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The Walking Dead: Don’t Run, Use Math!
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Abstract
To study the effect of a zombie outbreak, our team used several differential equations and techniques learned in class to predict the population of humans and zombies during a zombie outbreak. It is important to be able to study the population of both humans and zombies to understand the odds of getting infected and to predict how long the outbreak will last. This information could then be given to the Center of Disease Control for proper defensive measures to ensure the survival of humans. If there is an outbreak, it is best to be prepared.

Background
When people hear zombie, they hear interpretations of the fictional creature roaming around with a dead shelf look and razor sharp teeth. The fear is probably real and justified; head is probably the only barrier that body cannot support all that is left of them. Zombies are a carnivorous creature spawning from the dead corpse of a human (1). A zombie is a reanimated body after death and tends to act in an aggressive and instructive behavior. Zombies feed on the living and won’t stop at anything for human flesh. However, this portrayal comes from more than just the book and movies that has been so well known in society. For this project, the zombie we have chosen is the slow but aggressive zombie somewhat like the ones in games such as Dead Rising and the popular show the Walking Dead. All of these facts have a few things in common: the setting is post-apocalyptic, zombies are the dominant species and every living being is trying to survive some way or another. Why we chose the slow zombie is because most zombie entertainments often show the slow but aggressive zombie. Also, it is not obvious enough but a zombie apocalypse is a terrifying setting. Therefore, assumptions must be made and the knowledge of these fictional creatures will have to be based on movies and books. In addition, the slower zombie is a more balanced variable slow moving but deadly at the same time, easy enough to keep track of. Even though zombies are fictional creatures, it would never be considered too careful to be ready if there was an outbreak. And no! I am not just talking of a food chain plot. However, it is true that the slow zombies are much better for an outbreak because they are more sustainable. The slower zombies might also be able to move around and interact in the earth better. But the zombies still remain a mystery, a mystery to be solved at the end of it all. In order to find out how quick this zombie outbreak can infect everyone, mathematics is going to be involved heavily.

The SZR Model
To start off the solution, a mathematical model must be constructed so that every variable and number may be organized according to the model. This model can be called the Basic Model. Within the Basic Model, we consider three basic classes: Susceptible (S), Zombie (Z), and Removed (R). The point of this model is to show the total number of those who are living and are infected. If a person is completely dead, then the person will be thrown in the removed class. Susceptible can only be turned into Zombie through transmission. Zombies can be killed which means they can fall into the removed class. So given this model we can see that the parameter 'β'. The susceptible that are turned through zombie infection will be defined as the parameter 'β'. It is assumed that the birth rate of humans does not come into play during the apocalypse. Therefore, the total number of how many Susceptible are alive can come to this equation: $\delta S = \beta SZ$. When $\delta$ is the rate of change of how many Susceptibles are alive. The amount of people surviving through the apocalypse which are subtracted by the amount of susceptible affected by transmission and subtracted by those who die by natural causes. Now let’s look at the amount of zombies roaming the Earth. First off the Zombie population will most likely be growing but will be decreasing quite soon. While looking at all the zombie count from a few more parameters will have to be taken into account. Since Zombies are resurrected humans, then humans that are in the removed class can resurrect and become a Zombie. This resurrected Zombie can be known as the ‘I’ parameter. Zombies can also be taken by other human beings but not by other Zombies, so this parameter will be known as the ‘α’ parameter. The amount of zombies existing can be predicted by this equation: $\delta Z = \beta SZ - \alpha Z$. Here $\alpha$ is the rate of change in zombies and that is equal to the addition of transmitted human being plus the resurrected and subtracted by the disabled zombies. The last group to be taken into account is the removed. Like what is said before, the susceptible are able to become a part of the removed by natural cause and zombies however those moved into removed class can become a Zombie and that is what would get our removed equation: $\delta R = \alpha Z - \beta SZ$. The rate of change in the removed shows the addition of Susceptible lost through natural causes as well as the Susceptible list through Zombie attacks and this is subtracted by Resurrected.

Numerical Methods for Simulations
The SZR Model was simulated on three different techniques the Euler Method, ODE45 Method, and the ODE45 built-in functions of MATLAB.

Euler Method: Euler’s method is the simplest method to use and gives an answer quickly. However, this procedure is the least accurate and is given in three.

ODE45: The method of using ODE45 is a more accurate approach to solving ODEs. This function that is not available in MATLAB is more precise (as seen in the pilot).

Results

Conclusions
Being prepared for an epidemic; take more than stocking up on food and weapons and making an underground bunker. With the use of calculus, the zombie outbreak with the right precautions can be stopped at the perfect time. This report has explained the outcomes of the zombie outbreak and separated the different types of classes into other variables. From here this made a system of equations. As the report progressed graphs were made to show in a short amount of time (which was about 10 days) the possible outcomes of the outbreak. Figure 1 we can see that the human population rapidly decreases throughout the first few days, and is nearly by day 5. Likewise, the zombie population increases rapidly the first few days and steadily off around day 5 as well. This makes sense because as there are less humans to infect, there will be less increase of Zombie population. Unfortunately from this model, all of the Susceptible Humans die, and the Zombies population comes close to the Human population.

References and Acknowledgments