Radicalisation and the influx of foreign fighters into Syria:
Their epidemic spread and conceptualisation as a infectious disease.

Y. K. Kunkels – 10193634, University of Amsterdam.

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Abstract

The current article presents a novel approach in modeling the jihadist enterprise as an epidemic spread of infectious disease throughout social networks. In the first study I show that the staggering increase of foreign fighters in Syria between June 2014 and December 2015 was accurately predicted by a deterministic disease model. Additionally, the model was found capable in predicting the expected number of deaths during this period. In the second study I conducted a sensitivity analysis aimed at identifying the most effective strategy for suppressing the influx of foreign fighters in Syria. Results showed that both decreasing the number of radical social media outlets and the persuasiveness of such messages were more effective than increasing the number of deaths among foreign fighters. These results could serve as a stepping stone for further research on this novel approach to model radicalisation and foreign fighter influx.

Words: 144

Radicalisation and the influx of foreign fighters into Syria

The current paper aims to answer two main questions: how can we model the influx of foreign fighters into the Syrian conflict, and how can we assess strategies aimed at reducing this influx. Recently, the influx of fighters from European countries into the Syrian civil war has seen a sharp increase. Whereas by 2014 approximately 2,500-3,000 individuals from Europe had traveled to Syria to engage in its' cival war (Barrett, 2014; Vidino, 2014), by December 2015 this figure almost doubled; indicating more than 5,000 fighters originating from Europe engrossed in the fighting (Barrett, 2015). Additionally there are large discrepancies between European countries in foreign fighter percentages, as approximately 3,700 fighters hail from only four countries (France: 1700, United Kingdom: 760, Germany: 760, Belgium: 460) (Barrett, 2015).

An estimated 20-30% of foreign fighters return after participating in the conflict (Barrett, 2015), which is in line with the return rate of roughly one-third found in an earlier study regarding non-European foreign fighters (Pham, 2011). These individuals are considered by authorities to pose a considerable security risk as they: often return as hardened veterans, are further radicalised, are skilled with weapons and explosives, have embraced methods like suicide bombings and beheadings, and have formed international jihadist networks (Byman, 2015; Vidino, 2014). Even more worrisome, one in nine returning foreign fighters have concrete plans for attacking Western countries, while 67% of executed terror attacks with fatalities included at least one veteran fighter (Hegghammer, 2013). Highlighting its' gravity, the return of foreign fighters to France was deemed “the biggest threat that the country faces in the coming years” by former French Minister of the Interior Manuel Valls (Sherlock, & Whitehead, 2014).

The number of foreign fighters that is killed in action is harder to estimate as many disappear from government scrutiny and might go from one jihad to joining another. While no clear data exists about the death rate of foreign fighters, these rates are suggested to vary from anything from 5% (Afghanistan in the 1980s) to in excess of 90% (Chechnya in the late 1990s) (Hegghammer, 2011). However with a return rate of 20-30% (Barrett, 2015) death rates, at maximum, should not exceed 70-80%. In addition, fighters that move to other jihads and those who settle in Syria will decrease the maximum death rate even further. Regarding fighters that originate from Europe, the following approximate numbers of deaths per nationality have been reported: 170 French (Reuters, 2016), 120 Germans, (RT International, 2016), 100 Britons (Mail Online, 2016), 90 Belgians (van Ostaeyen, 2016), 40 Swedes (Speisa, 2016), 27 Danes (Thelocal, 2015), 20 Austrians (Reibenwein, & Amara, 2014), 15 Norwegians (Solholm, 2015), 14 Dutch (NU, 2016), 8 Finns (Yle Uutiset, 2015), and 3 Irish (The Irish Times, 2013). Although estimates from such various news agencies should be treated as anecdotal, they do allow for an estimation of the death rate of European foreign fighters. The aforementioned numbers total at 607 deaths which, with 5000 fighters originating from Europe, combines to a death rate of 12%. Such a death rate is nowhere near the extreme rate of 90% obtained in the late 1990s Chechnya, but is more than double of those found in 1980s Afghanistan.

