Hygiene in Action: Effectiveness of Cleaning Methods on Bathroom Door Handles

Austin Jeon, Palak Mahendru, Xiran Wei

Abstract

This study investigated the effectiveness of three cleaning methods - hand soap, sanitizing gel, and sanitizing wipes - in terminating bacteria and minimizing their growth. The experiment was conducted in the Chemistry Building at UBC, where each cleaning method was applied to nine different bathroom door handles. Samples were collected using sterile swabs and cultured on agar plates, which were then left in an incubator at 37°C to grow over the span of two weeks. The results were statistically inconclusive (p-value 0.128, which is greater than 0.05) as we didn't have enough data to formulate a general trend comparing the three cleaning methods. However, the sanitizing wipes had the least amount of bacterial colonies by the end (mean = 0 colonies, SD = 0), suggesting it to be the most effective. Future studies should include larger sample sizes and controlled environmental variables to better assess cleaning efficacy. Such studies could help inform better hygiene practices and contribute to the development of effective sanitization guidelines.

Introduction

In today's post-pandemic world, hygiene and sanitization play quite an important role in preventing the spread of infections. Personal hygiene is a crucial factor in keeping one and the community safe and healthy (Singh et al., 2023). With bacteria and viruses commonly residing on frequently touched surfaces, it is essential to evaluate the effectiveness of different cleaning methods. Understanding the efficiency of these methods not only supports better hygiene practices but also helps in creating new guidelines for a safer, cleaner environment. This leads to an important question: which cleaning method is most effective at reducing bacterial growth and contamination?

To investigate this, we examined three of the most commonly used cleaning procedures - hand soap, sanitizing wipes, and sanitizing gels (Government of Canada, Canadian Centre for

Occupational Health and Safety, 2024). Each of these methods provide different uses, with hand soap being the traditional staple for personal hygiene, sanitizing gels offering convenience on the go, and sanitizing wipes providing quick and easy cleaning on surfaces. All three of these methods are widely employed, but their relative effectiveness is not commonly known. This study aims to determine which cleaning method is most effective at reducing bacterial contamination, particularly on door handles of bathrooms, a frequently touched surface.

Previous research has indicated that sanitizing wipes are highly effective at reducing transient bacteria on hands, followed by liquid soap and hand sanitizers respectively (Truitt & Goldwater, 2018). However, most of these studies focus on skin as the target surface, rather than inanimate objects such as metal door handles, which may provide different results. Furthermore, their experiments had the bacteria growing for short periods (two days), while our study extended this incubation to two weeks, hopefully allowing for a more detailed analysis of the bacterial growth.

We propose two hypotheses: first, there will be a significant difference in the reduction of bacterial contamination on bathroom door handles among the three cleaning methods (hand soap, sanitizing gel, and sanitizing wipes) and second, that hand soap will be the most effective overall. We will test these hypotheses to ultimately provide insight on the true efficacy of these cleaning methods. The goal of our paper is to inform better cleaning practices for both personal and public use, and that this will contribute to a broader understanding of how best to minimize bacterial contamination on surfaces.

Methods

Study Design

We conducted this study to evaluate the effectiveness of three cleaning methods—hand soap and water, hand sanitizer gel, and sanitizing wipes—in reducing bacterial contamination on door handles. We performed the experiment in the male bathrooms of the Chemistry Building at UBC. We applied each cleaning method to a specific door handle and followed standardized protocols to ensure consistency across treatments and replicates.

Sampling and Control Setup

We used a total of 15 agar plates to evaluate the effectiveness of three cleaning methods—hand soap and water, hand sanitizer gel, and sanitizing wipes—in reducing bacterial contamination. The plates were categorized into three groups: negative controls, cleaning method treatments, and pre-cleaning baselines. This setup ensured that bacterial growth could be effectively monitored and compared across treatments and controls.

The negative control group consisted of three agar plates. Sterile cotton swabs dipped in distilled water were used to streak these plates, serving as a benchmark for bacterial contamination in the absence of any cleaning product or prior contamination. To maintain consistency and prevent bias, these plates were labeled with numbers only.

