SBML Model Report

Model name: “Munz2009 - Zombi Impulsive Killing”

May 6, 2016

1 General Overview

This is a document in SBML Level 2 Version 4 format. Table 1 shows an overview of the quantities of all components of this model.

Table 1: Number of components in this model, which are described in the following sections.

Element	Quantity	Element	Quantity
compartment types	0	compartments	1
species types	0	species	3
events	1	constraints	0
reactions	5	function definitions	0
global parameters	9	unit definitions	5
rules	1	initial assignments	1

Model Notes

Munz2009 - Zombie Impulsive Killing

This is the basic SZR model with impulsive killing described in the article.

This model was originally created by libAntimony v1.4 (using libSBML 3.4.1).

This model is described in the article:When zombies attack!: Mathematical modelling of an outbreak of zombie infectionP. Munz, I. Hudea, J. Imad and R.J. Smith?Infectious Disease Modelling Research Progress 2009, chapter 4, pp 133-150. Editors: Jean Michel Tchuenche and C. Chiyaka; Nova Science Publishers, Inc., NY, USA.

Abstract:

Zombies are a popular figure in pop culture/entertainment and they are usually portrayed as being brought about through an outbreak or epidemic. Consequently, we model a zombie attack, using biological assumptions based on popular zombie movies. We introduce a basic model for zombie infection, determine equilibria and their stability, and illustrate the outcome with numerical solutions. We then refine the model to introduce a latent period of zombification, whereby humans are infected, but not infectious, before becoming undead. We then modify the model to include the effects of possible quarantine or a cure. Finally, we examine the impact of regular, impulsive reductions in the number of zombies and derive conditions under which eradication can occur. We show that only quick, aggressive attacks can stave off the doomsday scenario: the collapse of society as zombies overtake us all.

This model is hosted on BioModels Database and identified by: MODEL1008060000 .

To cite BioModels Database, please use: BioModels Database: An enhanced, curated and annotated resource for published quantitative kinetic models .

2 Unit Definitions

This is an overview of eight unit definitions of which three are predefined by SBML and not mentioned in the model.

2.1 Unit `substance`

Name individuals(thousands)

Definition kitem

2.2 Unit `time`

Name days

Definition 86400 s

2.3 Unit `perday`

Name per day

Definition $(86400\ \mathrm{s})^{-1}$

2.4 Unit `perdayperind`

Name per day per thousand individuals

Definition $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}^{-1}$

2.5 Unit indperday

Name thousand individuals per day

Definition $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$

2.6 Unit volume

Notes Litre is the predefined SBML unit for volume.

Definition l

2.7 Unit area

Notes Square metre is the predefined SBML unit for area since SBML Level 2 Version 1.

Definition m^2

2.8 Unit length

Notes Metre is the predefined SBML unit for length since SBML Level 2 Version 1.

Definition m

3 Compartment

This model contains one compartment.

Table 2: Properties of all compartments.

Id	Name	SBO	Spatial Dimensions	Size	Unit	Constant	Outside
env	environment		3	1	litre	☑	

3.1 Compartment env

This is a three dimensional compartment with a constant size of one litre.

Name environment

4 Species

This model contains three species. Section 10 provides further details and the derived rates of change of each species.

Table 3: Properties of each species.

Id	Name	Compartment	Derived Unit	Constant	Boundary Condition
S	Susceptible	env	kitem	⊟	⊟
Z	Zombie	env	kitem	⊟	⊟
R	Removed	env	kitem	⊟	⊟

5 Parameters

This model contains nine global parameters.

Table 4: Properties of each parameter.

Id	Name	SBO	Value	Unit	Constant
N	starting Population		500.000	kitem	☑
p	birth rate		0.000	$(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$	⊟
delta			10^{-4}	$(86400\ \mathrm{s})^{-1}$	☑
beta			0.006	$(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}^{-1}$	☑
zeta			0.090	$(86400\ \mathrm{s})^{-1}$	☑
alpha			0.008	$(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}^{-1}$	☑
n	number of kills		0.000	dimensionless	⊟
k	kill ratio		0.250	dimensionless	☑
tau	kill intervall		2.500	86400 s	☑

6 Initialassignment

This is an overview of one initialassignment.

6.1 Initialassignment S

Derived unit kitem

Math N

7 Rule

This is an overview of one rule.

7.1 Rule p

Rule p is an assignment rule for parameter p:

$$\mathrm{p} = \mathrm{S} \cdot \mathrm{delta} \tag{1}$$

Derived unit $\mathrm{kitem} \cdot (86400\ \mathrm{s})^{-1}$

8 Event

This is an overview of one event. Each event is initiated whenever its trigger condition switches from `false` to `true`. A delay function postpones the effects of an event to a later time point. At the time of execution, an event can assign values to species, parameters or compartments if these are not set to constant.