The recruitment of foreigners to fight in the Syrian civil war has been heavily influenced by the internet and social media. While earlier media occurences focussed heavily on mainstream media, the turning point started in 2011 when many jihadi groups discovered the advantages of social media such as Twitter and Facebook. A 3-month study monitoring jihadist activity on Twitter found that a sample of 59 Western foreign fighter accounts produced 154,119 tweets, on average 2,612 tweets per account (Klausen, 2015), which means each account produces on average 29 tweets per day. Such high volumes of tweets can often be traced back to a limited number of hyperactive users as, for example, ISIS's social media presence depends largely on a maximum of 2,000 accounts (Center for Middle East policy, 2015). Given the estimated 200,000 ISIS members (including both front-line soldiers and supporting personnel) (Cockburn, 2014), this would mean that 10 in every 1000 ISIS members are hyperactive Twitter users. Such an estimated Twitter density would put ISIS among the highest scoring countries for Twitter users per capita, where only Kuwait can match ISIS's Twitter presence (Mocanu et al., 2013).

But such inflammatory material is more often only searched by, let alone effective in recruiting, individuals vulnerable to violent radicalisation. A study regarding violent radicalisation investigated a representative population sample of men and woman of Muslim heritage aged between 18 and 45 years old, in two English cities. This study showed that 2.4% of the sample showed sympathy for violent protests and terrorist acts (Bhui, Warfa, & Jones, 2014). When we assume, as a working thesis, that this percentage is generalisable to the 20 million Muslims (Palumbo & Vaniman, 2007) living in Europe, this would mean that there are 480,000 individuals at risk of violent radicalisation.

But how to model: the rate at which jihadist groups recruit foreign fighters, their influx into Syria, their attrition rates, and more importantly how to suppress or even decrease their threat? Related studies have suggested models and dynamics for individual and collective terror defence (Keohane & Zeckhauser, 2003), terrorism development after government concessions (Bueno de Mesquita, 2005), and the spatiality of terrorist social networks (Ettlinger & Bosco, 2004). Although informative, these studies inter alia lack formal definitions of the development of jihadist group demographics and the role of modern communication technologies in jihadist recruitment efforts. Furthermore, next to merely modeling the development of such extremist groups, a structured method of analysing various interventions for suppressing such development is warranted. Such a method could inform a government's counterterrorism efforts and would allow for an estimation of intervention efficacy without actually having to take any immediate action.

In the current paper, I therefore propose to model the jihadist enterprise and its consequences as an epidemic spread of infectious disease throughout social networks. Such a reconceptualisation of violent extremism through epidemic models has only recently and sparsely been mentioned in the literature (e.g., Foster & Butler, 2008), while its' empirical applications in counterterrorism efforts are still novel. Epidemic models are often compartimentalised in that they divide the population at risk into a number of states, e.g., susceptible and infected. Susceptible individuals are those that are not yet infected with the pathogen but can get infected, whereas infected individuals already carry the pathogen and can thus infect susceptible individuals. Such models furthermore state through which processes these compartiments interact. Epidemic models represent three basic processes that influence the population dynamics of infectious disease transmission, namely: the demographic process, the contact process, and the infection process (Jenness, Goodreau, & Morris, under review). In turn, the model structure resolves how the three processes interact at the micro-level which leads to such macro-level outcomes as infection prevalence and incidence (Anderson & May 1992). The infection rate at which susceptible individuals become infected depends on the number of contacts infected individuals have per time unit, the probability that the infection is transmitted per contact, and the proportion of infected individuals. Input parameters of the model can be estimated using available data or used as sensitivity ranges to investigate what impact differing strategies might have on macro-level outcomes.