The cleaning treatment group included three replicates for each cleaning method: hand soap and water, hand sanitizer gel, and sanitizing wipes. Plates were labeled S1–S3 for hand

soap, G1–G3 for hand sanitizer gel, and W1–W3 for sanitizing wipes. This labeling ensured clear differentiation between treatments and replicates.

Additionally, three plates were used to establish the baseline bacterial load on the door handles prior to any cleaning. These samples were collected using sterile cotton swabs and streaked onto agar plates labeled "NC" for "No Clean," with replicate identifiers NC1–NC3. By assessing bacterial growth in these baseline samples, the experiment provided a reference point to measure the effectiveness of each cleaning method in reducing bacterial contamination. All samples were handled under sterile conditions to ensure the accuracy and reliability of the results.

Cleaning Procedures and Sample Collection

We standardized the cleaning procedures to ensure consistency. The cleaning duration for each method was standardized at 15 seconds, timed using a smartphone. This duration was chosen based on practical constraints, as we were on a time constraint. Each door handle was cleaned using the assigned method:

- Hand Soap and Water: Applied and scrubbed on the handle surface for 15 seconds.
- Hand Sanitizer Gel: Applied and spread across the handle surface for 15 seconds.
- Sanitizing Wipes: Wiped across the handle surface for 15 seconds.

After cleaning, we collected post-cleaning samples using sterile swabs. We wiped each swab back and forth 10 times across the handle to ensure consistent bacterial collection.

Sample Processing

All collected samples were streaked onto pre-labeled agar plates near an alcohol flame to maintain sterility. Plates were labeled with the group name and corresponding treatment condition. To prevent condensation from interfering with bacterial growth, the plates were sealed and placed upside down.

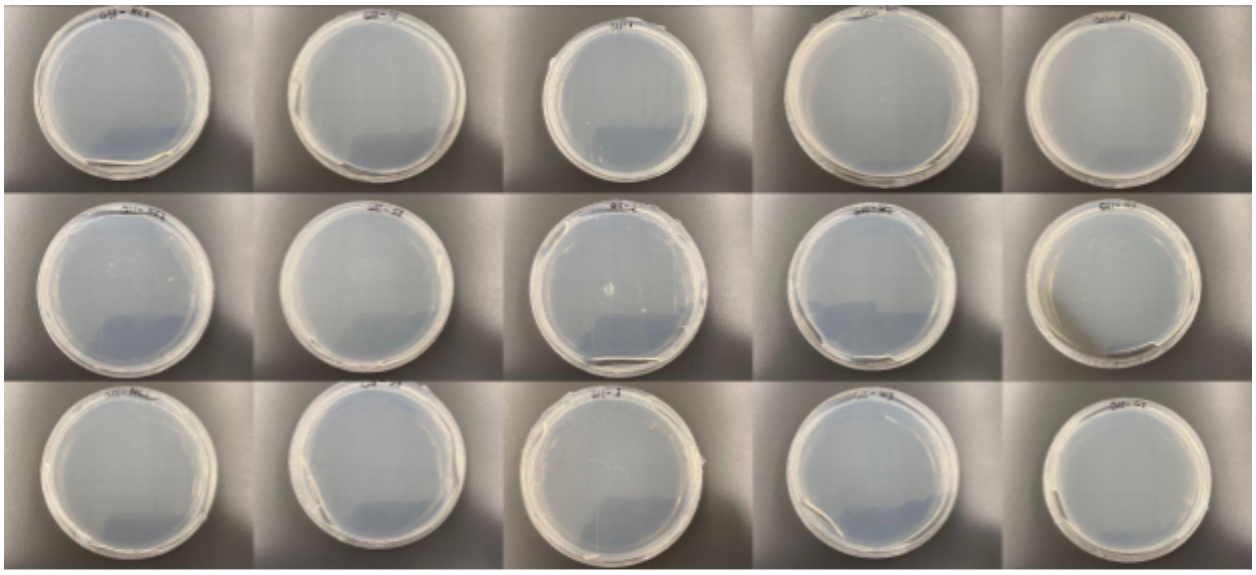

Figure 1. The observation photo of day 5 as a representative.

