What is the Difference Between Expensive Surgical/Cloth Masks and Cheap Surgical/Cloth Masks? Should One Be Preferred Over the Other?

Purpose

The purpose of this project is to determine which mask is the most effective to use against respiratory bacteria and virions.

Abstract

COVID-19: The pandemic that initiated mask mandates around the world has been controversial, partly due to mask effectiveness. The purpose of this experiment is to determine which masks are the most effective against bacteria. Testing if bacteria can pass through the masks will indicate their ability to prevent viral transmission; viruses are approximately 100 times smaller than bacteria. In this experiment, five of the most popular masks were tested; one-ply cloth, two-ply cloth, cheap surgical, expensive surgical, and KN95. Each was tested twice for effectiveness other than one-ply because the initial results could not be determined due to high water absorption. Brain-Heart Infusion Agar was used to test which mask allowed the least amount of respiratory bacteria (Neisseria sicca) to pass through and grow. The initial hypothesis stated the KN95 mask would have the most protection since it is recommended by the CDC and medical experts. After observing the first trial, an alternate hypothesis suggested the cheap surgical mask would have the most protection due to its non-absorbent material. Studies show bacteria pass through wet materials more easily than dry. The BHI Agar is composed of bovine and porcine cells, amino acids, and glucose to cultivate the Neisseria sicca in a suitable environment. This experiment is closely related to reality, considering how these aerobic bacteria are found in the respiratory system; they were also grown in agar made of mammal cells and essential organic molecules. The final results indicate the cheap surgical mask was the most effective of the five.

Introduction

Masks are currently being used worldwide as an urgent response to the COVID-19 pandemic. Throughout several months, masks have been developed in different materials and sizes, some being up to $30 each, and some as low as $1. Which mask is the most effective against COVID-19, regardless of price? In this experiment, five of the most popular masks were collected; one-ply cloth, two-ply cloth, cheap surgical, (C.S.), expensive surgical (E.S.), and KN95. According to studies, KN95 masks are known to have electrostatic filtration and are the most effective of the five used in the experiment.

The initial hypothesis stated that if masks that are more expensive provide more safety and reduce the risk of getting a bacterial infection or a virus, then KN95 or (expensive) surgical masks should be used because they have been proved to be highly effective by medical experts and have better protection against bacteria or viruses trying to get in through the mask. The experiment was conducted twice to ensure repeatable results that would either support or disprove the initial hypothesis. However, the initial hypothesis was reformulated after observing the first trial because it was noted that the C.S. mask was the most effective possibly due to its material and low water absorption.

There were few experiments on the effectiveness of masks against bacteria online which prompted the experiment to discover which mask was the most effective against bacteria rather than viruses. Using a unique approach, five of the most popular masks were tested using bacteria instead of viruses to determine if prokaryotic cells could pass through the masks. Bacteria are larger in size than viruses, thus, assuming if bacteria can pass through, viruses should pass through more easily. Without assuming extraneous variables, the fewer bacteria that pass through the mask and onto the BHI agar, the fewer viruses will pass through as well. The initial expectation of this experiment was to determine if the KN95 mask offers the most protection as discovered in the research.

Procedure

1. Materials were collected: Brain Heart Infusion Agar Plates, Live Neisseria sicca, five types of masks (one-ply, two-ply, cheap surgical, expensive surgical, KN95), incubator, ruler, map pins, wire cutter, 50 ml beaker of water, dropper, compound light microscope
2. Table surfaces were cleaned thoroughly with Envirocleanse A (disinfectant)
3. BHI Agar plates, Neisseria sicca tube, ruler, map pins, wire cutter, and masks were placed on the table
4. Each mask was taken out of the plastic bag and cut in half (the extra went back into the bag) and then into 6" by 6" squares in the middle [sides (thick material) was avoided]
5. Twenty map pins were cut to fit the depth of the agar (about 1") and pinned through the corners of each mask (four pins were used for each mask)
6. Masks were carefully placed on the agar (inside part facing the agar) and pins were pushed through the agar to keep the mask in place
7. Using an inoculating loop, about half of Neisseria sicca was collected on the inner part of the inoculating loop and spread on the surface of the mask
8. Each Petri dish was taped securely using three pieces of tape
9. The Petri dishes were then taped together, flipped over, and placed in an incubator for one week
10. Results were measured by counting the number of colonies present on each dish, the length and width (or diameter) was measured to make a conclusion
11. All materials were sterilized and sanitized after experimentation was done, agar plates were cleaned with ammonia, put in a plastic bag, and thrown in the trash
12. Repeat steps 1-11 again for the second trial
13. Petri dish with the least bacteria colonies on the agar plate (not on the mask) was deemed/concluded that it is the most protective and vice versa
14. (Optional) Bacteria was scooped from the agar and was diluted in water; one drop of the solution was collected on a slide and observed under a compound light microscope [on low power (10x) and high power (40x)]