Although a novel approach, the conception of a jihadist enterprise as an infectious disease can make intuitive sense. As in compartimentalised disease models, we have a population divided in susceptible individuals and those already infected with the pathogen, in this case violent radicalisation. In addition there is a contact process that can be likened to the way extremist groups communicate with possible foreign fighters. The infection process goes beyond the contact process as its' consequences include the actual recruitment of foreign fighters. Deaths among foreign fighters actively changes the demographic network structure of their organisation, while such losses can also rob them of the manpower needed to spread their message over social media. Hence, such a conceptualisation can facilitate the investigation into what kind of strategies are effective in combating their growth, whether it is focussed on increasing casualties among foreign fighters (e.g., Starr & Browne, 2016), or on undermining their online recruitment platforms (e.g., Yadron, 2016). Such an analysis of strategy effectiveness is useful as some strategies are suggested to produce counter-intuitive effects, e.g., the hypothesised effect that the targeted killing of terrorist group members makes the killing of civilians by this terrorist group more likely (Asal, Gill, Rethemeyer, & Horgan, 2015).

During this study I will treat the jihadist enterprise as a two-state *Susceptible/Infected* (SI) disease which causes lifetime infection without recovery. This is akin to pathogens such as the human immunodeficiency virus (HIV) from which there is no recovery. Although alternative conceptualisations, such as a three-state *Susceptible/Infected/ Susceptible* (SIS) disease, are also possible we yet lack associated estimates, e.g., numbers of returned foreign fighters, for such a model's parameterisation. The epidemic model we used is the *Deterministic Compartmental Model* (DCM), which is a continuous time model. This model uses differential equations to assess population development through discrete stages, which include population entry and exit at predetermined rates. Being a deterministic model, its' outcomes do not vary. While the 'EpiModel' package also allows for modeling stochastic models, I chose the deterministic model for its' simplicity and ease of computation regarding large networks, while it allows for non-variant estimation of compartimental population development using only the history of such populations.

In the current paper, I will first present a proof of concept by modeling the rapid increase in foreign fighters over the 18-month period between June 2014 and December 2015 (Barrett, 2014; Barrett, 2015). Thereafter, I will conduct a sensitivity analysis in order to assess the effect of various strategies targeting population dynamic processes. The result will be interpreted in context while the investigated strategies will be evaluated as possible government interventions. The mathematical modeling is performed using a freely available software package called 'EpiModel' (Jenness, Goodreau, & Morris, 2016) for R statistical software (R Core Team, 2015).

Study 1

To assess the rapid increase of foreign fighters during the aforementioned 18-month period, I first establish a baseline model which only uses the average number of transmissible acts per person per time unit and the probability of infection per transmissible act between a susceptible and an infected person. Time units are taken as days, which accumulates to 540 days in the 18-month period. The number of susceptible individuals is taken to be the estimated 480,000 Europeans at risk of violent radicalisation mentioned earlier, whereas the number of infected individuals are the 2,500 foreign fighters in Syria in June 2014. Based on these two numbers we can estimate that the infection rate of going from to susceptible to radicalised is about 0.005. In this case, a hypothetical infection rate of 0 would mean that none of the transmissible acts would lead to infection. The number of transmissible acts is abstracted to Twitter activity, i.e., radicalising tweets, where given the average of 29 tweets per day and 10 in 1000 jihadists being Twitter users accumulates to a transmissible acts rate of 0.29. Here, a hypothetical transmissible act rate of 0 would signal no transmissible acts within each time unit. Given these parameters, the 'EpiModel' package was used to predict the number of foreign fighters at the end of the 540-day period. Indeed, results show a predicted number of 5028 foreign fighters in Syria, close to the 5000 fighters estimated by Barrett (2015).

Now a second model is constructed which aims at predicting the number of casualties among foreign fighters. The expected number of casualties can be estimated by dividing the aforementioned number of 607 European foreign fighter casualties over the 1,863 days that the fighting raged since the start of the Syrian civil war on 15 March 2011 (as of 20 April 2016). When this number is multiplied times the 540 days of the 18-month period we find that we should expect around 162 casualties. The death rate of foreign fighters in the Syrian civil war can be obtained by dividing the percentage of foreign fighter casualties mentioned earlier, that is 12%, over the number of days the conflict has been raging. The resulting death rate among foreign fighters is 0.00006, whereas a hypothetical death rate of 0 would signal that there are no casualties among foreign fighters. The death rate of susceptible individuals and the general birth rate are deemed negligable for our current analysis and are thus set to zero. The remaining parameters are identical to the baseline model. This second model predicted a number of 4,856 foreign fighters, indicating that 172 fighters perished in the fighting. This number of predicted casualties is close to the expected number of 162 casualties. Figure 1 shows the development of the second model over time for both the 540-day period (left panel) and a long-term 8000-day period (right panel). From the long-term prognosis it can be deducted that, under unchanging circumstances, only after approximately 4000 days (or about 11 years) the number of foreign fighters surpasses the number of susceptible individuals.

