SIMULATING AIRBORNE TRANSMISSION OF SARS-CoV-2 AMONGST BUS RIDERS

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Checkpoint #1, DSC 180a

Introduction

COVID-19 has drastically changed the way we live our lives. As of October 2020, there have been 45.5 million cases in the world and around 1.19 million deaths, making it one of the worst epidemics in history [1]. There have been large efforts made in order to slow the spread of the disease and a lot of research is being done to find a vaccine. However, until a vaccine is created, it’s important to understand how the virus works and how it spreads in order to prevent future epidemics from happening. One of the largest industries affected by COVID-19 has been the transportation industry; as mandated quarantines were set around the world and more and more people became fearful of infection, the airline industry has lost nearly 314 billion USD. New research supports airborne transmission being one of the largest factors of the spread of the disease, and with public transports generally being small areas with recirculating air, it’s important to understand how the virus is spread and how air conditions can affect it. In doing so we can set effective guidelines that enable air to be cleaner and prevent the spread of these respiratory droplets, thus minimizing the transmission of COVID-19.

Problem Context

What makes COVID-19 such a dangerous disease is the fact that it is so easily transmittable. Early research has shown that COVID-19 is transmitted typically through respiratory droplets from coughing, sneezing or talking. One of these research papers observed an early rapid transmission of the virus during bus travel after an event in China [2]. This paper ultimately concluded that infection rates varied greatly between the event and the bus and largely attributed the difference due to the smaller area within the bus along with the recirculating air due to the air conditioning. Additional research inspired by this research paper can help us better understand how airborne transmission of the virus occurs and what the best air conditions might be in order to minimize the spread of the disease.

Description of the Observed Data

The research paper we’re replicating is an observational study that studies a worship event and the bus travel that followed shortly after. The event had initially started off with 300 individuals with only one having COVID-19[1]. After the event, 128 of the 300 individuals travelled by bus, with 60 participants going in bus one and 68 going in bus two. Both busses had relatively similar conditions: the air conditioning system was on a heating and recirculating mode, weather conditions were the same, and passengers remained seated during the whole duration on both busses.

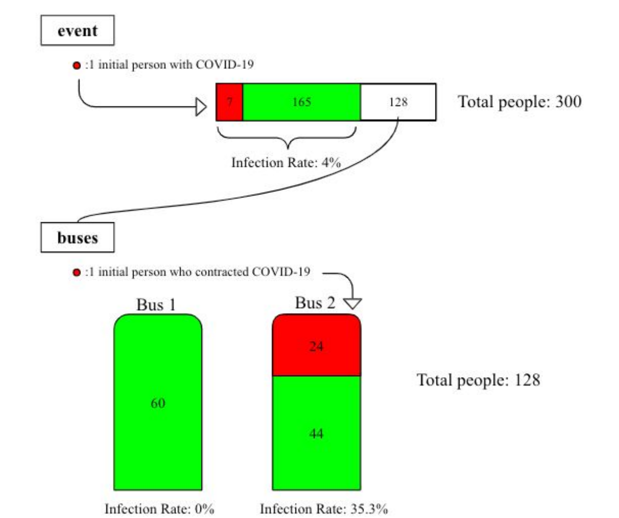

Figure 1. A visual representation of the event and the bus, with red representing those who are infected, green representing those who are uninfected, and white representing those on the bus.

After the initial participant began to experience symptoms and received the diagnosis of COVID-19, the rest of the participants began to get tested. It was found that none of the individuals in bus one were infected but 24 individuals in bus two were infected (leading to a 35.3% infection rate). Surprisingly, of the 172

[1] All participants were diagnosed by throat swabs a few months after the event

individuals who did not travel by bus after the event, only 7 were infected (leading to a 4% infection rate). Even more surprising was that the 24 individuals that were infected on bus two were scattered amongst the bus, rather than grouped closely together. A visual representation of these results can be seen below in Figure 1.

As mentioned within the research paper, the much larger infection rate within the bus along with the lack of a significantly increased risk depending on seat location suggests that the airborne spread of the virus most likely plays a significant role in the transmission of the disease. This data is extremely helpful in our investigation and will help us better simulate the airborne transmission of the disease within a small location. By simulating the transmission of COVID-19 within the air based on these findings, we can hopefully develop an accurate simulation that can then later be applied to larger areas.

A Description of the Data Generation Process

In order to simulate airborne transmission of COVID-19 we'll utilize agent based modeling which is a system modeling the interaction between agents within an environment over time. In this simulation, agents will be the passengers within the bus and the environment will be the two different busses. We are utilizing a package called mesa which will help us with our agent based model. These agents will remain stagnant within the bus, and each agent will have an additional airborne transmission habit variable. This variable is a random probability of the agent coughing or sneezing. Because large droplets are spread at different distances depending on whether an agent breathes, coughs, or sneezes, we can then implement more realistic airborne transmission habits and simulate a more accurate airborne transmission. We can then use a random probability of infection to determine whether the agents around the agent get infected after a breath, cough, or sneeze.

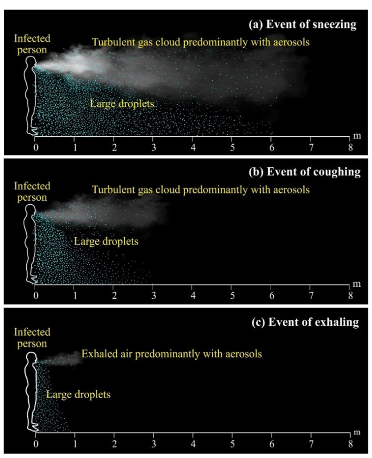

Figure 2. Research done showing the distances large droplets spread based on sneezing, coughing, and breathing [3].

Based on research, it seems that breathing spreads large droplets approximately one meter forward, coughing spreads large droplets approximately 3 meters forward, and sneezing spreads large droplets approximately 6 meters forward [3]. This research can also be found in Figure 2. We can utilize this information and accurately portray it in our model. We will then run the model step by step with each step being an airborne action (whether it be breathing, coughing or sneezing). Assuming that the average person breathes around 16 breaths per minute, we will aim to simulate around 800 breaths to match the 50 minute bus ride done in the research paper.

Additionally, we will attempt to simulate recirculating air by simulating air flow going down the middle of the bus, thus taking into account not only the spread of large droplets due to airborne action but also due to air conditions present in the environment. In the future we hope to make the model adjustable, with the ability to change the rate of air flow, probability of airborne actions, and other settings.

References

[1] "Template:COVID-19 Pandemic Data." *Wikipedia*, Wikimedia Foundation, 30 Oct. 2020, en.wikipedia.org/wiki/Template:COVID-19_pandemic_data.

[2] Shen Y, Li C, Dong H, et al. Community Outbreak Investigation of SARS-CoV-2 Transmission Among Bus Riders in Eastern China. JAMA Intern Med. Published online September 01, 2020. doi:10.1001/jamainternmed.2020.5225.

[3] Jayaweera M, Perera H, Gunawardana B, Manatunge J. Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy. Environ Res. 2020 Sep;188:109819. doi: 10.1016/j.envres.2020.109819. Epub 2020 Jun 13. PMID: 32569870; PMCID: PMC7293495.