Samples of Neisseria sicca

Results and Data Analysis

Amount of Bacterial Growth on Five Different Masks After a Seven Day Period

Trial #	Measurement (average)	Control	One-Ply Cloth	Two-Ply Cloth	Cheap Surgical (C.S.)	Expensive Surgical (E.S)	KN95
1	Length (longest bacterial spread)	5 cm	Could not be determined	7.3 cm	(Diameter of largest colony) 0.5 cm	7.2 cm	7 cm
	Width (perpendicular to length)	3.7 cm	Could not be determined	5.4 cm	(Diameter of smallest colony) 0.2 cm	5.3 cm	5.5 cm
2	Length (longest bacterial spread)	Not tested	Not tested	9 cm	6.7 cm	6.5 cm	7.5 cm
	Width (perpendicular to length)	Not tested	Not tested	7.5 cm	6.5 cm	5.4 cm	5.3 cm

Figure 1

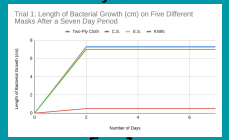
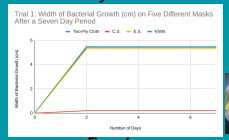


Figure 2



Trial 1 Results

Figure 3

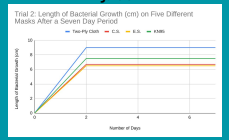
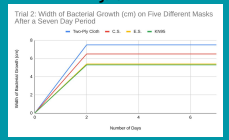


Figure 4



Trial 2 Results

After being incubated for one week, the bacterial growth on the Petri dishes was measured by length (longest bacterial spread) and by its width (perpendicular to the length). According to the data table and Figures 1 and 2, the C.S. mask was the most effective, because it had the least amount of bacteria passing through the mask after one week. However, according to Figures 3 and 4, the results are mixed. For example, while the KN95 has the second longest bacterial spread in Figure 3, it has the fourth widest bacterial spread in Figure 4. Another example is how the C.S. has the third longest bacterial spread in Figure 3 and the second widest bacterial spread in Figure 4. This also differs from the results of Trial 1, where the C.S. had the least long and wide bacterial spread as shown in Figures 1 and 2. The results of the experiment were ultimately determined by qualitative observations. In this case, the C.S. had the most transparent "lawn" of bacteria when compared to the rest. The results of the one-ply mask could not be determined due to high water absorption. However, there were some visible colonies on the surface area around the mask. Overall, the results stayed generally the same for the two-ply cloth, E.S., and KN95 for both qualitative and quantitative observations, the thickness and transparency of the bacterial "lawn" were similar and the measurements of the length and width were about the same in both trials. Alternatively, the C.S. mask had somewhat of a similar thickness and transparency of bacteria, but the measurements were completely different; instead of having a bacterial "lawn", the first trial was observed as separate colonies, while the second trial had a bacterial "lawn." Each petri dish in the first trial reached its carrying capacity after two days, while the second trial reached its carrying capacity after three days. The temperature of the incubator was set to 35℃ in both trials, an optimal temperature for bacteria growth. In the first trial, bacteria did not spread as much and stayed in distinct colonies on the C.S. mask; the biggest colony measured 0.5 cm, while the smallest measured 0.2 cm. However, in the second trial, the bacteria spread out instead of staying in colonies. The length of the C.S. mask was measured to 6.7 cm and the width was measured to 6.5 cm. The second most effective was the E.S. mask, the third was the KN95, and the least was the two-ply cloth mask. In the first trial, the KN95 mask had a length of 7 cm and a width of 5.5 cm. In contrast, in the second trial, the KN95 mask had a length of 7.5 cm and a width of 5.3 cm. Some qualitative observations that were noted were the thickness and transparency of the bacterial growth on each mask and the textures of the masks. The C.S. mask is ranked for having the thinnest bacterial growth because the texture of the mask is clearly seen through the bacteria. The E.S. is ranked second, the two-ply cloth is ranked third, and the KN95 had the thickest bacterial "lawn" in both trials. The material of the C.S. mask was quite different from the others. Streaking the plates on the C.S. using an inoculating loop due was difficult because the material was rough and shifted when trying to spread the bacteria. This material also had the least water absorption compared to the rest, while the one-ply had the most due to its elasticity and transparency. That is why the results could not be determined for that mask even though there was little bacterial spread on the surface area surrounding the mask.

