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Comparing the effectiveness of various hand-sanitizers against *E. coli*

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Abstract
Objective: The objective of this research is to experimentally compare the effectiveness of various hand-sanitizers, both commercial and home-made, against *E. coli* bacteria (Strain K-12).
Method: An agar plate with *E. coli* bacteria plate was prepared and using sterile discs saturated with the particular anti-bacterial solution, the zones of inhibition of the different samples (4 commercial, 1 home-made, 1 control) were compared to correctly determine which solution was most effective against the particular bacteria.
Results: The Wellness tree anti-bacterial gel was found to be the most effective with a zone of inhibition of diameter of 0.85cm followed by Zuci Junior with 0.75cm, Himalaya Pure Hands with 0.65cm, and Dettol with 0.60cm. The home-made solution ($5/7^{th}$ 77% isopropyl alcohol + $2/7^{th}$ aloe vera gel) was found to be the weakest of all solutions with a zone of inhibition of diameter of 0.55cm, just 0.05cm outside the boundary of the circular disc (0.5cm in diameter). The control disc showed no inhibitory action.
Conclusion: From the above results, we could conclude that there exist minor fluctuations in the efficacy of the different commercial hand-sanitizer and that that of the home-made solution was below that of the commercial solutions. This allows us to predict which solution would be more reactive and more effective in a bacteria-laden environment.

Keywords: hand-sanitizer, *E. coli*, public health, sanitation, effectiveness, anti-bacterial

Introduction
Over the years, I have noticed that my hands would react vigorously to hand-sanitizers. The anti-bacterial gel could cause my skin to burn with a slight redness, but the degree to which this happened varied. This led me to wonder why this burning sensation was different for different sanitizers, or why some sanitizers were more reactive than others. With research, I understood that this difference was due to differences in the effect on live bacteria. During my internship at the Shri Baidyanath Research Institute, an ayurvedic pharmaceutical institute, I learned in detail the manner in which the effectiveness of their antibacterial medicines was experimentally tested. Using the breadth of knowledge I gained from my time there, I decided to investigate, through experimentation, the effectiveness of different hand-sanitizers against bacteria, or more specifically, *E. coli* strain K-12.

Background Information
A hand-sanitizer, by definition, is an alcohol based liquid that is generally used to decrease the count of infectious agents on the hand. The active ingredient in hand sanitizer, usually alcohol, disrupts the coating of virus and bacteria particles. By damaging the outside of the particle, the virus becomes deactivated. The sanitizer works on contact, meaning it's only effective on the parts of your hands that it touches. That means if you miss a spot between your fingers, there could still be viruses or bacteria in that place. Research shows that alcohol hand sanitizers do not pose any risk by eliminating beneficial microorganisms that are naturally present on the skin. The body quickly replenishes the beneficial microbes on the hands, often moving them in from just up the arms where there are fewer harmful microorganisms. However, alcohol may strip the skin of the outer layer of oil, which may have negative effects on barrier function of the skin. A study also shows that disinfecting hands with an antimicrobial solution results in a greater barrier disruption of skin compared to alcohol solutions, suggesting an increased loss of skin lipids.

Reasons to Use and Some Myths
Generally, people use hand-sanitizers when they are unable to wash their hands with soap or after making contact with a surface in a public area (e.g., public transport, shaking hands with someone, touching something dirty, before having food in a restaurant, etc.) that is exposed to bad bacteria.
While sanitizers have their benefits, they are also not necessarily a form of "be all, cure all" for all situations.

- Sanitizers may kill up to 99.9% of germs. However, the bacteria that survive tend to develop a form of immunity against the particular anti-bacterial gel.
- Sanitizers can't keep flu viruses away as they have antibacterial properties that kill bacteria but not viruses.
- Some experts state that the more we grow in a sterile environment, the more allergies we may develop in the near future. Exposure to different types of bacteria, especially early in life, helps kids' immune systems develop.

Experiment
Research Topic
"To experimentally compare the effectiveness of different hand-sanitizers, both commercial and home-made, against bacteria".

Hypothesis

1. The effect of different commercial hand-sanitizers against live bacteria is slightly different to one-another.
2. The effectiveness of the home-made solution against bacteria is lesser in comparison to that of commercial hand-sanitizer solutions.

Variables

Table 1

Independent Variable	Brand of hand sanitizer
Dependent	Number of bacteria colonies formed after 48 hours
Controlled	Volume of sanitizer, temperature, air pressure

Materials Required

1. Samples of different commercial hand-sanitizers. For this research, hand-sanitizers of brands Dettol, Wellness Tree, Himalaya, Zuci Junior.