Incubation and Observation

The sealed plates were incubated at 37°C and monitored daily for bacterial growth. Observations included bacterial colony counts, qualitative assessments of growth patterns, and measurements of colony size, ranging from 0.5 mm to 2.5 mm in diameter.

Data Collection and Analysis

Bacterial colonies were counted using a microscope and recorded for each plate as

Figure 2 shows. Results were averaged across the three replicates for each cleaning method. Statistical analysis was performed to determine the effectiveness of the cleaning methods:

- Testing for normality was conducted to select appropriate statistical tests.
- One-way ANOVA test and post-hoc test were used to compare bacterial growth among the cleaning methods.

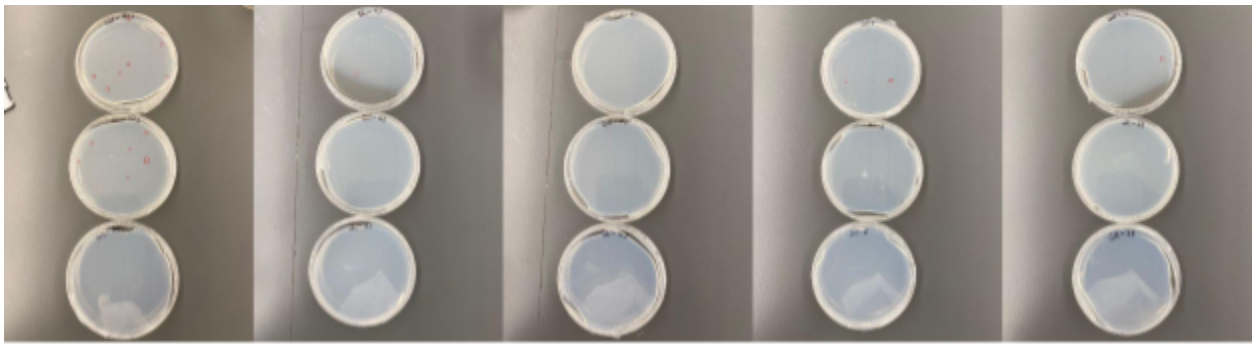

Figure 2. The photo of our final result (colonies marked with red marker).

Minimizing Errors

Efforts to reduce variability included using timers to standardize cleaning durations, using only male bathrooms for measurements, consistently wiping back and forth, and labeling plates systematically. Sterile techniques, such as working near an alcohol flame, minimized contamination risks.

Results

Bacterial Colony Counts

The bacterial colony counts varied significantly among the treatment groups. The "No Clean" group exhibited the highest bacterial growth, with a mean of 4.67 colonies per plate

(variance: 10.33). The "Hand Soap and Water" and "Hand Sanitizer Gel" groups both demonstrated significantly reduced bacterial growth, with a mean of 0.33 colonies each (variance: 0.33). The "Sanitizing Wipes" group showed no bacterial growth across all replicates, confirming its superior effectiveness. The negative control group, which was treated with distilled water, exhibited an average of 0.67 colonies per plate (variance: 1.33).

Bacterial Colony Counts					
	No Clean (NC)	Hand Soap	Sanitizing Wipes	Sanitizer Gel	Negative Control
Plate 1	1	1	0	0	2
Plate 2	6	0	0	0	0
Plate 3	7	0	0	1	0
Mean	4.666666667	0.3333333	0	0.333333333	0.666666667
Variance	10.33	0.33	0	0.33	1.33

Table 1. Raw data and mean values of our final results.

