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Lab Section: L14, Wednesday 2-5pm

Effectiveness of Various Cleaning Solutions in Eliminating Bacteria from Surfaces; An Application to Cellular Device Surfaces

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Abstract:

The objective of this study is to compare the effectiveness of different household cleaners with the goal of recommending cleaning solutions for cellular devices that will promote both hygiene and mitigation of disease transmission (Olsen, M. et al.). 1% Bleach, 3% Hydrogen Peroxide, 2.5% Iodine, 70% Ethanol and Sodium Lauryl Sulfate (commonly found in detergent) were used as treatment to measure reduction in bacterial contamination on phone surfaces. Concentrations were chosen based on common availability. Series dilution was used to obtain desired concentration of specific treatments, micropipettes to deliver the treatments, and water-based agar plates to colonize bacterial swabs. Percent reductions in bacterial colonies were analyzed, and ANOVA tests assessed the significance of results. 70% Ethanol, 3% hydrogen peroxide and 2.5% iodine are the most practical and effective options for cleaning phone surfaces due to their accessibility, safety, and strong disinfecting properties, while the detergent proved to have the most bacterial growth out of the tested cleaners.

lntroduction:

Personal devices, such as cellular smartphones, are in contact with various surfaces throughout the day, making them potential carriers for bacteria and fungus. Due to phones being in close contact with skin and bodily systems, proper and consistent disinfection techniques should be conducted to decrease the risk of disease transmission. By identifying which disinfectants are most effective, consumers will become informed on how to best reduce the microbial presence on cellular devices. This information is also valuable for healthcare settings, where sanitizing personal devices and tools can support infection control efforts and reduce contamination in clinical environments. Additionally, with increased awareness of device hygiene, manufacturers could improve device design by making materials more resistant to microbial colonization or by developing coatings that are compatible with disinfectants to maintain high hygiene standards.

Different disinfectants operate through distinct mechanisms to eliminate bacterial growth. Iodine specifically disrupts microbial cell walls through the creation of pores, allowing cell death through cytosol leakage (Eggers, 2019). Similarly, ethanol works to denature coagulating proteins within microbial cell

walls and disrupts the membrane (Mathew & Goyal, 2024). Both hydrogen peroxide and bleach act as oxidative agents. Bleach, being a stronger oxidative agent, produces hydroxyl radicals that interact and damage the lipid membrane as well as promote bacterial DNA denaturation, compromising microbial integrity. This effectively kills bacteria, yeast, fungi and viruses (Indelicato, 2018). Lastly, sodium lauryl sulfate can be used as a surfactant that has the potential to disrupt microbial cell membranes (Piret, 2002). For the sake of convenience as well as available literature, the above five mentioned disinfectants were chosen to be used as treatment in developing conclusions on the most effective solution in eliminating bacteria. These treatments were used in application to phone surfaces, which are widely known to house many types of bacteria. It is predicted that bleach will be the most effective due to its strong oxidative properties and wide target range.

Materials:

Table 1: Chemical Treatments Used

Chemical Name	Concentration	Purpose	Comments
NaClO	1%	Strong oxidizing agent that disrupts both proteins and lipids	Clorox brand was used
Sodium Lauryl Sulfate	N/A	Surfactant that disrupts membranes	Gain laundry detergent was used
Iodine	2.5%	Causes cell wall damage and protein denaturation	N/A
EtOH	70%	Denatures proteins and disrupts membranes	N/A
H_2O_2	3%	Oxidative damage to bacterial cells	3% hydrogen peroxide is most commonly found in department stores
Sterile Distilled H_2O	N/A	Used as a control	Control to determine swabbing technique consistency along with sterilization technique comparisons

a. **Water-based agar plates (33x)**: Used to swab and observe microbial growth.
b. **Sterile cotton swabs:**: Used to transfer contents from cell phone surfaces to agar plates
c. **Micropipette**: Delivers measured amounts of liquid solutions onto cellphone surfaces
d. **Gloves:** Prevents cross contamination from experimenters, used as PPE
e. **Paper towel**: Clean and sterile form of solution spreading onto cellphone surfaces
f. **Parafilm**: Creates an airtight seal on sides of agar plates to prevent cross-contamination
g. **Alcohol Lamp:** Creates a sterile environment while swabbing

Procedure:

Pre-lab:

All phones were wiped clean with 70% ethanol two weeks before Phase Two, using one spray to achieve similar levels of cleanliness on the surfaces. (October 16th, 2024)

Phase One: Treatment Preparation (Series dilution of concentrated bleach, Clorox branded, to 1%.

