Investigating Bacterial Loads on Different Playground Surfaces

Lowell Cheung, Janice Fan, Erica Na, Timothy Wan

Abstract

Urban playground equipment is made from a wide array of materials, designed for children to use as a means of entertainment during their breaks in their daily academic schedule. However, the extent to which these surfaces may harbour potentially disease-causing bacteria is not well understood. This study investigated the bacterial load on playground equipment made from wood, plastic, and metal to assess material-specific differences and evaluate the efficacy of a standard alcohol-based sanitizer. Swabs were collected from wood, plastic, and metal surfaces of playground equipment and streaked onto agar plates in a controlled lab environment. The plates were incubated at 37°C and monitored for bacterial growth across 10 days, which were examined under light microscopes to determine bacterial load upon the end of the incubation period. Results showed a significant amount of organic growth from the agar plates streaked with swabs collected from wooden surfaces and a lack of organic growth in plates streaked from plastic and metal surfaces. Sanitization resulted in an average of 70% reduced organic material compared to their untreated counterpart. These findings highlight the importance of material choice in playground design and show the critical role sanitization plays in preventing bacterial transmission and protecting children's health in their school environment.

Introduction

Bacterial contamination of playground surfaces poses a crucial public health concern, specifically for children since they frequently interact with playground materials. According to Chatziprodromidou et al. (2022), different types of bacteria strains, like *Escherichia coli* or *Staphylococcus aureus* can persist on surfaces and potentially cause infections if proper hygiene is not maintained. This experiment aims to investigate the correlation between bacterial contamination and different playground materials, focusing on wood, plastic, and metal. Additionally, we aim to investigate how sanitization affects these bacterial loads.

Different playground materials have unique physical characteristics influencing their interaction with bacteria. For example, wood, a highly porous substance, can hold moisture and grow bacteria within its microstructures. These physical characteristics create an ideal condition for bacterial growth (Porter et al., 2024). Metal and plastic materials are less prone to trapping moisture since they are not as porous as wood. However, these materials still can collect bacteria from children's hands and their frequent touching (Meadow et al., 2014). In a study conducted by Saha et al. (2021), results show that using an alcohol-based hand sanitizer lowers bacterial levels significantly. These results are true for materials like metal and plastic. However, because of the porous substance of wood, bacteria within its microstructures can still grow even after being sanitized.

Our study hypothesizes that wood surfaces will exhibit a higher bacterial load compared to metal and plastic due to their porosity and moisture retention. Additionally, wood surfaces will likely maintain a higher bacterial load even after sanitization since the bacteria can remain within its porous structure. These hypotheses are supported by findings indicating that the survival of bacteria is influenced by surface material, environmental conditions, and the cleaning methods applied (Katzenberger et al., 2021; Kramer & Assadian, 2014). To explore our hypotheses, we propose a controlled experiment that involves swabbing sanitized and unsanitized surfaces of playground equipment made of wood, metal, and plastic. The bacterial samples will be grown on agar plates and analyzed for colony-forming units (CFUs). Percent coverage will assess the amount of bacteria found in each sample and the impact of sanitization.

This study is relevant for elementary schools where young children are in contact with playground material and, thus, highly susceptible to bacterial infections. Our study focuses on improving cleanliness in playgrounds by determining high-risk materials and evaluating sanitization methods. Through this investigation, our group aims to enhance our understanding of bacterial contamination on playground surfaces.

Methods

The swab samples were collected on October 28th, 2024, at 14:00 from various playground equipment at University Hill Elementary School. The weather was partly cloudy at a temperature of 12°C. Three distinct playground surfaces were chosen to be swabbed which consisted of metal (Figure 1), plastic (Figure 2), and wood (Figure 3). Each surface was swabbed three times in unsanitized and sanitized conditions, resulting in six samples per playground material. Additionally, three sterile swabs were wet with deionized water and used as controls to assess contamination from the swabbing process. In total, 21 samples were collected.

