Effects of Hand Soap, Detergent and Dishwashing Soap on Bacterial Microbiome, Sebum and pH of Skin

Kalyani Palaniappan, Li Yu Xin Karin, and Medha Shridharan

Abstract Investigation on the effects of different types of soap (hand soap, detergent and dishwashing soap) on our skin was done to test the effects of different soaps on the density of bacteria commonly found on our skin and how sebum [1] and pH are affected by the microfauna. The research question was "Is it healthy to use laundry detergent or dish soap instead of hand soap/body foam to wash our hands? How does washing hands with different types of soap affect your skin—specifically its bacterial microbiome, sebum and pH?" Experimental results found that dish soap was the most effective in killing *Escherichia coli* (E. coli) bacteria, while laundry soap was the most effective in killing *Bacillus subtilis*; Hand soap B removes the least sebum and that dish soap has the pH closest to skin pH. Dish soap is the healthiest soap to wash our hands with by the criteria we have studied.

1 Introduction

Many people of today's world regularly wash their hands with specialised soaps, designed to moisturise and gently clean their skin. However, some occasionally wash their hands with other soaps such as dish soap and detergents for convenience. We wanted to find out if this will affect the health of our skin in the long term, and if so, how it does.

A microbiome is defined as the community of microorganisms inhabiting a particular environment. The bacterial microbiome on our skin is the community of bacteria commonly inhabiting human skin. We wanted to investigate a particular species of bacteria, *Escherichia coli,* on the skin [2, 3] We also wanted to test the effects of these

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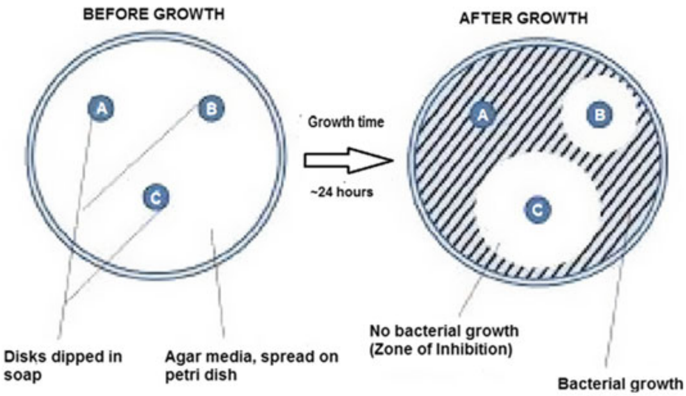

Fig. 1 Experimental design of Phase 1

soaps on a strain of bacteria, *Staphylococcus epidermidis,* which has been found to protect against certain forms of skin cancer [4–6]. However, as this particular species of bacteria was unavailable, we decided to test the effects of these soaps on another type of gram positive bacteria, *Bacillus subtilis* as we thought the soaps would have similar effects on both.

2 Materials and Methods

2.1 Phase 1

Dilute the body foam, dish soap and laundry detergent with DI water in a 1:5 soap to DI water ratio. Wet the punched disks of filter paper with the diluted soaps and DI water. Divide an agar-coated petri dish into 4 sections with permanent marker. In the laminar flow, use the micropipette to pipette 100 μl of the bacteria sample into the agar-coated petri dish. Use an L-shaped spreader to spread liquid *Escherichia coli* sample over the agar. Repeat 6 more times. Make 7 samples with *Bacillus subtilis* instead of *Escherichia coli.* Place the petri dishes in an incubator. Wait for 24 h. Measure the furthest distance from the edge of the stain to the centre of the disk using a ruler. Record results in table [7] (Fig. 1).

2.2 Phase 2

Dilute the body foam, dish soap and laundry detergent with DI water in a 1:5 soap to DI water ratio in a beaker. Use a dropper to add 1 ml of jojoba oil and 1 ml of diluted body foam to an empty test tube. Shake the test tube for 5 s. Repeat 6 times. Repeat with dish soap, detergent and DI water (negative control), 7 times each. Record results in table.

2.3 Phase 3

Measure the pH of each liquid 7 times using a pH meter connected to a data logger.

2.4 Assumptions Made

We took the longest diameter of zone inhibition. This could indicate a bias if the zone was more of an oblong, irregular shape instead of a circular shape. Thus, we made the assumption that the zone of inhibition is circular in shape. We also made the assumption that there is a negligible amount of foam in the dropper when we measured out the soap for our phases. Due to fungal contamination of Hand A in phase 1.1, Hand B was used for phases 1.2, 2 and 3.

