

Carleton Engineering Competition 2023

RATTS (Rapid Aerosol Testing and Treatment System)

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Bio-Engineering

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The “Whooping Cough” (*Bordetella pertussis*):

Bordetella pertussis (“whooping cough”) is a bacterial infection that targets a human's respiratory system, by entering through the mouth and damaging and killing the cilia in the lungs (ALA). The cilia clear the lungs of microbes and debris, thus a reduced number of cilia results in a large buildup of mucus leading to a whooping cough. The bacteria is extremely contagious with one person expected to infect up to 17 people, and affects 80-90% of susceptible people (ECDC, 2014). Symptoms can develop in three to five days but can take up to one week to fully develop. A patient suffering from the whooping cough would initially experience flu-like symptoms with little to no fever. This would develop to an intense coughing followed by a “whoop” (rapid air intake by the body). The coughing can reach intensities such that symptoms like appearing to be choking or gagging, complexion changing to blue/red due to lack of oxygen and can even cause broken ribs and result in hospitalisation. Patients are infectious from the onset of symptoms until up to 21 days later. Current treatment methods include both reactive and preventative methods (CDC, 2022). Antibiotics (azithromycin) which attacks the bacteria and prevent further bacterial growth (ALA). Different vaccines include the DTaP vaccine (for infants) and the Tdap vaccine (for adults and teens). Both of these methods inject bacterial load into the bloodstream to increase antibody concentration with DTaP being a full bacterial load and the Tdap dose being more of a booster load (Werner, C., 2020).

Containment Procedure:

The bacteria spreads by a contagious (symptomatic) person coughing and releasing droplets into the air containing the bacteria. Another person then either inhales these droplets, or touches a surface with them and touches their mouth, nose or eyes. The droplets can remain on surfaces for 3-5 days (PHA, 2011). The proposed containment procedure is a two week plan. Face masks will be supplied with an attachable PCR test swab and vaccine/antibiotic dispenser. This test allows for rapid bacterial identification via genetic code allowing sick patients to be rapidly identified and quarantined appropriately (CDC, 2022). As the patient breathes, fluid samples accumulate onto the swab and can be later tested for contamination. The testing assembly will include an aerosol DTaP vaccine (also retrofitted in the mask). Villagers that are sick/symptomatic will be treated with an aerosol antibacterial (azithromycin) spray using the same system as the vaccine to manage symptoms and reduce recovery time. In addition to the antibacterial spray, the distributed face masks will also be used as another layer of protection. Ongoing prevention and containment methods are as follows:

Category 1: Patient is not sick/symptomatic

- Avoid contact with sick people
- Wear mask when outside the household

Category 2: A person is symptomatic and is either unvaccinated OR has been vaccinated for less than 14 days

- Administer aerosol antibiotic spray to everyone in household once a day for 5 days (PHA, 2011)
- All household members must wear mask at all times
- Household should attempt to limit contact with people not in their household

Category 3: A person sick and has been vaccinated for at least 14 days

- If person is symptomatic: take antibiotic spray once a day for 5 days
- If person is asymptomatic: wear a mask for 7-10 days

The plan spans across two weeks to account for the time it would take to distribute materials and do rapid tests (1-3 days), treat the people that were already infected (and those in close proximity to them) such that they are no longer contagious (5 days), and then an additional week of testing to ensure that the number of positive cases has drastically declined, indicating that the epidemic is under control and the containment methods are effective. This containment procedure has limited effects on the community. Since it limits the severity and length of quarantines, villagers can continue to go out and live their lives as much as possible. This is crucial for two reasons. The first is if containment methods required an extreme change of behaviour or day to day life of people, it would be much more difficult to get everyone to participate, thereby drastically reducing the efficacy of that method. The second reason is so they can continue to do their jobs such as farming, which are crucial to the sustainment of their family, and village as a whole.

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