipment, and necessary funds to conduct in-depth microbial research studies, limiting opportunities to evaluate hand hygiene educational programs' effectiveness. The institution's Institutional Review Board approved this study.

The team lead identified new technology, ready-to-use sampling swabs, and microbial growing media, which could significantly simplify microbial research by reducing the need for additional equipment, sterilization, broth, and media preparations for sampling use. This easy-to-use technology did not require background knowledge or significant funding or investment in equipment. It was also readily accessible to educators. The lead author, who had no microbial research experience, worked with a University Food Safety specialist to create a step-by-step protocol. The 3M™Quick Swab instruction packet and Petrifilm were referenced for proper


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swabbing technique and provided instruction on incubation included in the protocol (3M Microbiology, 2003; 3M, 2014). Use of the protocol standardized the sampling procedure used for each site throughout the state. The protocol included photographs for a visual representation of steps to be conducted for recordkeeping, sampling, incubation, and analysis. These techniques were developed to meet the needs of Extension educators with little to no scientific sampling background.

The handwashing lessons utilized a fluorescent lotion to simulate "germs" on participants' hands during the handwashing lesson. Students then washed off the lotion using proper handwashing techniques taught during the lesson. The lotion was utilized as a visual indicator for students to evaluate their proper handwashing technique. The team conducted a control test to ensure the fluorescent lotion used in the lesson did not affect the microbial presence being examined within the study. The control showed that the fluorescent lotion did not impact microbial counts before or after handwashing.

Students' hands were sampled using a 3M™ Quick Swab moistened by a self-contained broth solution. Each 3M™ Quick Swab was individually equipped with a pre-mixed broth for ease-of-use for Extension educators. Using the 3M™ Quick Swab eliminated the need to mix a broth solution or pipette onto the swab, limiting cross-contamination while collecting samples. A pre-sample was collected by swabbing a 1-inch square area on the palm of both students' hands before washing their hands. The lotion was then applied to students' hands to represent germs on their hand surfaces. The students then washed their hands practicing the lesson's steps and were swabbed with a new 3M™ Quick Swab for post-sample collection. The protocol is included in the Appendix.

To pair pre- and post-sample collection while keeping data anonymous, each student was assigned a coded green sticker and a corresponding coded pink sticker. These correlating stickers were placed on a shirt sleeve before sampling. As the pre-sample was collected, the green sticker was removed from the student and applied to the 3M™ Quick Swab sample. The 3M™ Quick Swabs were then stored to be plated following the lesson. The same procedure was used for the post-sample, and the pink coded sticker was removed from the student and applied to the corresponding post-3M™ Quick Swab sample. The pre- and post-samples were collected with coded labeling, ensuring students' confidentiality while allowing pre- and post-samples to be matched.

Following the lesson's completion, the swabs were then double plated to reduce sampling and plating error on 3M™ Petrifilm Plates by Extension educators and incubated at room temperature for a minimum of 24 hours. This incubation period allowed colony forming units (CFUs) to grow large enough to count. According to Biology Online Dictionary, a colony forming unit is a measure of viable cells called a colony. It represents an aggregate of cells derived from a single cell (Biology Online, n.d.). The purpose of using CFUs was to measure the


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number of viable bacterial cells in a sample. This unit of measure can determine the degree of contamination in samples. A CFU is different from direct microscopic counts because it does not include both dead and living cells; instead, it only measures viable, living cells.

The 3M™ Petrifilm Plate was a simplified petri dish in a ready-to-use form containing a dried medium on cardstock and a lightweight cover sheet. The film used in this study indicated aerobic bacteria CFUs by forming a red dot on the film. The colonies that visually appeared on the 3M™ Petrifilm Plate were counted after incubation occurred.

The pre-and post-sample colony units were then compared for each of the sites involved in the study. Comparing pre- and post-CFUs allowed educators to evaluate the students' handwashing effectiveness after receiving the lesson.