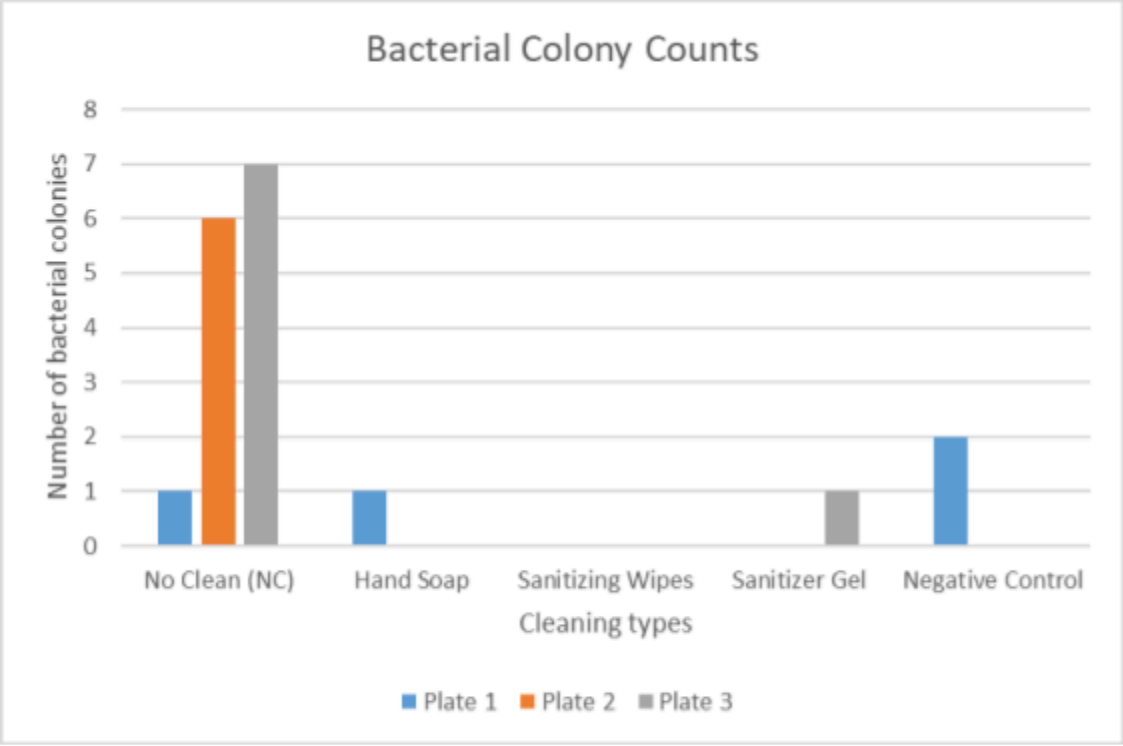

Figure 3: Bar graph of bacterial colony counts per plate across all cleaning methods and control groups.