Figure 1a **Figure 1b** **Figure 1c**

Figure 1 Pictures of swab sites for the metal surface from University Hill Elementary School **A** View of money bar - swabbed first bar **B** unsanitized metal surface and **C** sanitized metal surface

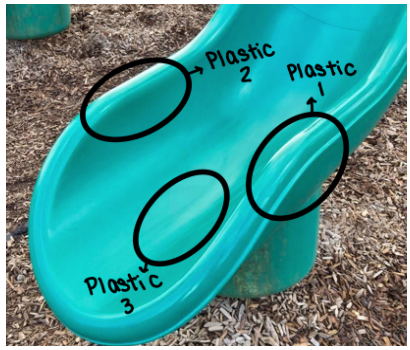


Figure 2a **Figure 2b**

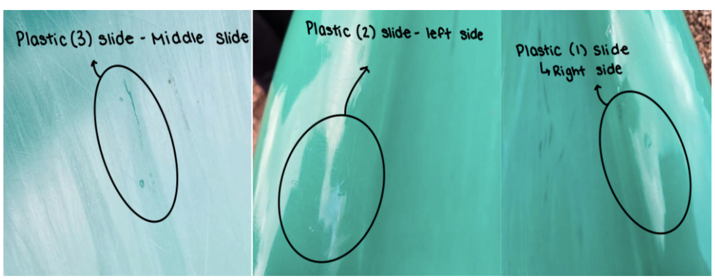
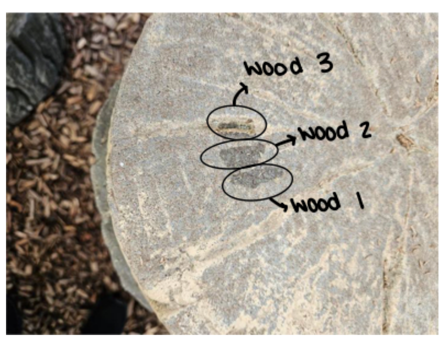


Figure 2c

Figure 2 Picture of swab sites for the plastic surface from University Hill Elementary School playground: **A** General view of the plastic slide - swabs were taken from the slide with the arrow **B** unsanitized plastic surface **C** sanitized plastic surface



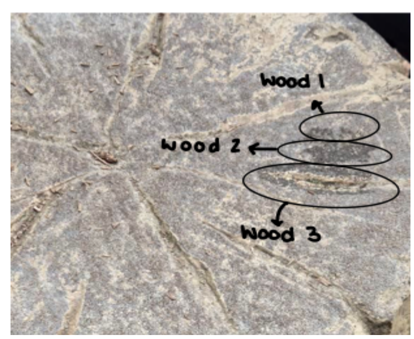


Figure 3a **Figure 3b** **Figure 3c**

Figure 3 Pictures of swab sites for wood surfaces from University Hill Elementary School playground. **A** View of wood stumps - tallest stump was swabbed **B** unsanitized wood surface, and **C** sanitized wood surface

Each playground equipment was sanitized using "Ethanol Thieves Waterless Hand Sanitizer," containing 65% ethyl alcohol, peppermint oil, and moisturizing aloe. Hand sanitizer was applied to each surface and spread using Kimtech's delicate task wipers to ensure uniform coverage. The swabs were then transported to the laboratory in sterile containers.

In the lab, a sterile field was created using an alcohol flame, and the swabs were streaked onto sterile agar plates. Each swab was streaked twice in a consistent top-to-bottom motion across the agar surface to ensure consistency. These plates were sealed with parafilm to prevent any contamination, labelled by their surface type, and whether they were sanitized/unsanitized. They were then inverted to prevent condensation from interfering with bacterial growth.

The agar plates were incubated at 37°C to replicate the average human body temperature and to limit mold growth. The plates were incubated and monitored for 11 days, from October 28th to November 7th, 2024. Observations consisted of colony size and coverage and each observation was documented with photographs.

Results

After the incubation period, the agar plates were examined under a light microscope. The following tables document the observed percent coverage of the contents found within the agar plates across the control and various materials.

Table 1 – Coverage (%)		
Control	Unsanitized	

Plate #1	0	
Plate #2	0	
Plate #3	0	

Table 1: The estimated coverage of organic content found on the controls at the end of the incubation period.

Table 2 – Coverage (%)		
Wood	Unsanitized	Sanitized
Plate #1	~20	~1
Plate #2	~5	~3
Plate #3	~30	~6

Table 2: The estimated coverage of organic content found on the agar plates streaked from wooden surfaces at the end of the incubation period.

Table 3 – Coverage (%)		
Metal	Unsanitized	Sanitized
Plate #1	0	0
Plate #2	0	0
Plate #3	0	0

Table 3: The estimated coverage of organic content found on the agar plates streaked from metal surfaces at the end of the incubation period.

Table 4 – Coverage (%)		
Plastic	Unsanitized	Sanitized
Plate #1	0	0
Plate #2	0	0
Plate #3	0	0

Table 4: The estimated coverage of organic content found on the agar plates streaked from plastic surfaces at the end of the incubation period.