## Results

This study aimed to assess the effectiveness of Extension handwashing lessons taught to students across Idaho. It was identified that an analysis utilizing innovative and inexpensive products could determine if there were a significant decrease in CFUs after teaching a handwashing lesson. The double plated sample CFUs for each student pre- and post-samples were averaged, resulting in a mean pre-CFU count and a mean post-CFU count for each student (Mean Pre, Mean Post). Comparing the Mean Pre and the Mean Post samples were identified as the form of data interpretation, considering the inevitable variability of multiple data collectors. Because the CFU counts were paired pre- and post-lesson, and the same observer recorded the number of CFUs for each pre- and post-pair, the change from pre to post remains a valid measure of the handwashing lesson's effect.

The Mean Pre for each observer was calculated as Observer A: 14.4 CFUs, Observer B: 51.7 CFUs, Observer C: 37.8 CFUs, and Observer D: 161.0 CFUs. The Mean Post for each observer, respectively, was 15.6 CFUs, 14.0 CFUs, 9.1 CFUs, and 29.0 CFUs, as shown in Figure 1. The percent reduction in the Mean CFU count was Observer B: 73%, Observer C: 76%, and Observer D: 82%. Observer A saw an increase in CFU counts by 8%. These differences are compared in Figure 1. This contributed to the very low CFU counts, to begin with, in the Observer A sampling. All of Observer A's data were collected at one site. It was noted by Observer A that hand sanitizer was routinely used in the classrooms at this site. It is suspected that hand sanitizer was used shortly before the lesson, and students' hands were cleaner at this site. A 79% average reduction in Mean CFU pre/post counts occurred when the outlier count was removed.


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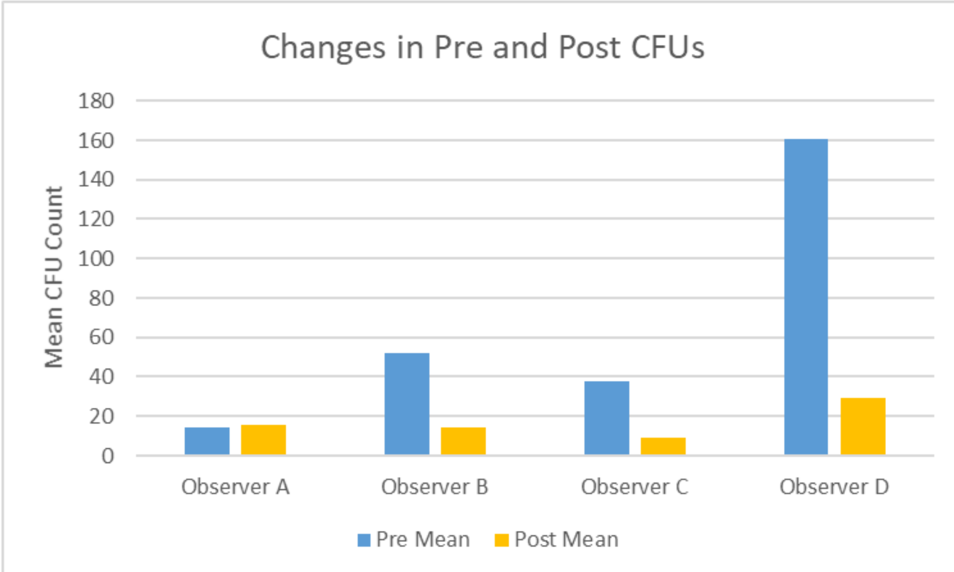
***Figure 1. Mean CFU Counts in Pre- and Post-Handwashing Lessons Compared Across Observers and Collection Sites***




A two-sided sign test was performed to determine if there was a negative change (CFU reduced pre to post), a neutral change (CFUs remained the same pre to post), or a positive change (CFUs increased pre to post). A sign test was used to account for the varying CFU counts between observers. It was hypothesized the CFUs increased after the handwashing lesson and the students washed their hands. Using the sign test (Median 0), the median values of the pre-and post-sample indicated ($p < .001$) the change in CFUs from pre to post was -3. The negative number showed a statistically significant reduction in the median CFUs from pre- to post-sampling.

