# Epidemiology Investigation

## Objectives

1. To model the epidemiological process
2. To use sampled data to determine “patient zero” in a population group
3. To calculate the R0 (“R-naught”) value for an epidemic

## Background

In this lab we will investigate the processes of **epidemiology**. Epidemiology is the study of the distribution and determinants of health-related states in a population. This includes the study of matters like the frequency and pattern of disease, as well as the causes and risk factors that contribute to the disease. But it doesn’t only include diseases – environmental exposure, injury, natural disasters, etc. impact human health and are therefore part of the study of epidemiology.

We will model the process of disease transmission by using identical Dixie cups to represent each person, taking samples at each point so that we can identify the point in time where each individual became infected. One person in the class (“patient zero”) is infected with sodium hydroxide. Basic solutions like sodium hydroxide react with the acid-base indicator phenolphthalein to produce a magenta color, so we can easily identify “infected” individuals at the end of the exercise. Each person will choose a different classmate to infect/be infected by simply by mixing the contents of their cups together and dividing the mixed solution between them. If you both mixed water, no problem – nobody’s infected. But if you mix with somebody that has some sodium hydroxide in their water, you become infected.

We will also attempt to calculate the R0 value for our model “disease”. This is a measure of how many new incidents of disease each infected person causes. For example, the H1N1 strain of the flu is estimated to have an R0 value between 1.4 and 1.6 (Fraser, Donnelly et al. 2009). This means that each person with the H1N1 flu strain infects about 1.5 people on average. An R0 value less than 1 means that the number of infected people in the population will shrink, just as a value more than 1 means that the number of infected people is increasing, and an outbreak or epidemic may be occurring. Estimates for Covid-19’s R0 vary somewhat, but have been estimated as high as 5.7 (Sanche, Lin et al. 2020).

**Materials**

15 (or more) Numbered Dixie cups approximately ¼ full with water

One Numbered Dixie cup ¼ full with 1M NaOH

Phenolphthalein dropper bottle

Dropper pipettes

4 Empty Dixie cups for sampling per student.

**Procedure (prior to lab)**

1. Prepare in secret a set of numbered cups with as many cups as students. If you have an odd number of students, prepare one for yourself as well; It is helpful if there is an even number of students; you will need at least 16 students for this to work well. Fill each cup ¼ full with tap water or distilled water
2. Prepare a single cup, also numbered, ¼ full of 1M NaOH

**Procedure (in lab)**

1. Each student should prepare 4 Dixie cups labelled with their name and letters A, B, C, and D. Similarly, each should label their dropper pipette with a tape flag or Sharpie label.
2. Direct each student to sample their Dixie cup with their dropper pipette. Take care that students do not mix up cups or dropper pipettes. This sample should be placed in cup “A”.
3. Direct each student to “mix bodily fluids” by pouring one cup into the other and back a couple of times until well-mixed. Divide the mixed solution as equally as possible between the cups. Each student should then sample their Dixie cup and place this sample in cup “B”.
4. Repeat the process by mixing with a new partner each time, and withdrawing a sample for cups “C” and “D”.
5. Each student should choose one last partner to mix with.
6. Finally, add a few drops of phenolphthalein to each cup, starting with A-D, and ending with the final cup itself. Record the data in the table on the page following:

My cup#:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |
| --- | --- | --- |
| Sample: | Mixed with (name or cup #): | Result after phenolphthalein addition |
| A |  |  |
| B |  |  |
| C |  |  |
| D |  |  |
| Final  |  |  |

1. Have students share data with each other to determine who was the original source of the sodium hydroxide “disease”. This person is “patient zero”.
2. Have each student determine how many people they directly infected. The average number of people directly infected is the R0 value of this disease. Don’t count individuals infected by people you infected (e.g. if A infects B and B infects C they both have an R0 of 1 from this interaction)

**Study Questions**

1. What effect does the R0 value have on the passage of disease? Given below are some R0 values for known diseases. Where does this one fit in? (Measles: 18, Mumps 10, Covid-19: 5.7, H1N1 Influenza: 1.5 )

2. How might you model the effect of vaccination on the disease model in this lab?

3. How does the mode of transmission affect the epidemiology of a disease? Consider diseases that involve close contact (HIV, Ebola) compared to droplet transmission (Flu, Covid-19).

**References:**

Fraser, C., C. A. Donnelly, S. Cauchemez, W. P. Hanage, M. D. Van Kerkhove, T. D. Hollingsworth, J. Griffin, R. F. Baggaley, H. E. Jenkins, E. J. Lyons, T. Jombart, W. R. Hinsley, N. C. Grassly, F. Balloux, A. C. Ghani, N. M. Ferguson, A. Rambaut, O. G. Pybus, H. Lopez-Gatell, C. M. Alpuche-Aranda, I. B. Chapela, E. P. Zavala, D. M. Guevara, F. Checchi, E. Garcia, S. Hugonnet, C. Roth and W. H. O. R. P. A. Collaboration (2009). "Pandemic potential of a strain of influenza A (H1N1): early findings." Science **324**(5934): 1557-1561.

Sanche, S., Y. T. Lin, C. Xu, E. Romero-Severson, N. Hengartner and R. Ke (2020). "High Contagiousness and Rapid Spread of Severe Acute Respiratory Syndrome Coronavirus 2." Emerg Infect Dis **26**(7): 1470-1477.