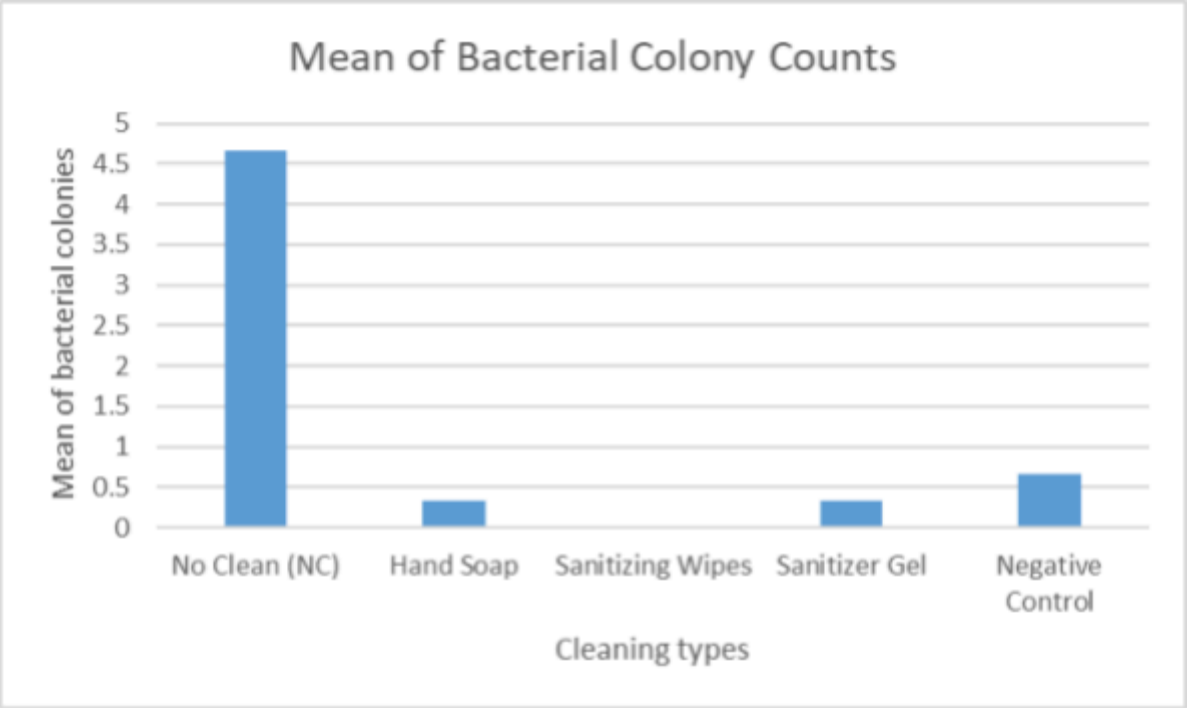

Figure 4: Bar graph displaying the mean bacterial colony counts for each cleaning method and control group.

One-Way ANOVA Analysis & Post-Hoc Analysis

To evaluate the statistical significance of the observed differences among the treatment groups, a one-way ANOVA test was performed. From the ANOVA test, we got an overall p-value of 0.022. In order to do pairwise comparisons between different groups, a post-hoc analysis was performed using t-tests with Bonferroni correction to account for multiple comparisons (Table 2). The corrected p-values determined whether the differences between specific cleaning methods were statistically significant.

Condition 1	Condition 2	P-Value
No Clean (NC)	Hand Soap	0.14065718
No Clean (NC)	Sanitizing Wipes	0.12839807
No Clean (NC)	Sanitizer Gel	0.14065718
No Clean (NC)	Negative Control	0.15326653
Hand Soap	Sanitizing Wipes	0.42264973
Hand Soap	Sanitizer Gel	1
Hand Soap	Negative Control	0.68559841
Sanitizing Wipes	Sanitizer Gel	0.42264973
Sanitizing Wipes	Negative Control	0.42264973
Sanitizer Gel	Negative Control	0.68559841

Table 2. The result of post-hoc analysis within the 5 groups.

Colony Size Observations

The largest colony observed was approximately 2.5 mm in diameter, while the smallest colony was approximately 0.5 mm.

Trends and Observations

The "No Clean" group showed significantly higher bacterial growth compared to all cleaning treatments, as expected. Among the cleaning methods, "Sanitizing Wipes" completely inhibited bacterial growth, demonstrating superior effectiveness. "Hand Soap and Water" and "Hand Sanitizer Gel" both effectively reduced bacterial counts but did not completely eliminate them. The negative control group exhibited minimal growth, as expected, serving as a validation of experimental procedures.

Discussion

The results of this study provide insights into the effectiveness of three most common cleaning methods—hand soap and water, hand sanitizer gel, and sanitizing wipes—in reducing bacterial contamination on door handles. We found that each cleaning method reduced the bacterial contamination to a large extent, with sanitizing wipes consistently showing no bacterial growth on all replicates. Hand soap and sanitizer gel had equally low yet nonzero bacterial colony counts. However, our results were not statistically significant. The p-value between the groups “No Clean” and “Wipes” was 0.128, which is more than the significance level of 0.05. This indicates no statistically significant difference between these groups in terms of efficacy. Similarly, the rest of our pairwise t-tests showed no statistical difference in effectiveness between the specific pairs. Note that our p-values for “No Clean” and “Soap” and “No Clean” and “Gel” were the same due to similar values of colony counts for each. Therefore, we fail to reject the null hypothesis (H_0) and consequently, fail to support the alternative hypothesis (H_a), which suggested at least one cleaning method was more effective than the others.