8.1 Event `zombie_eradication`

Trigger condition

$$(\text{time} \geq (\text{n} + 1) \cdot \text{tau}) \land (\text{k} \cdot (\text{n} + 1) \leq 1) \tag{2}$$

Assignments

$$[\text{Z}] = \text{Z} \cdot (1 - \text{k} \cdot (\text{n} + 1)) \tag{3}$$

$$\text{n} = \text{n} + 1 \tag{4}$$

9 Reactions

This model contains five reactions. All reactions are listed in the following table and are subsequently described in detail. If a reaction is affected by a modifier, the identifier of this species is written above the reaction arrow.

Table 5: Overview of all reactions

№	Id	Name	Reaction Equation	SBO
1	`birth`		$\emptyset \longrightarrow S$	
2	`death`		$S \longrightarrow R$	
3	`infection`		$S \longrightarrow Z$	
4	`resurrection`		$R \longrightarrow Z$	
5	`destruction`		$Z \xrightarrow{S} R$	

9.1 Reaction `birth`

This is an irreversible reaction of no reactant forming one product.

Reaction equation

$$\emptyset \longrightarrow \mathrm{S} \tag{5}$$

Product

Table 6: Properties of each product.

Id	Name	SBO
S	Susceptible	

Kinetic Law

Derived unit $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$

$$v_1 = \mathrm{p} \tag{6}$$

9.2 Reaction `death`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{S} \longrightarrow \mathrm{R} \tag{7}$$

Reactant

Table 7: Properties of each reactant.

Id	Name	SBO
S	Susceptible	

Product

Table 8: Properties of each product.

Id	Name	SBO
R	Removed	

Kinetic Law

Derived unit $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$

$$v_2 = \mathrm{delta} \cdot \mathrm{S} \tag{8}$$

9.3 Reaction `infection`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{S} \longrightarrow \mathrm{Z} \tag{9}$$

Reactant

Table 9: Properties of each reactant.

Id	Name	SBO
S	Susceptible	

Product

Table 10: Properties of each product.

Id	Name	SBO
Z	Zombie	

Kinetic Law

Derived unit $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$

$$v_3 = \mathrm{beta} \cdot \mathrm{S} \cdot \mathrm{Z} \tag{10}$$

9.4 Reaction `resurrection`

This is an irreversible reaction of one reactant forming one product.

Reaction equation

$$\mathrm{R} \longrightarrow \mathrm{Z} \tag{11}$$

Reactant

Table 11: Properties of each reactant.

Id	Name	SBO
R	Removed	

Product

Table 12: Properties of each product.

Id	Name	SBO
Z	Zombie	

Kinetic Law

Derived unit $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$

$$v_4 = \mathrm{zeta} \cdot \mathrm{R} \tag{12}$$

9.5 Reaction `destruction`

This is an irreversible reaction of one reactant forming one product influenced by one modifier.

Reaction equation

$$\mathrm{Z} \xrightarrow{\mathrm{S}} \mathrm{R} \tag{13}$$

Reactant

Table 13: Properties of each reactant.

Id	Name	SBO
Z	Zombie	

Modifier

Table 14: Properties of each modifier.

Id	Name	SBO
S	Susceptible	

Product

Table 15: Properties of each product.

Id	Name	SBO
R	Removed	

Kinetic Law

Derived unit $(86400\ \mathrm{s})^{-1} \cdot \mathrm{kitem}$

$$v_5 = \mathrm{alpha} \cdot \mathrm{S} \cdot \mathrm{Z} \tag{14}$$

10 Derived Rate Equations

When interpreted as an ordinary differential equation framework, this model implies the following set of equations for the rates of change of each species.

10.1 Species S

Name Susceptible

Initial assignment S

This species takes part in four reactions (as a reactant in death, infection and as a product in birth and as a modifier in destruction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{S} = v_1 - v_2 - v_3 \tag{15}$$

10.2 Species Z

Name Zombie

Initial amount 1 kitem

Involved in event zombie_eradication

This species takes part in three reactions (as a reactant in destruction and as a product in infection, resurrection).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{Z} = v_3 + v_4 - v_5 \tag{16}$$

Furthermore, one event influences this species' rate of change.

10.3 Species R

Name Removed

Initial amount 0 kitem

This species takes part in three reactions (as a reactant in resurrection and as a product in death, destruction).

$$\frac{\mathrm{d}}{\mathrm{d}t}\mathrm{R} = v_2 + v_5 - v_4 \tag{17}$$

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