1. Micropipette 200µL of bleach into a clean test tube.
2. Micropipette 800µL of dH_2O into the same clean test tube for a final volume of 1mL.
3. Using the above created sample, pipette 200µL into a new clean test tube, along with 800µL dH_2O.
4. Use the above created sample, pipette 250µL into a new clean test tube, along with 750µL dH_2O to complete final dilution in the series.

Phase Two: Incubation of Initial Growth Plates (no treatment applied)

1. Light alcohol lamp to create sterile umbrella
2. Label the plate on the edge *deviceID_date_time_treatment/notreatment_swab#*

3. Using a sterile cotton swab, dip into dH_2O immediately upon opening, dampening the tip. Swipe 8x across the bottom half of the device screen (the keyboard) while rolling the tip to cover all sides.
4. Immediately swipe 8x across the water-based agar plate, holding the agar plate upside down and near the alcohol lamp. Rotate agar plate 90° and swipe 8x to make a cross hatch pattern.
5. Seal plate with parafilm.
6. Repeat steps 1-5 with a new swab each time gaining 3x replicas for each device, and 1 control set of dH_2O.
7. Incubate agar plate at 37°C for 2 weeks, checking growth every 24 hours after the first 48 hours.

Phase Three: Application of Treatments

1. Apply 1mL of treatment to the bottom half of a device screen
2. Use a paper towel to apply/spread the treatment to the bottom half of the device screen, ensuring edges are reached.
    a. Wipe using the paper towel until the screen appears dry
3. Repeat phase one steps 1-7 with new water-based agar plates.

Results:

Figure A: NT vs. Iodine

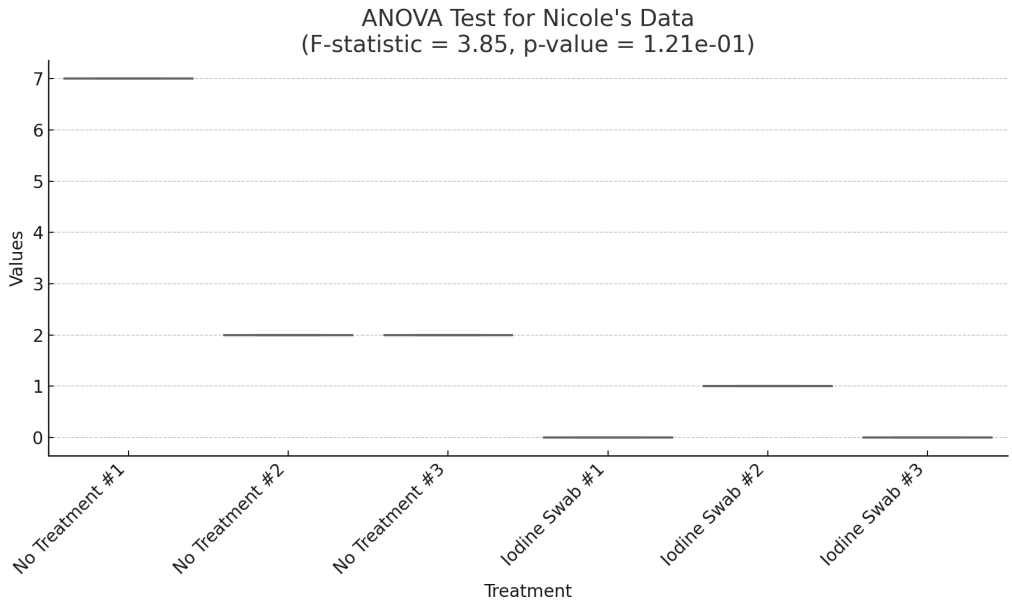

Figure A: ANOVA test for NT vs. Iodine. No significant difference between NT and Iodine treatment since $p > 0.05$.