## Summary

There was a 79% reduction in CFUs, and an adverse change in Median CFUs, leading to the conclusion that the handwashing lessons effectively reduced the microbial presence on students' hands. Results indicated that microbial counts decreased with students' handwashing, indicating proper technique was used. This study documented that youth handwashing education by Extension educators in Idaho was effective, and the research supports that CFUs were reduced with proper handwashing. The measured reduction in CFUs may support the effectiveness of Extension handwashing education to reduce microbial presence on school-age children's hands. The pre-and post-samples results demonstrated a statistically significant reduction in CFUs before and after the handwashing lesson took place, validating the effectiveness of youth handwashing education that Extension educators provide throughout Idaho.

However, this study only evaluated a one-time handwashing event. Students may not continue proper handwashing techniques over time. A longitudinal study to assess effectiveness would be beneficial to examine this limitation. An additional limitation of this study was that although all sites were given the same protocol, including a photo tutorial, not all lessons taught at sites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across the state were conducted by the same Educator. The difference in educators who taught the handwashing lesson, implemented the swabbing technique, and conducted the CFU analysis created the potential for a discrepancy in results. The team worked to reduce the second and third limitations by creating a step-by-step protocol (which included both a photo and video tutorial) for all onsite Educators to follow, averaging data results and comparing both within and between Educators. A final limitation is the grouping of all school-age children located at one site rather than differentiating between grade levels. By not distinguishing the difference in age and handwashing capability, this team may not be accounting for variables in the data based on differing ages, skill levels, and learning abilities.

Implementing ease-of-use research products to measure program effectiveness with microbial counts can have implications for Extension educators. Microbial counting could be implemented into an evaluation method for educational programs focused on proper sanitation of workstations, cross-contamination, food safety, and more. Using ease-of-use research tools in the education environment offers Extension a new opportunity to conduct simple evaluation studies with educators who have a limited research background and scientific expertise.

Effective handwashing skills are being learned and applied by school-age children sampled in more than four sites in the state of Idaho. According to the Wisconsin Department of Health Services (2015), the implementation of effective handwashing was the single most effective way to prevent the spread of communicable diseases. Good handwashing techniques can significantly reduce the spread of infectious diseases among children and adults (Wisconsin Department of Health Services, 2015). Through this team's documented effectiveness with CFU reduction, the research suggests that the Extension's handwashing lesson reduced microbial presence on children's hands. As a result, this reduced microbial presence could likely reduce illness and illness-related school absence in school-age children.

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*Katie Hoffman* is an Extension Educator in Family & Consumer Sciences with University of Idaho.

*Surine Greenway* is an Extension Educator in Family & Consumer Sciences with University of Idaho.

*Julie Buck,* EdD, is an Extension Educator in Family & Consumer Sciences with University of Idaho.

*Grace Wittman* is an Extension Educator in Family & Consumer Sciences with University of Idaho.

*Jang Ho Kim,* PhD, is an Extension Food Safety Specialist with University of Idaho.



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## Appendix

## Hand Washing Study Protocol

### Sample Labeling

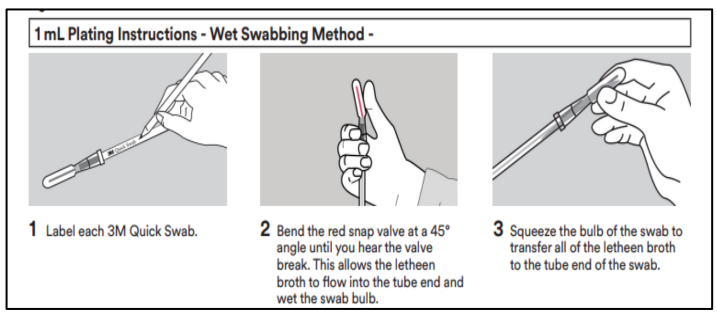
You have 2 sets of color-coded sticky dots. One is green, and one is pink. You will label them with your last name's 1st initial (i.e., mine would be H) and an alphabetical letter to link to a coded sheet for location. For example, "A" would represent my first location at the 1st grade class. Then, the dots will be numbered for the number of students participating. The student will receive a green dot labeled HA1 and a pink dot labeled HA1 to represent student one. These need to be labeled before the class. They will be used to label Petrifilms efficiently while taking the samples.