Table 5 – Wooden Surfaces Comparison				
Plate #	Unsanitized Coverage (%)	Sanitized Coverage (%)	ΔCoverage (%)	% Reduction
1	~20	~1	19	95
2	~5	~3	2	40
3	~30	~6	24	80
Average			15	70

Table 5: The raw difference and percent reduction in agar plate coverage from wooden surfaces before and following sanitization.

The control samples were shown to have zero microbial growth following the 10-day incubation period, which were swabbed with a sterile technique. Similar results were observed in the samples from plastic and metal surfaces, regardless of sanitization. However, unsanitized wooden surfaces displayed a considerable amount of organic content over the incubation period, showing continual growth over time monitored at discrete intervals. In contrast, the same wooden surfaces showed significantly reduced organic growth when sanitized before initial swabbing. An average of 15% less coverage (raw) of the streaked agar plates was found from the sanitized wooden surfaces, averaging a 70% difference in organic content compared to the untreated surfaces.

A paired t-test was conducted on the values between the agar plates streaked with swabs from the untreated and treated (sanitized) wood surfaces. This resulted in a p-value of 0.153, which is not statistically significant at $\alpha=0.05$.

Upon close inspection with a light microscope, it was discovered that the large majority of colonies found were, in fact, fungal growths, and not bacteria. The fungi were identified by their morphology, as the micro-organisms found were fuzzy, unlike expected of bacteria. Trace amounts of bacteria were found in co-existence with the fungi.

Additionally, hair-like threads were found under microscopy of a number of agar plates, with a wide range of lengths and cluster sizes. Various coloured debris was also visible upon inspection of certain plates.

Discussion

The goal of the study is to investigate the bacterial load present on different playground surfaces, with a specific focus on comparing metal, plastic, and wood equipment. It was hypothesized that wood surfaces would harbour a higher bacterial load due to the porosity, allowing moisture retention and creating a conducive environment for bacteria growth (Katzenberger et al., 2021). In addition, it was anticipated that the bacterial load would be reduced after sanitizing the surfaces with hand sanitizer, which children who use the playground often rely on as a disinfectant. The results of the study revealed minimal bacteria growth and a notable presence of fungi in the wood samples. Among the wood samples, the third sample of unsanitized wood exhibited the most significant growth with ~30% coverage. This may be attributed to the presence of a crevice in the wood where the third sample was swabbed, which contained dirt and other substances (Figure 3b), In contrast, samples one and two had percent coverage of ~20% and ~5% and the samples were retrieved from a relatively flat surface (Figure 3a, b), possibly explaining the lower growth observed in these samples. The minimal growth on the sterilized samples of wood indicates that sterilizing playground equipment does contribute to the reduction of fungi and bacteria on equipment surfaces with an average reduction of 70%.

However, the paired t-test showed a p-value of 0.153, indicating that the observed difference between sanitized and unsanitized wood samples was not statistically significant at $\alpha=0.05$. Therefore, the null hypothesis cannot be rejected, suggesting that sanitization does not significantly reduce bacterial load on wood surfaces. This may be due to the environmental variability or limitations in the experimental design.

Interestingly, no fungi or bacteria growth was observed on the metal and plastic surfaces, contrary to expectations of some growth, though less than on wood. The lack of growth is likely due to the smooth nature of metal and plastic surfaces, which minimizes bacterial retention and adherence compared to porous materials like wood (Ciolacu et al., 2022). Moreover, the absence of bacterial growth on the metal and plastic surfaces was surprising, considering that the school did not have a regular cleaning schedule for the playground. Additionally, the *BC Provincial Communicable Disease Guidelines* do not address playground sanitation, implying that the school did not clean the playground at all (Government of British Columbia, 2023).

Escherichia coli and Staphylococcus aureus are common types of bacteria found on playgrounds (Chatziprodromidou et al., 2022)**.** *Escherichia coli* is typically present in the environment through faeces and wastewater discharge (Jang et al., 2017). On playgrounds, bird faeces are the most likely source of these bacteria due to the open nature of the environment. However, there were no visible signs of faeces or other substances, indicating that the surfaces sampled were contaminated.

The lack of bacteria growth may be due to the weather conditions and playground environment. There was light rain overnight on October 28 that lasted about 2.5 hrs (Time and Date AS, n.d.). Therefore, any bacteria that may have been present on the playground may have been washed away. This, however, depends on the porous nature of the material on the playground equipment as porus equipment retains moisture and has more surface area for bacteria to harbour. Additionally, during adverse weather conditions, such as rain, the frequency of playground equipment use significantly decreases, therefore less opportunity for bacteria transmission.