Figure B: NT vs. Detergent

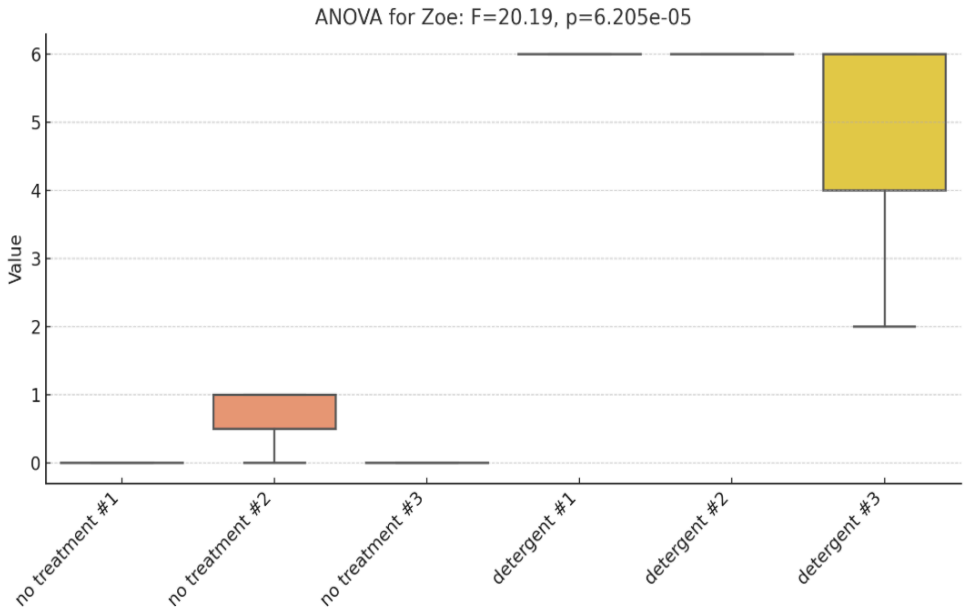

Figure B: Significant difference was detected since $p < 0.05$; Results may be inconclusive.