3 Results, Discussions & Implications

3.1 Phase 1.1

Figure 2 shows pictures of two of the results obtained for the *Escherichia coli (E.coli)* bacteria. As shown in Figs 2 and 3 above, dish soap had the largest diameter of the zone of inhibition, with a mean of 19.9 mm and median of 20.0 mm. The mean diameters for laundry, hand A and DI water were 11.6 mm, 11.0 mm and 8.7 mm respectively.

However, the results for dish soap also had the largest standard deviation of 7.180 mm and the largest interquartile range of 13.0 mm. Thus, due to this large variation and range of results, the results can be considered inconsistent. The laundry soap had the smallest standard deviation of 4.686 mm while hand A had the smallest interquartile range of 7.5 mm. From this, we can conclude that the dish soap had the greatest effect on the *E.coli* bacteria and is thus most effective in this phase. However, the inconsistency in the results might indicate possible contamination. The DI water, a negative control, showed some antibiotic properties, which is false. It is also important to take into consideration that the results for the hand soap may not be accurate due to possible fungal contamination.

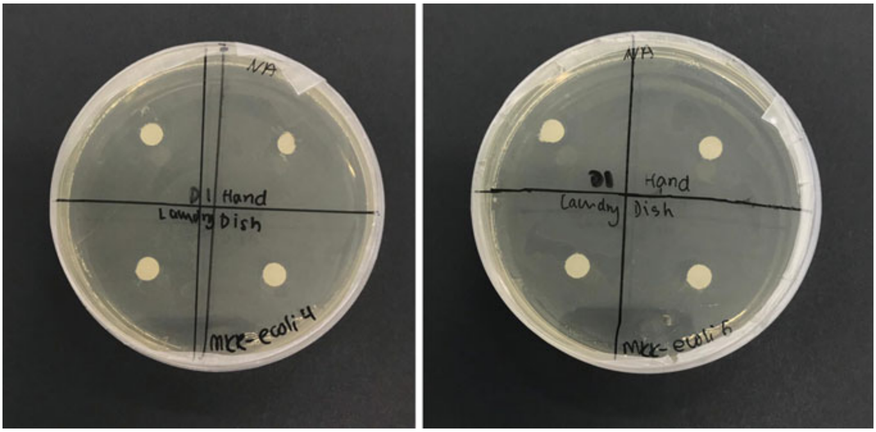

Fig. 2 Results obtained for Escherichia coli bacteria in Trials 4 and 6

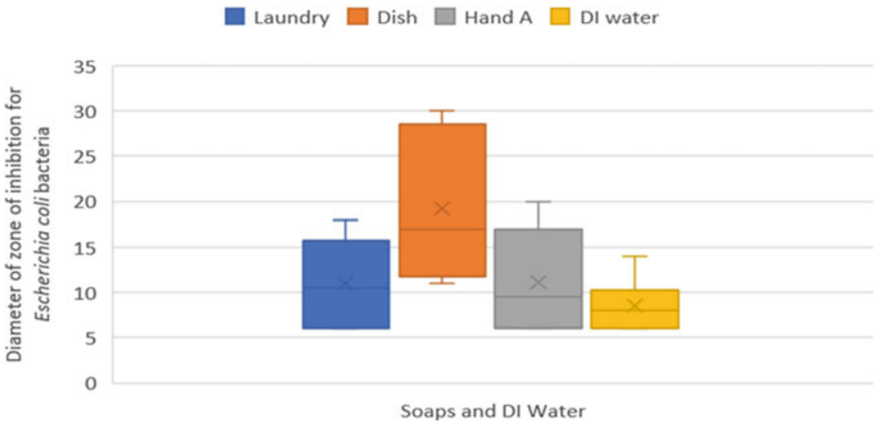

Fig. 3 Box and whisker plot of diameter of zone of inhibition/mm for Escherichia coli bacteria in laundry dish, hand A and DI water

3.2 *Phase 1.2*

Figure 4 shows the results obtained in trials 5 and 6. Figure 5 shows the results of trial 3, which was nulled during data collection due to the bacteria being improperly spread. As shown in Table 1.2 and Fig. 6 above, hand soap B had the lowest mean and median diameters of their zones of inhibition, at 22.2 mm and 22.0 mm respectively. Hand soap B had the smallest standard deviation of 1.951 mm, followed by laundry soap at 2.115 mm and dish soap at 3.145 mm. Dish soap had the smallest interquartile range of 2.5 mm, followed by laundry at 3.0 mm and hand soap B at 3.8 mm. As the hand soap is shown to have the smallest diameter of the zones of inhibition and has

