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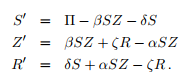
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# 04-07 Oct 2017

## WHEN ZOMBIES ATTACK!: MATHEMATICAL MODELLING OF AN OUTBREAK OF ZOMBIE INFECTION

<http://mysite.science.uottawa.ca/rsmith43/Zombies.pdf>

An equation of the three different classes in a “zombie apocalypse”

**Classes**

**S’** is the susceptible class i.e. the humans that can act as a host

**Z’** is the zombie

**R’** is the removed I.e. the dead of either zombies or humans

**Other factors**

**Π** denotes the birth rate; the rate at which more humans get born. To simplify the simulation, this will most likely be ignored, if not an optional feature.

**β** is the “transmission parameter” i.e. the rate of the spread of the infection; this could possibly be replaced by the r-nought

**δ** is the natural death rate parameter

**ζ** is the ratio of the corpses turning into zombies

**α** denotes the ease of turning zombies back into their lowest energy level. i.e. a corpse

**Further explanation**

The equation above explains how to get the current value of the human (alive population) i.e. **S’**. The value is calculated by adding to the existing value the number of new-born humans (**Π**) and then consequently subtracting the number of humans that become infected or are turned into zombies (**-βSZ)** as well as the humans that die of natural (or naturally selected) causes **(-δS)**.

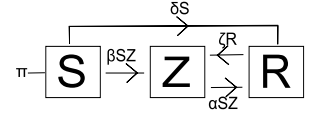
The next equation is used to find the current zombie population i.e. **(Z’)**. The value is calculated by adding the number of infected humans that can turn into zombies **(βSZ)** and the reanimated corpses **(ζR)** to the existing number of zombies. The zombies are not completely invulnerable and therefore this is solved the adding **(**-**αSZ)** to the equation; this is basically how many zombies the humans are able to destroy.

Note to self: Separate class may be needed so corpses that can be converted to zombies is separate to corpses that are mush i.e. R for removed and D for destroyed. One more thing is to add an equation which allows the zombies to decay possibly something like (-xZ)



The final equation is the class which will hold the dead of both zombies and humans **(R’)**. The value is calculated by adding the humans that die of natural causes **(δS)** and the zombies that get killed by humans **(αSZ)** to the list of the existing removed entities. However, some of these can be re animated to create zombies, hence the addition of **(-ζR)**

**Closed Systemness**



As can be seen from the above flowchart, ignoring the **Π** value, the entire system is a closed system, where the sum of S, Z and R remain the same throughout the entire model. This means that during the simulation, the sum of starting populations for all S, Z and R should be the same as the final values of S, Z and R.

The system simplifies the parameters which may be involved in the simulation but this is a good start since it allows for easily adding different items to the system, such as cures, quarantines, etc

# 09-12 Oct 2017

## DIFFERENT TYPES OF ZOMBIES IN MEDIA

<http://zombie.wikia.com/wiki/Romero_zombies>

In media, usually films and tv shows, there are 2 types of zombies; fast zombies as seen in 28 days later or slow zombies as seen in the walking dead. The fast zombies are usually more fragile, seeing as they are treated more as infected and still alive, whereas the slower zombies have been reanimated i.e. whatever is causing the slow zombies to bring the corpse back to life would be likely to repair the body to be usable.

### Relevance to the project

This is relevant to this project as the type of zombie can affect how difficult it will be to move the zombie to the “destroyed” category as well as how fast the zombies themselves would travel across the countries. How fast zombies move can affect the value of **α**, increasing it for a faster zombie, however since faster zombies are less resistant to being damaged it can also negate this value.

These are parameters which can be changed to affect the simulation. If the value of **α** is a value more than 0, this means that zombies can be moved to the “destroyed” category i.e. there are no indestructible zombies; a higher **α** value means that it is easier for the humans to beat the zombies.

**α** is a value that can be derived from other parameters; as mentioned above, speed and zombie fragility are parameters which can affect its value. Other values which may affect this are the zombie intelligence; slow zombies may be acting on pure instinct – in which case have a low intelligence compared to the infected (fast) zombies which may retain some of their intelligence before infection.

# 11-16 Oct 2017

## looking at other factors

### **β** - transmission parameter

<http://apps.who.int/iris/bitstream/10665/44768/1/9789241502801_eng.pdf>

In epidemiology, diseases can be transmitted via “vectors”. A disease vector is any object that carries and transmits a pathogen between living organisms. A vector can both be another living organism (i.e. mosquitos are a vector for malaria) or a non living medium (such as water, for cholera).

Different vectors have different effectiveness for transmitting the pathogen. Some pathogens may not be built to be transmitted via air, however some may be exclusively airbourne. These different types of vectors can become parameters in the simulation, where if the simulated pathogen is transmissible via the named vector, then its value should be > 0.

Possible transmission vectors:

* Air
* Water
* Insects
* Bats
* Food (meats; pork, beef, chicken)
* Birds
* Fomite (dead skin cells, hair, bedding, clothes)
* Blood

Of course these transmission vectors can be controlled as well. Should the simulation permit, the simulated governments would be able to use insecticides to kill the insects that could transmit the pathogen, or even in the case of bird flu, chickens could be culled to ensure that the pathogen does not get transmitted via people eating the infected chickens. These are underlined by the World Health Organisation’s IVM (Integrated Vector Management) i.e. limiting a spread of pathogens via a specific vector.

### **δ -** natural death rate

<https://www.cia.gov/library/publications/the-world-factbook/fields/2066.html>

<https://www.indexmundi.com/g/r.aspx?v=26>

<https://data.worldbank.org/indicator/SP.DYN.CDRT.IN>

Over time, the humans in the simulation can naturally die. This system should be implemented to be able to compare the deaths from the disease and zombies to the natural death rate. This also adds to realism because having a child during a pandemic / zombie apocalypse is a terrible idea. Having a birth rate was initially planned, however this may be harder to implement since it requires being able to program the fact that a new human cannot be born if there is only one person in the world left (or if there is a huge separation between humans). Above, I have tried to find the natural death rate per country, with some success, because all the sources have different values for each country.

The best plan at the moment may be to use a comma separated value file (CSV) that is provided by the world bank link which has all the values for each country. The link may also be used for other values such as population per country.

### **ζ -** zombie conversion ratio