Figure C: NT vs. H2O2

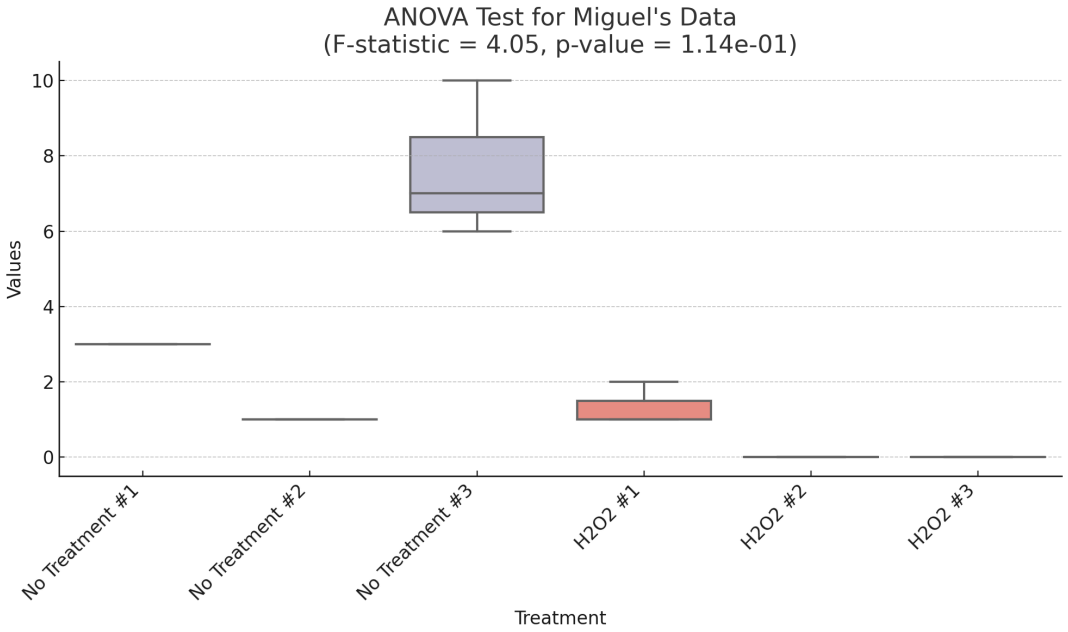

Figure C: No significant difference was detected since $p > 0.05$.

Figure D: NT vs. Bleach

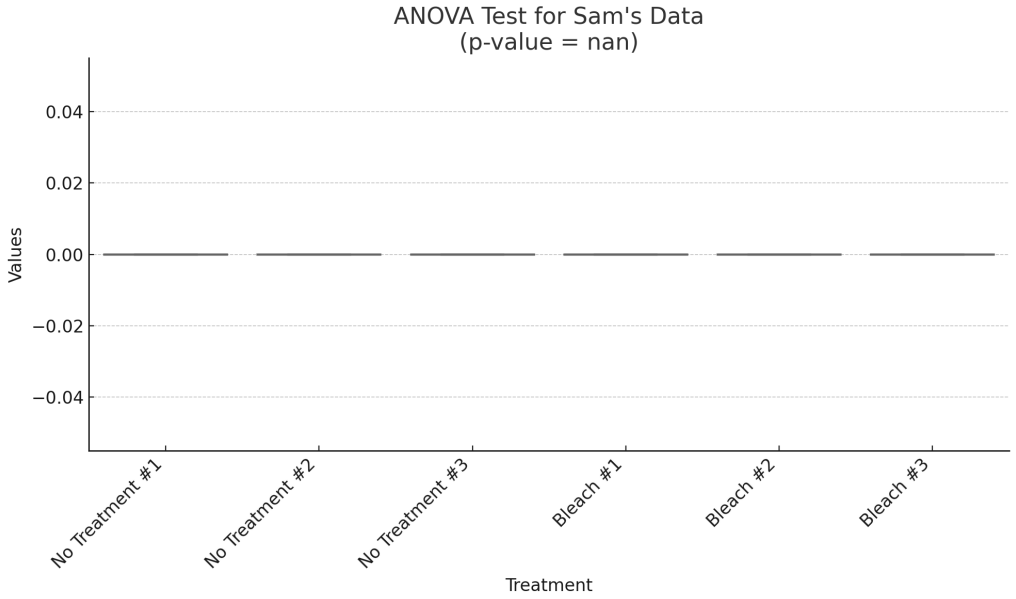

Figure D: All values remained constant during this trial and thus results are undefined.