Fig 2

2. Sample of homemade hand-sanitizer solution (5/7th 77% isopropyl alcohol + 2/7th aloe vera gel).
3. Sterile discs (1 per hand-sanitizer and 1 for control). Alternatively, disks may be made using a hole punch and filter paper, but they will need to be sterilized in the oven.
4. 1 Nutrient Agar Plate.
5. Sterile cotton-tipped applicator swabs. Alternatively, cotton-tipped swabs from a new, unopened box may be used.
6. *E. coli*, strain K-12.
7. Forceps. Alternatively, tweezers may be used.
8. Permanent Marker.
9. Incubator for bacterial culture plates.
10. Ruler, metric (least count=0.5mm)

Procedure/Method

1. Use the permanent marker to label the sterile discs as per the brand of hand-sanitizer, and then sterilize the discs in a 300°C oven for 30 minutes.
2. Divide the top of the nutrient agar plate into 6 equal sections (5 hand-sanitizer solutions + 1 control (without any solution)).
3. Using a proper sterile technique, inoculate each plate uniformly. Dip a sterile cotton-tipped applicator swab in the K-12 *E. coli* bacterial solution and gently wipe the swab over the surface of the plate, swabbing in three directions (120° apart) to ensure complete coverage of the plate. Cover the plate and wait at least five minutes for the plate to dry.
4. Hold a single sterile disc by the edge with sterile forceps and dip it into the sanitizer solution to be tested (make sure it matches with the label on the disk). Touch the disk against the side of the container to drain off excess liquid.
5. Use sterile forceps to place a single disinfectant disc in the center of each of the marked sections on your test plates. Use the forceps to gently press each disk against the agar surface to insure good contact. Remember to use the exact same technique for each disk—consistency is very important for this experiment. Make note of which brand sanitizer saturated disc is present in which section of the nutrient agar plate.

Fig 3

6. Incubate the plate, with the nutrient agar on top (inverted), overnight at 37°C or for longer if incubator is set at a lower temperature.
7. Take the plate out of the incubator and examine the zones of inhibition for the different sanitizer solutions.

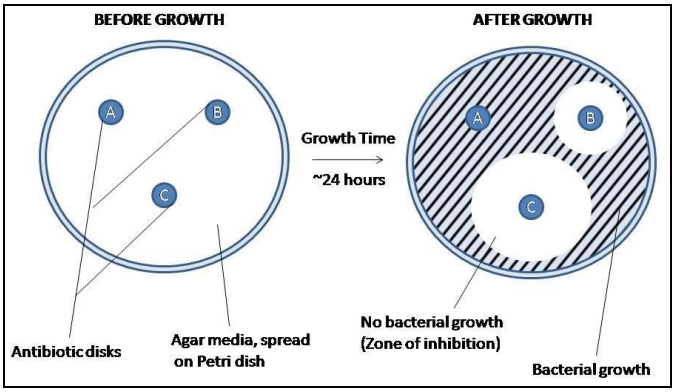

Fig 4

Results
Observations/statistics

Table 2

Hand Sanitizer brand (Commercial/Home-made)	Diameter of Zone of Inhibition (cm)
Dettol (Commercial)	0.60
Wellness Tree (Commercial)	0.85
Himalaya Pure Hands (Commercial)	0.65
Zuci Junior (Commercial)	0.75
5/7th 77% isopropyl alcohol + 2/7th aloe vera gel (Home-made solution)	0.55
No hand-sanitizer (Control)	No inhibitory action

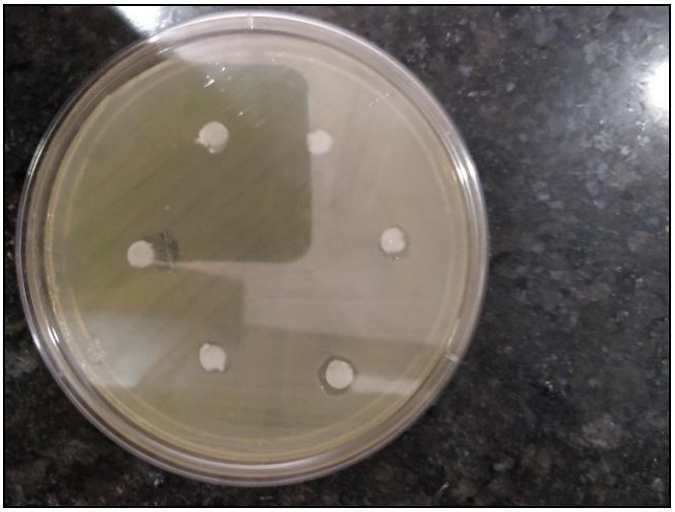

Fig 5

Conclusion

Note: We understand that the anti-bacterial solution with the largest zone of inhibition (measured in terms of its diameter) has the strongest effect on *E. coli* bacteria and vice-versa. According to the experiment along with the above understanding, we can conclude that the strongest hand-sanitizer solution is Wellness Tree whereas the weakest is the home-made anti-bacterial solution.

Wellness Tree > Zuci Junior > Himalaya Pure Hands > Dettol > Home-made hand-sanitizer

As for our hypothesis, we can conclude that both parts are, in fact, correct according to our experiment. The zones of inhibition of the four commercial hand-sanitizers differ slightly and that of the home-made anti-bacteria solution is less than that of its commercial counterparts.

What is extremely surprising, however, is that the effect on *E. coli* bacteria of all anti-bacteria solutions is minimal. This could prove to be an alarming concern amongst those of us who depend on such solutions rather than good old hand-washing!

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