Due to incubation for a prolonged period, the parafilm used to seal the Petri dishes dried up and cracked, breaking the seal for some of the samples. Therefore, the environment of the samples is disrupted, and it contributes to the drying of the agar. Additionally, the samples were taken by different people introducing the possibility of error due to inconsistent swabbing technique.

In conclusion, the findings indicate that bacterial and fungal growth was only detected on wood surfaces, likely due to their porous nature, while metal and plastic surfaces showed no detectable fungi or bacteria growth. This highlights the importance of material choice in playground equipment in relation to bacteria contamination on playgrounds. While sterilization remains an effective method for reducing bacterial load on surfaces, further research needs to be done to determine the type of fungi and bacteria present.

Conclusion

In conclusion, our findings support our hypotheses that wood surfaces have a higher bacterial load compared to metal and plastic surfaces before and after sanitization. This is due to wood's porous nature and ability to retain moisture. Our study demonstrates that while no bacteria were detected on the metal and plastic samples, both bacteria and fungi were found on the wood samples. This was the same for the samples after sanitization. Overall, our study highlights the importance and the need for hygiene practices, especially for children who frequently play on school playgrounds.

Acknowledgements

We respectfully acknowledge that this research was conducted on the traditional, ancestral, and unceded territory of the xʷməθkʷəy̓əm (Musqueam) people. We extend our gratitude to the University of British Columbia for its resources and support, and to University Hill Elementary for their participation. Special thanks to Dr. Celeste Leander, Mindy Chow, Josh Yang, and Miriam Fenniri for their invaluable contributions and guidance throughout this project.

References

Chatziprodromidou, I. P., Chatziantoniou, S., Vantarakis, G., & Vantarakis, A. (2022). Risk Factor Analysis of Children's Exposure to Microbial Pathogens in Playgrounds. *Risk Analysis*, *42*(2), 334-343. https://doi.org/10.1111/risa.13752

Ciolacu, L., Zand, E., Negrau, C., & Jaeger, H. (2022). Bacterial attachment and biofilm formation on antimicrobial sealants and stainless steel surfaces. Foods, 11(19), 3096. https://doi.org/10.3390/foods11193096

Government of British Columbia. (2023). *BC provincial communicable disease guidelines for K-12 settings*. BC Centre for Disease Control. https://www2.gov.bc.ca/assets/gov/education/administration/kindergarten-to-grade-12/safe-caring-orderly/k-12-communicable-disease-guidelines.pdf

Jang, J., Hur, H. -., Sadowsky, M. J., Byappanahalli, M. N., Yan, T., & Ishii, S. (2017). Environmental escherichia coli: Ecology and public health implications—a review. *Journal of Applied Microbiology*, 123(3), 570-581. https://doi.org/10.1111/jam.13468

Katzenberger, R. H., Rösel, A., & Vonberg, R. P. (2021). Bacterial survival on inanimate surfaces: a field study. *BMC research notes*, *14*(1), 97. https://doi.org/10.1186/s13104-021-05492-0

Kramer, A., & Assadian, O. (2014). Survival of microorganisms on inanimate surfaces. *Use of biocidal surfaces for reduction of healthcare acquired infections*, 7-26. https://doi.org/10.1007/978-3-319-08057-4_2

Meadow, J.F., Altrichter, A.E., Kembel, S.W. et al. Bacterial communities on classroom surfaces vary with human contact. Microbiome 2, 7 (2014). https://doi.org/10.1186/2049-2618-2-7

Porter, L., Sultan, O., Mitchell, B. G., Jenney, A., Kiernan, M., Brewster, D. J., & Russo, P. L. (2024). How long do nosocomial pathogens persist on inanimate surfaces? A scoping review. *Journal of Hospital Infection*, 147, 25-31. https://doi.org/10.1016/j.jhin.2024.01.023

Saha, T., Khadka, P., & Das, S. C. (2021). Alcohol-based hand sanitizer – composition, proper use and precautions. *Germs (Bucureşti)*, 11(3), 408-417. https://doi.org/10.18683/germs.2021.1278

Time and Date AS. (n.d.). Weather in October 2024 in Vancouver, British Columbia, Canada – Historic weather. Time and Date. Retrieved November 16, 2024, from https://www.timeanddate.com/weather/canada/vancouver/historic?month=10&year=2024

Wilks, S. A., Michels, H., & Keevil, C. W. (2005). The survival of *Escherichia coli* O157 on a range of metal surfaces. *International Journal of Food Microbiology, 105*(3), 445-454. https://doi.org/10.1016/j.ijfoodmicro.2005.04.021