Figure E : NT vs. 70% Ethanol

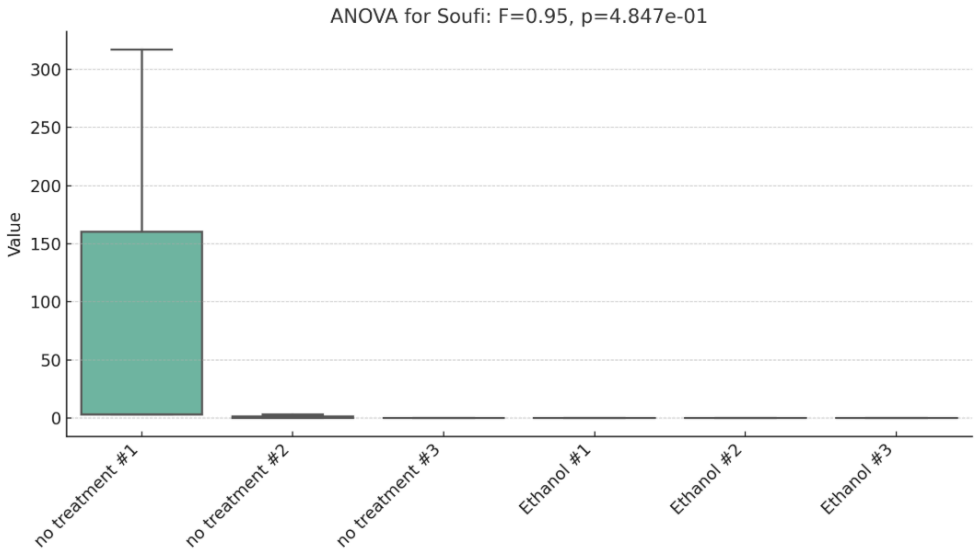

Figure E: No significant difference was detected since $p > 0.05$.

Table 2: Average Percent Reduction of Colony Growth

Treatment	Average Percent Reduction
2.5% Iodine	83.3% effective
Sodium Lauryl Sulfate (Detergent)	-72.23% effective
3% Hydrogen Peroxide	81.3% effective
1% Bleach	N/A
70% Ethanol	100% effective

Table 2: 70% ethanol was measured to be the most effective in eliminating bacterial colonies as its treatment plates were observed to have no bacterial growth. Sample calculation can be found in Appendix II. Detergent treatment increased bacterial growth, while bleach treatment values remained constant and effectiveness could not be measured.

Discussion:

Original hypotheses predicted the effects of bleach-based cleaners to be most effective as it is the strongest oxidizing agent that can disrupt both proteins and lipids of a bacterial cell, thus having the strongest effect in disinfection. Majority of the plates by week 2 had no bacterial growth, as well as the control dH_2O agar plates, thus proving sterile techniques as well as swabbing consistency posed no issue. Most initial plates after 144 hours had no bacterial growth. Literature states that bacterial growth should be present after approximately 24 hours of incubation at 37℃. Because no growth was detected on the initial plates, it suggests that inorganic surfaces may play a role in bacterial life cycles on device surfaces. Nutrient-based agar plates could be used in future to determine if bacteria was present, but was simply depleted in nutrients thus died before growth could be observed on the initial plates. Bleach results were inconclusive as a result of this. No bacterial growth was present neither initially nor finitely, thus values remained constant and no conclusions could be made.

Agar plate labeled *zoephone_october 27_115pm_detergent_swab2* had growth, (after treatment), even though the initial plate (no treatment) had no bacterial growth. Surfactants primarily trap dirt/debris and lower surface tension when liquids are applied to be able to remove these dirt molecules. Because sodium lauryl sulfate (detergent) is more commonly used as a surfactant, as opposed to a disinfectant, it is likely that the detergent allowed the spreading/trapping of bacteria along the device screen that was later picked up by the swabs done post-treatment, rather than eliminating bacteria, explaining the negative effectiveness.

ANOVA tests were done to determine significance of the results of the 5 treatment plans. As iodine, ethanol, and hydrogen peroxide are all deemed 80%+ effective in eliminating bacterial growth, with no statistical difference between each treatment.

During the course of the procedure, limitations such as inconsistency among swabbing techniques impact the data reliability. Inconsistent pressure, angle, and/or coverage during swabbing could lead to fluctuations in the detection of microbial presence, making comparisons less accurate. Alternatives for future procedural methods may look at using a mechanical swabbing device, or having one person designated for swabbing during the course of the whole experiment. A larger sample size also could have been used to be more representative of broader populations and more robust in terms of concluding patterns/trends. Furthermore, each device was exposed to different environmental conditions, affecting microbial exposure in ways not directly accounted for. This variability could be mitigated by isolating devices and/or grouping devices based on similar exposure environments.

Future studies should also consider the effect of inorganic surfaces on microbial presence to be able to definitively suggest that no bacterial growth on initial agar plates is due to no bacterial presence. Additionally, all of the devices had screen protectors, which are often marketed as having antimicrobial properties to maintain hygiene. Moreover, the distance of the agar plate while swabbing from the sterile umbrella of the alcohol lab may have affected bacterial presence in the agar and/or the swab, if the swabbing was done too close to the lamp, bacteria may have been eliminated before it reached the agar plate. This is unlikely, as measurements were made at least 10 cm away from the sterile umbrella, but could be considered in future studies for safety purposes.