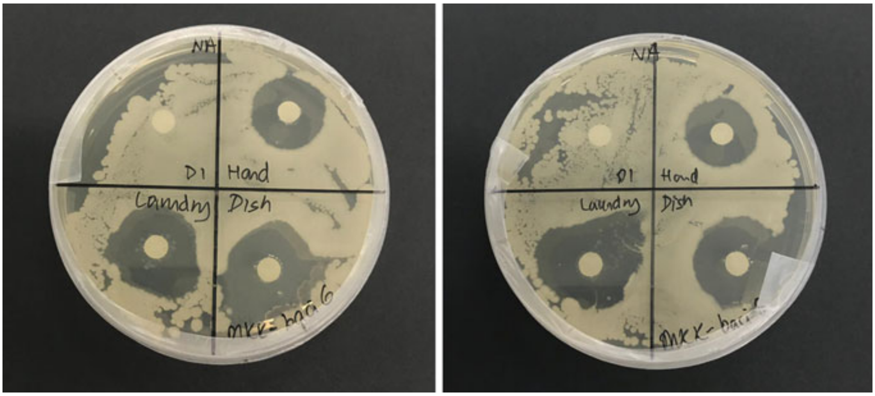

Fig. 4 Results obtained for Bacillus subtilis bacteria in Trials 5 and 6

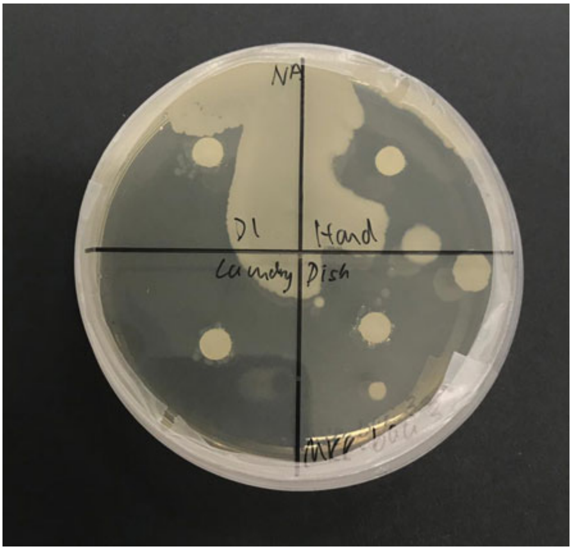

Fig. 5 Nulled results obtained in Trial 3 (Bacteria not spread properly)

a relatively small interquartile range and standard deviation, it is the least effective soap at killing *Bacillus subtilis* bacteria. Additionally, as the negative control of DI water yielded the expected results, the results obtained are reliable. As the hand soap is shown to be the least effective at killing *Bacillus subtilis* bacteria, it is likely to be similarly ineffective at killing other gram positive bacteria, such as *Staphylococcus epidermidis*. If applied directly to the skin, the hand soap B is least likely to affect the bacterial microbiome of *Staphylococcus epidermidis* on the skin. Thus, it would inflict the least negative consequences. This is due to the fact that *Staphylococcus epidermidis* helps to protect the skin from solar ultraviolet (UV) radiation and other harmful bacteria, such as *Staphylococcus aureus*.