It is likely that the slightly higher efficacy of sanitizing wipes is attributed to the alcohol content and mechanical removal of bacteria, which together cause more disruption in bacterial cell membranes than in the other two methods (Song et al., 2019). This also agrees with previous studies showing how alcohol-based wipes could reduce bacterial contamination on frequently touched surfaces much more effectively (Truitt & Goldwater, 2018). Studies also show how the presence of antimicrobial agents in wipes can impact their ability to clean. Wipes with no such agents are proven to be inferior to soap, which is considered as the best cleaning method overall (Wilkinson et al., 2018).

While soap’s popularity as a cleaning method is owed to its emulsifying properties (Burton et al., 2011), our results indicate that it might not be a suitable choice for surfaces. The

uniformity in the groups of hand soap and sanitizer gel may indicate that these methods reduce bacterial contamination but may not completely eliminate bacteria on surfaces. This could be explained by variable mechanical action during cleaning, which may not have fully removed more adherent bacterial colonies. Moreover, due to the short cleaning time of only 15 seconds, hand soap or sanitizer gel might not have achieved maximum efficacy because, as other studies demonstrate, longer exposure times can positively enhance bacterial reduction (Knapp, 2020).

Despite significant results, a number of factors could have led to variation within our experiment. Environmental factors, such as humidity, temperature, and human traffic, were not controlled for and may have interfered with the growth and survival of the bacteria. Previous research (Kramer et al., 2006) links cold temperatures and high humidity values to longer periods of persistence of bacteria on surfaces. While we standardized cleaning time to 15 seconds, we did not control for pressure or surface coverage, possibly introducing inconsistencies in application, regardless of using the same collection approach for each sample group. The high variance (10.33) of the 'No Clean' group, highlights the natural variation in the contamination of door handles with bacteria, which could affect our baseline measurements.

Other possible sources of errors include the sterile swabbing used for sampling, which might not have been able to pick up all the bacterial colonies on the surface. In addition, the time for drying was unequal (not recorded), and residual cleaning agents in the door handles could be an influencing factor in the bacterial counts after cleaning. Since, the building's bathrooms had a designated weekly cleaning schedule.

The results are in general agreement with similar studies that have demonstrated the importance of both physical contact and chemical composition in cleaning effectively (Department of Medical Laboratory Science, College of Science, Knowledge University, Erbil,

Kurdistan Region, Iraq & Zefenkey, 2021). On the other hand, there are some studies which reported higher efficacies for hand-sanitizing gel. Such discrepancies may have arisen from fundamental differences in experimental design, for example, testing surface type or strain variety of bacteria (Bayer et al., 2023).

This discussion has major implications beyond individual cleaning. The adoption of best cleaning methods in public places, such as schools, hospitals, and offices, may be crucial to protecting the health of the public at large, especially in flu seasons or infectious outbreaks. Sanitizing wipes are convenient and specifically fitting in situations where immediate cleaning is necessary or access to water and soap is limited. This also highlights the multidimensionality of hygiene. Cleaning of surfaces is important but has to be complemented with other preventive measures like frequent handwashing, use of PPEs, and effective ventilation in places of congregation. Beyond that, organizations may wish to consider hygiene education for the public as a way to help create healthy and safe ecosystems.

Future tests could refine our method to increase the sample size and also include controlled environmental parameters to minimize variability. It would also yield a more universal outcome on the efficacy of these cleaning agents by increasing the range of cleaning products and testing them under varied conditions, including distinctive surfaces and exploring specific strains of bacteria for more detailed analysis. This would serve to reinforce our results and give a more dependable directive on hygiene practices to be applied in public places.

Conclusion

Our study analyzed the efficiency of the following treatments: hand soap, sanitizing gel, and sanitizing wipes, to reduce bacterial contamination on door handles. All cleaning treatments reduced the bacterial colony counts from that of the control; however, we found no statistically significant difference between their efficacy. Our p-values were greater than the significance threshold of 0.05 and we failed to reject the null hypothesis. These findings point to the need for further research on proper hygiene practices that will help maintain cleanliness on high-touch surfaces and contribute to the higher objective of infection prevention in public spaces.