At the lesson, you will give each youth one of each colored sticker (one green, one pink), each with the same code. This means the first student would be HA1. Before presenting the lesson, you will collect the pre-sample. Once the pre-sample is collected, label the Quick Swab with the green dot. Once the post-sample is collected after washing hands, label the Quick Swab by adhering the corresponding pink dot.

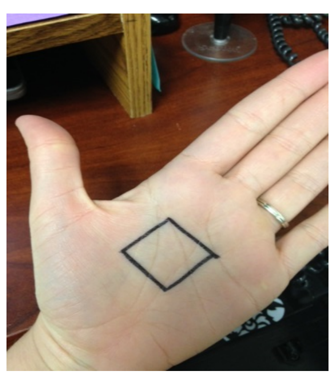
### Taking the Sample

To ready the Quick Swab, bend the end to release the broth (Picture 1; 3M, 2014, p. 2). Squeeze the end to push broth to the swab end. Swab a 1-inch X 1-inch square in the middle of the child's palm (Picture 2).

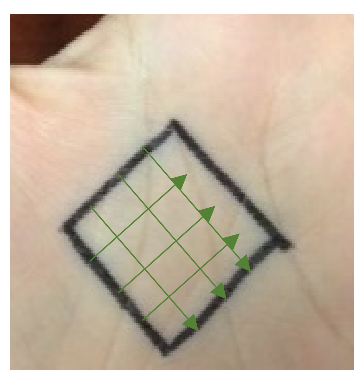
Swab back and forth and up and down, covering the 1-inch area (Picture 3). Cap your Quick Swab. Remove the appropriate colored label from the child and apply it to the sample. Green is for pre, and pink is for the post. Take the pre-sample before the lesson is taught. Take the post sample after the students have washed their hands.




Picture 1



Picture 2

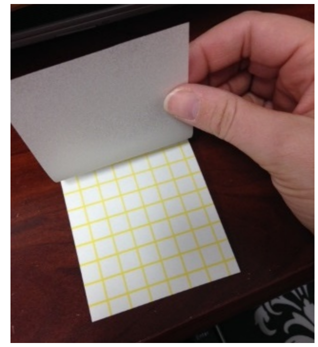


Picture 3

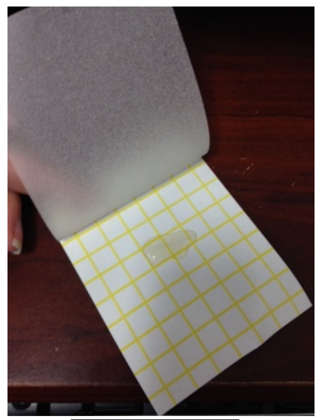
**Plating the Sample**

Plate the sample as soon after the class as possible. Prepare two Petrifilms per sample. Label them with the same code as on the Quick Swab and label them pre and post or use the stickers (Picture 4). Shake the Quick Swab vigorously for 30 seconds. Lift the clear film on the top of the Petrifilm (Picture 5).

Picture 4


Picture 5

Pour half of the swab broth onto the center of the film (Picture 6). Or measure out with a pipette if you have one available. Pour the other half onto the second Petrifilm. Cover with the clear film. “Spread” the sample by placing a glass on top of the sample (Picture 7). Let incubate for 24 hours (+/- 2 hours). You can stack the film up to 20 films high while incubating. Keep temperature stable and around 70 degrees.


Picture 6


Picture 7

**Reading the Sample**

After 24 hours, read the sample by counting how many red “dots” or colonies are present (Picture 8). Record the results in the provided table. Send the table along with the location code for your classes to the team lead. Collect all of your used Petrifilm in a sealable plastic bag. Locate an autoclave near you to process the material before discarding.

Picture 8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