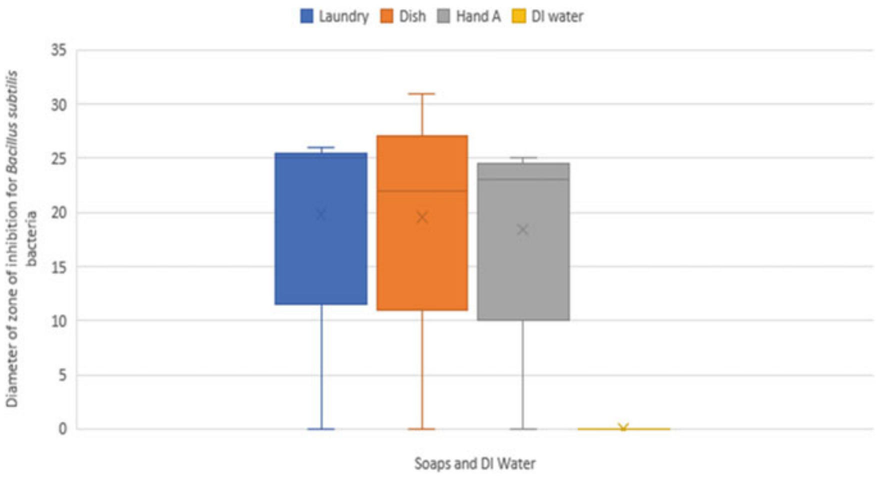

Fig. 6 Box and whisker plot of diameter of zone of inhibition/mm for Bacillus subtillis bacteria in laundry, dish handA and DI water

3.3 Phase 2

For the soaps, the jojoba oil becomes slightly foamy and settles on top of the mixture. For the DI water, jojoba oil remains clear and settles on top of the mixture.

As shown in Fig 7, hand B has the longest median column of foam at 16.0 mm. Laundry, dish and DI water have column lengths of 10.0, 15.0 and 0.0 mm.

Dish soap has the longest mean column of foam at 14.4 mm, closely followed by hand B which has a mean column length of 14.3 mm. Laundry and DI water have mean foam column lengths of 10.0 mm and 0.0 mm respectively. The median is used to compare results to avoid outliers, and there is also a large interquartile range

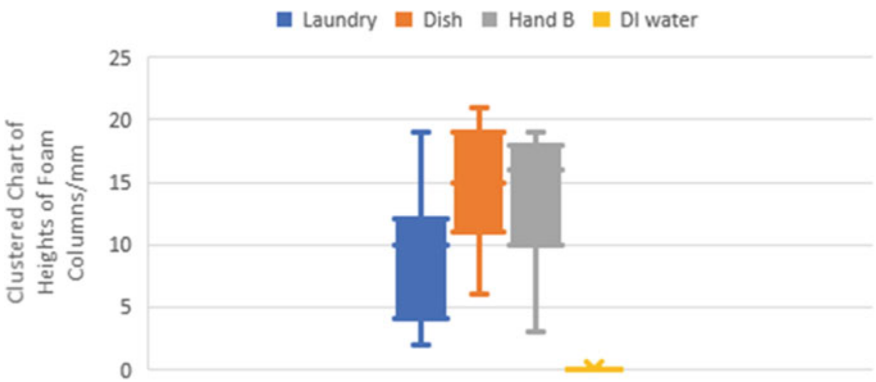

Fig. 7 Clustered chart of heights of foam columns/mm

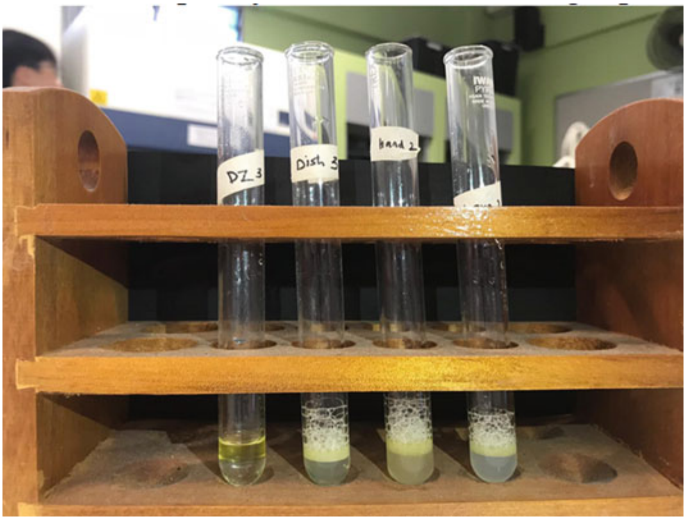

Fig. 8 Examples of results obtained during experiment

for the 3 soaps which shows that the results are quite inconsistent. The jojoba oil in the experiment is used to simulate the sebum found on human skin [8], and the length of the foam column corresponds to how ineffective the soap is at removing the jojoba oil. Thus, the longer the foam column, the lesser the oil removed; therefore, the longest column would be the healthiest to wash hands with. Thus, hand B would be the healthiest to wash hands with (Fig. 8).