Conclusion

The purpose of this experiment was to test the effectiveness of the five most popular masks: one-ply cloth, two-ply cloth, cheap surgical (C.S.), expensive surgical (E.S.), and KN95. The initial hypothesis stated that if masks that are more expensive provide more safety and reduce the risk of getting a bacterial infection or a virus, then KN95 or (expensive) surgical masks should be used because they have been proved to be highly effective by medical experts and have better protection against bacteria or viruses trying to get in through the mask. After testing the first trial, the alternate hypothesis suggested that the C.S. mask was the most effective due to its material and low water absorbency. The alternate hypothesis was supported by the results of both trials. The relationship seen between the independent variable, type of mask, to the dependent variable, amount of respiratory bacteria (Neisseria sicca), that pass through the mask and grow on the BHI agar is almost entirely dependent on the material and water absorbency. This can be supported with data and observations. As it is seen, the results of the one-ply mask could not be determined due to its high water absorption and the fact that the company manufactured it as a microbial mask. A microbial mask kills bacteria and germs on the surface of the mask, this also contributed to the fact why results could not be seen. The one-ply mask was also very thin and elastic, which made it very absorbent. On the other hand, the C.S. mask was deemed the most effective due to its material and water absorbency. The material was very rigid and dry, it was hard to pull apart, and it showed little to no water absorption. Studies show that bacteria can easily pass through wet material compared to dry material. The thickness of the bacteria "lawns" and spread varied throughout the different mask types as seen in the data analysis. In conclusion, the alternate hypothesis was supported by the results and the C.S. mask proved to be the most effective out of the five.

Limitations

Some limitations and errors were caused by introducing additional variables accidentally. Additional variables that may have affected the data were the exact distribution of bacteria, the precise amount of bacteria scooped up by the inoculating loop from the culture tube, the time of mask exposure to air, using a thin microbial one-ply mask, accidental splits in agar with the use of pins, using a masks with different water absorbency, the amounts of condensation in each plate, and the streaking technique. These limitations and errors could have affected the results in various ways, such as the different materials of the masks. There were also uncontrollable variables as well such as bacteria and possibly virions present in the surrounding air during the experiment. These variables will forever exist and cannot possibly be rid of completely.

← This is the two ply cloth mask. As it is seen, there are splits in the agar. This was an error but could possibly be an additional variable.

← This is the one ply cloth mask. As it is seen, there is no bacterial residue on neither the mask nor the where the mask was on the agar, except on surrounding areas.

Areas for Future Study

If this project were to be repeated, instead of testing five completely different masks, five similar masks could be tested from different manufacturers. Another variable that would be changed would be the one-ply cloth mask, which was microbial. This was an error that greatly affected the outcome of the experiment. It completely got rid of one variable due to the inability to get determinable results. The last variable that could be changed is getting a different "cheap surgical" mask, possibly one that has similar absorbency to the other masks that will be tested. Another experiment that could be conducted in relation to this experiment would be testing the survival rate of bioaerosols on different masks in order to determine their effectiveness by blocking the most bioaerosols. The same masks from the initial experiment could be used, as well as masks of similar material and texture from different manufacturers. This experiment can determine the effectiveness and the microbial viability of each mask.

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