

Antibiotic Use and Resistance

What is the relationship between antibiotic use and the evolution of antibiotic resistance?



Warm up

Watch the video below from Harvard Medical School showing rapid evolution of antibiotic resistance in bacteria.

How do you think the pattern of evolution seen in the video would have looked different if the bands in the giant petri dish had alternated between large amounts of antibiotic and no antibiotic as the bacteria grew towards the middle band?



Background

Evolutionary pressures impact all life on earth. Even among single-celled bacteria, only the fittest survive. As you saw in the video, single-celled organisms are ideal for observing evolutionary dynamics because they can rapidly evolve as selected traits can be passed down from generation to generation in a matter of minutes.

Antibiotics have long been an effective weapon for killing bacteria that cause disease. Unfortunately for us, antibiotics are not 100% effective in killing all bacteria. Within any bacterial population there is natural genetic variation for the trait of resistance to antibiotics. When that bacterial population encounters antibiotics, the most resistant individuals will be the last to die and may even survive the antibiotic treatment. If only those highly resistant individuals survive, they will reproduce and the genes for antibiotic resistance that they pass on to their offspring will become more represented in the next generation. If this natural selection for antibiotic resistance continues, it is expected that the population as a whole may become resistant to antibiotics. It is easy to see how this could play out in a way that might be good for bacterial populations, but bad for humans.

In light of this evolutionary dynamic it is very possible that by frequently prescribing antibiotics, modern medicine is driving the evolution of more antibiotic resistant bacterial populations. If this is the case, we would predict that bacterial populations found in places where they frequently encounter antibiotics will evolve greater levels of resistance to antibiotics as compared to bacterial populations that encounter

antibiotics less frequently. What do the data have to say about this testable prediction?

Dataset

A high profile **2005 study published in the medical journal, The Lancet**, examined the rates of outpatient antibiotic use across a group of countries in Europe. We have pulled a subset of that data from that study from 19 countries from the year 2000. Each row in the dataset is a different country for which antibiotic use and penicillin resistance rates for the bacteria *Streptococcus pneumoniae* were measured.

Variables

Outpatient use of penicillin (DDD) - This numeric variable is a measurement of use of the antibiotic penicillin. It is measured in units of DDD, which is the assumed average maintenance dose per day, per 1000 people, for a drug used for its main indication in adults.

Penicillian Resistant Pneumoniae (%) - This numeric variable is an estimate of the level of antibiotic resistance of the *Staphylococcus pneumoniae* population within a given country. It is measured as a percentage of the total number of infections that are resistant to penicillins.

Country - This categorical value indicates in which European country the observations were made.

Activity

You will need to construct a graph in order to complete this activity. [Click here to see a short tutorial on graphing in DataClassroom.](#)

Clicking on any of the links within the text below will show you User Guide tutorials on those topics.

1) [Go to the Graph view](#) and show “Penicillian Resistant Pneumoniae (%)” on the Y-axis and “Outpatient use of penicillans (DDD)” on the X-axis. [Click the Regression line check box](#) that appears on the right hand panel to add a line of best fit.

Click the edit button (pencil icon) on the right. Then use the camera icon  to paste your graph into this Google Doc

2) Does the level of use of antibiotics within a country appear to predict the level of antibiotic resistance within pneumoniae bacteria populations? How tight is this relationship between antibiotic use and antibiotic resistance?

3) Is the graph evidence for or against the claim that widely prescribing antibiotics renders less effective as a medical treatment?

4) Show the categorical variable “Country” on your graph. [Click the Z indicator on the right-hand panel to color code your data points](#) by country. Now [open a map of Europe in another browser window](#). What regional trends in antibiotic use and resistance can you describe?