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| Math 667 Project Proposal |
| Implications of Antimicrobial Resistance for Common Bacterial Infections |
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# Description

For decades, humans have relied on antimicrobial drugs to treat bacterial and fungal infections. Some of which were the cause of widespread pandemics before antibiotics were discovered; such as the Plague, caused by the bacteria Yersinia pestis (Piret, 2021). Because of the use (and misuse) of these drugs, some bacteria and fungi have developed survival strategies, making infected individuals increasingly difficult to treat. Drug-resistant microbial infections are already considered “an urgent public health threat, killing at least 1.27 million people worldwide and associated with nearly 5 million deaths in 2019” (Centers for Disease Control and Prevention, 2022).

The proliferation of drug-resistant microbes means that diseases that are currently considered not a public health threat, may once again become pathogens that spark a public health emergency. Common bacterial infections include:

* Strep throat
* Gonorrhea
* Syphilis
* Pneumonia

In addition to bacterial infections being a potential primary pandemic driver, antibiotic resistance can also affect health outcomes for individuals infected by viral pathogens. In fact, most mortalities during the 1918 influenza pandemic were actually caused by bacterial pneumonia (National Institutes for Health, 2008).

This project will anticipate questions that a public health authority may request relating to an outbreak of antimicrobial resistant Streptococcus pyogenes (strep throat) and will provide an answer to these questions with a mathematical model.

# Background

Strep throat is caused by the bacteria Streptococcus pyogenes and has the following characteristics:

| Symptoms | Sore throat  Pain when swallowing  Fever  Red and Swollen Tonsils  Red spots on roof of mouth  Swollen lymph nodes |
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| Transmission | Respiratory droplets  Direct contact |
| Incubation period | 2-5 days |
| Most susceptible | Children 5-15 years old |
| Complications | Abscesses  Sinus infection  Ear infection  Rheumatic fever  Kidney disease |
| Testing | Rapid strep test  Throat culture |
| Treatment | Antibiotics |
| (Centers for Disease Control and Prevention, 2022) | |

If left untreated, Streptococcus can produce a toxin that causes scarlet fever, a condition that caused deadly worldwide pandemics in 1820 and 1880 and has had increasing outbreak frequency since the mid-1980s (Swedlund & K, 2003). The primary public health concern for an antimicrobial resistant strain of strep throat is the potential for an outbreak of scarlet fever that is highly transmissible, has a high mortality rate, and becomes increasingly difficult to treat.

# Public Health Questions

The goal of a public health authority is to preserve life and reduce transmission of debilitating infectious diseases. Assuming different data and information that may be available, some relevant health questions would be:

* Is there a mortality rate that could signal microbial resistant Streptococcus?
* What is the threshold of drug efficacy that would result in an epidemic?
* Assuming a certain level of drug efficacy, what would be the epidemic’s final state?

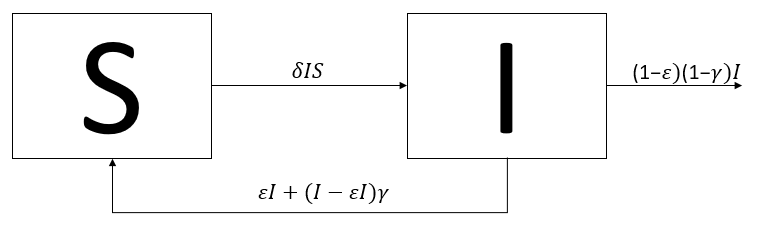
# Mathematical Modeling Approach

Given the characteristics of a strep throat infection, a simple SIS model with deaths would suffice as a starting point. Assumptions to simplify the model are:

* No acquired immunity
* Horizontal transmission
* Homogeneous mixing
* Rate of transfer is proportional to population size
* No latency period
* Death rate proportional to drug efficacy and baseline recovery rate
* Everyone who becomes infected takes antibiotics
* No new or removed susceptible hosts

The model will investigate the implications of decreasing drug efficacy.

# Preliminary Model



S := number of susceptible hosts

I := number of infected hosts

𝛿 := incidence rate

𝜀 := antimicrobial efficacy rate

𝛾 := baseline recovery rate

Links to potential data sources:

<https://dsol-smed.phac-aspc.gc.ca/dsol-smed/ndis/charts.php?c=pl>

<https://data.cdc.gov/Public-Health-Surveillance/Active-Bacterial-Core-surveillance-ABCs-Group-A-St/9y49-tura>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8393181/>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9102071/>

<https://www.gov.uk/government/publications/group-a-streptococcal-infections-activity-during-the-2021-to-2022-season/group-a-streptococcal-infections-report-on-seasonal-activity-in-england-2021-to-2022>

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