3.4 Phase 3

As shown in the results above, laundry detergent has the highest pH, with a mean and median of pH 8.4. The mean pH for dish, hand soap and DI water are pH 5.2, pH 3.5, and pH 6.0 respectively. But as the aim for this phase is to find out the soap whose pH is closest to the skin's pH, which has a pH of 4.0–5.0. Thus, from Fig. 9, we can see that the dish soap has the closest pH to the skin's pH, with a pH of 5.2 [9]. All of the soaps have a small standard deviation that does not exceed 0.1 and a small interquartile range that does not exceed 1, which means that the results gotten are quite consistent. From this, we can conclude that out of all four soaps and DI water, laundry has the highest pH, but dish soap has the closest pH to the skin's pH.

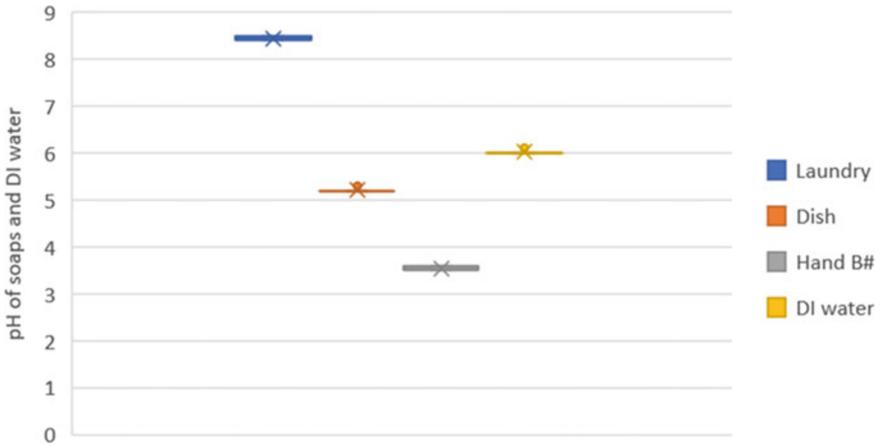

Fig. 9 Box and whisker plot of pH of soaps and DI water

3.5 Limitations and Future Work

We switched hand soap halfway through the experiment as hand soap A had been contaminated by fungi. We could have been more consistent in which hand soap we use. Secondly, the bacteria could have been spread more evenly in Phase 2, and lastly, more samples can be prepared so that more accurate results can be obtained, and attempt to achieve a smaller interquartile range and standard deviation. The small sample size of 7 may not provide the necessary consistency of results needed, thus a larger sample size would make the results of the analysis more reliable.

As dish soap yielded the best results in both phases 1 and 3, we believe this shows that **dish soap** is the healthiest to wash hands with.

References

1. Philip WW (2009) Sebum—an overview. Retrieved 10 July 2019, from https://www.sciencedirect.com/topics/medicine-and-dentistry/sebum
2. Alisa M, Allison M The ABCs of our body bacteria. Retrieved 10 July 2019, from https://www.livescience.com/19913-body-microbiome-nigms.html
3. Regina B (2018) 5 Types of bacteria that live on your skin. Retrieved July 10, 2019, from https://www.thoughtco.com/bacteria-that-live-on-your-skin-373528
4. Atlas of Oral Microbiology (2015) *Staphylococcus epidermidis*. Retrieved 10 July 2019, from https://www.sciencedirect.com/topics/medicine-and-dentistry/staphylococcus-epidermidis
5. Teruaki N, Tiffany HC, Anna MB, Lynnie LT, Sang-Jip N, Karina TS, Wei Z, Julia O, Michael O, William F, Richard LG (2018) A commensal strain of *Staphylococcus epidermidis* protects against skin neoplasia. Retrieved 13 July 2019, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5834004/

6. Sabia R, Shahida H, Abeel A (2009) Antibacterial activity of soaps against daily encountered bacteria. Retrieved 9 September 2019, from https://www.researchgate.net/publication/237255933_Antibacterial_activity_of_soaps_against_daily_encountered_bacteria
7. Narang A (2018). Comparing the effectiveness of various hand-sanitizers against *E.coli*. Int J Pharm Sci Res 3(4):16–18
8. Keen S Which oil is closest to body oil? Retrieved 10 July 2019, from https://www.leaf.tv/articles/which-oil-is-the-closest-to-body-oil/
9. Blaak J, Staib P (2018). The relation of pH and skin cleansing. Retrieved 17 July 2019, from https://www.ncbi.nlm.nih.gov/pubmed/30130782