Acknowledgements

We would like to express our gratitude to everyone who contributed to the successful completion of our study. First, we thank the Biology Department at UBC, specifically under the guidance of Professor Celeste Leander, for providing the lab space and resources necessary for this study as part of the BIOL342 course term project. We are especially thankful to our TAs, Mindy Chow and Josh Yang, for their invaluable supervision, support, and guidance throughout the project. We also acknowledge the course staff for supplying the equipment and materials used in our experiments, as well as their assistance in ensuring we adhered to proper lab protocols. Additionally, thanks to the Chemistry department at UBC for granting us access to their facilities to collect our samples. Finally, we extend our appreciation to our peers in BIOL 342 for their constructive feedback during the planning and analysis stages, which greatly enhanced the quality of our study. Thank you all for your contributions to this research. We are proud of the commitment and effort that all of us brought to this project.

References

Bayer, G., Shayganpour, A., & Bayer, I. S. (2023). Efficacy of a New Alcohol-Free Organic Acid-Based Hand Sanitizer against Foodborne Pathogens. *Toxics*, *11*(11), 938. https://doi.org/10.3390/toxics11110938

Burton, M., Cobb, E., Donachie, P., Judah, G., Curtis, V., & Schmidt, W.-P. (2011). The Effect of Handwashing with Water or Soap on Bacterial Contamination of Hands. *International Journal of Environmental Research and Public Health*, *8*(1), 97–104. https://doi.org/10.3390/ijerph8010097

Department of Medical Laboratory Science, College of Science, Knowledge University, Erbil, Kurdistan Region, Iraq, & Zefenkey, Z. (2021). The Impact of the Three Most Common Hand Cleansing Methods on the Bacterial Profile: A Randomized Clinical Trial. *Iberoamerican Journal of Medicine*, 4–10. https://doi.org/10.53986/ibjm.2022.0001

Government of Canada, Canadian Centre for Occupational Health and Safety. (2024, May 10). *Hand washing: reducing the risk of common infections*. https://www.ccohs.ca/oshanswers/diseases/washing_hands.html

Knapp, E. (2020). The effects of cleaning solutions on bacteria concentration on hospital wheelchairs. *Journal of Student Research*, *9*(1). https://doi.org/10.47611/jsrhs.v9i1.1106

Kramer, A., Schwebke, I., & Kampf, G. (2006). How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. *BMC Infectious Diseases*, *6*(1), 130. https://doi.org/10.1186/1471-2334-6-130

Singh, P., Faisal, A. R., Alam, M. M., Saeed, A., Haider, T., Asif, H. M. A., Rauniyar, J., Rai, N., Janjua, M. A. K., & Pasha, A. R. (2023). An Assessment of Personal Hygiene Practices Among Young Adults: A Cross-Sectional, Descriptive Study. *Cureus*. https://doi.org/10.7759/cureus.44308

Song, X., Vossebein, L., & Zille, A. (2019). Efficacy of disinfectant-impregnated wipes used for surface disinfection in hospitals: A review. *Antimicrobial Resistance & Infection Control*, *8*(1), 139. https://doi.org/10.1186/s13756-019-0595-2

Truitt, C., & Goldwater, W. (2018). 464. The Efficacy of Alcohol Based Wipes, Gel, Foam, and Spray Compared With Liquid Soap in Eliminating Transient Hand Bacteria. *Open Forum Infectious Diseases*, *5*(suppl_1), S174–S174. https://doi.org/10.1093/ofid/ofy210.473

Wilkinson, M. A. C., Kiernan, M. A., Wilson, J. A., Loveday, H. P., & Bradley, C. R. (2018). Assessment of the efficacy of a patient hand wipe: Development of a test method. *Journal of Hospital Infection*, *98*(4), 339–344. https://doi.org/10.1016/j.jhin.2017.08.013