Conclusion:

Properties of surfactants, like detergent, that allow the adhesion of dust and other particles may contribute to microbial growth on surfaces, and the user should follow label instructions to not only properly handle the solution but also mitigate these unwanted effects when used on surfaces. Bleach is widely known as a powerful disinfectant that also poses harmful hazards and requires dilution for safe experimental handling. While the scope of this study could not conclusively recommend its use, the absence of bacterial growth in bleach-treated trials aligns with existing literature, confirming its effectiveness. Lack

of growth post-treatment suggests the efficiency of cleaning products; This leaves the suggested products to be 70% ethanol, which was deemed to be the most effective in eliminating bacterial growth, with both 2.5% iodine and 3% hydrogen peroxide serving as strong alternatives. As such, it can be concluded that ethanol, iodine, and hydrogen peroxide are reliable and effective surface cleaners for smartphones. These products are readily available in local grocery stores at affordable values thus disinfecting maintenance is readily available and should be employed to disinfect devices and mitigate disease transmission.

References:

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On behalf of me and my colleagues, we thank you.

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Appendix

Appendix I: Colony Count Measured In Lab

Sample	Nov 4th	Nov 6	Nov 7	Nov 14
Nicole no treatment #1	0.0	7.0	7.0	X
Nicole no treatment #2	0.0	2.0	2.0	2
Nicole no treatment #3	0.0	2.0	2.0	X
Nicole Iodine swab #1	0.0	0.0	0.0	X
Nicole Iodine swab #2	0.0	1.0	1.0	X
Nicole Iodine swab #3	0.0	0.0	0.0	X
Zoe no treatment #1	0.0	0.0	0.0	0
Zoe no treatment #2	0.0	1.0	1.0	0
Zoe no treatment #3	0.0	0.0	0.0	X
Zoe detergent #1	0.0	6.0	6.0	X
Zoe detergent #2	1.0	6.0	6.0	6
Zoe detergent #3	0.0	6.0	6.0	2
Miguel no treatment #1	1.0	3.0	3.0	3
Miguel no treatment #2	1.0	1.0	1.0	X
Miguel no treatment #3	2.0	6.0	7.0	10
Miguel H2O2 #1	1.0	1.0	2.0	1.0
Miguel H2O2 #2	0.0	0.0	0.0	0
Miguel H2O2 #3	0.0	0.0	0.0	0
Sam no treatment #1	0.0	0.0	0.0	0
Sam no treatment #2	0.0	0.0	0.0	X
Sam no treatment #3	0.0	0.0	0.0	0
Sam bleach #1	0.0	0.0	0.0	0
Sam bleach #2	0.0	0.0	0.0	0
Sam bleach #3	0.0	0.0	0.0	0
Soufi no treatment #1	0.0	3.0	3.0	317
Soufi no treatment #2	0.0	0.0	0.0	3
Soufi no treatment #3	0.0	0.0	0.0	0
Soufi Ethanol #1	0.0	0.0	0.0	X
Soufi Ethanol #2	0.0	0.0	0.0	0
Soufi Ethanol #3	0.0	0.0	0.0	0
dH2O #1	0.0	0.0	0.0	0
dH2O #2	0.0	0.0	0.0	0
dH2O #3	0.0	0.0	0.0	0

Appendix II: Sample Calculation for Percent Change Effectiveness

1. $(No\ Treatment\ \#\ /\ Treatment\ \#)\ *\ 100\ =\ Percent\ Change\ for\ Treatment\ on\ Date$
2. $(\sum Percent\ Change\ for\ Treatment\ on\ Date(s))/3\ =\ Average\ Percent\ Change\ of\ Treatment$
3. $Average\ Percent\ Change\ of\ Treatment\ =\ Measured\ Effectiveness\ of\ Treatment$