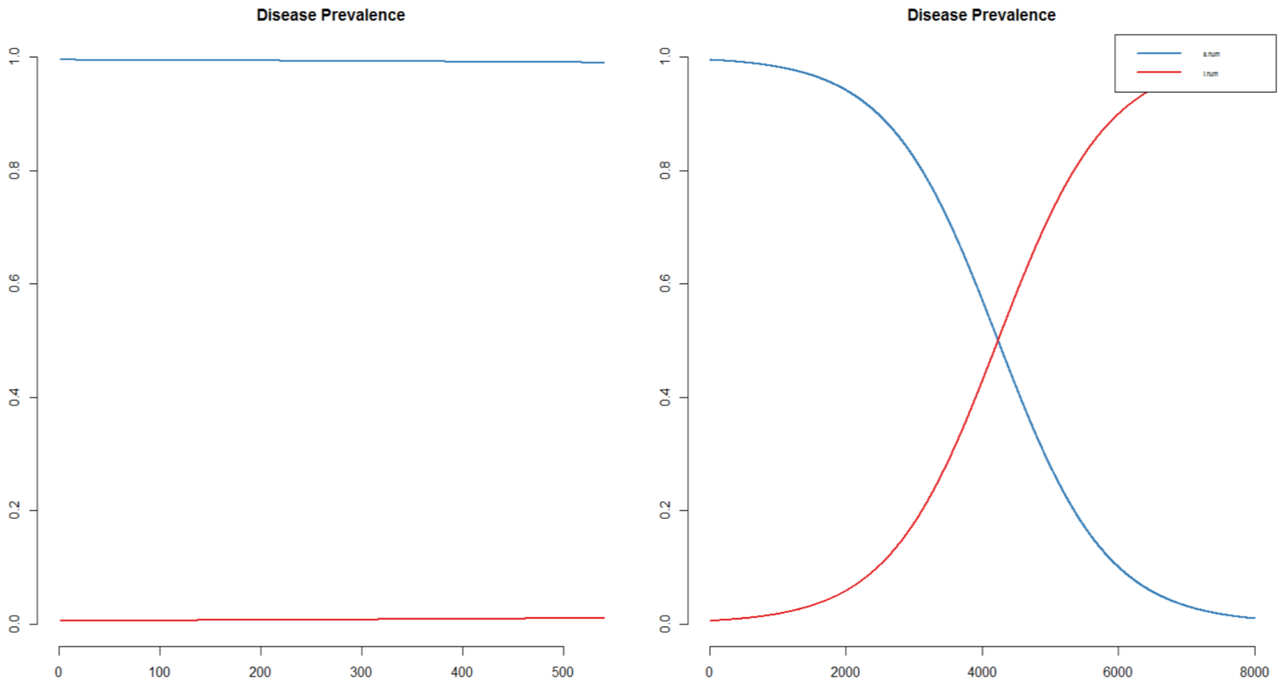


Figure 1: Short-term (left) and long-term (right) disease prevalence.

Study 2

In the previous study I showed that the jihadist enterprise can indeed be modelled as an epidemic spread of infectious disease throughout social networks. The presented model was able to predict both the sharp increase in foreign fighters during a 18-month period and the expected death toll among foreign fighters during this period. Now, using a similar model setup, I will conduct a sensitivity analysis to investigate the effects of various strategies. These strategies will revolve around intervening in one of the three possible attack vectors, namely the death rate, the number of transmissible acts, and the probability of infection. The first model will intervene through the rate of death, that is we will try to suppress the threat by increasing the number of foreign fighters that are killed. I will investigate the current death rate and death rates 5, 10, and 15 times higher than the current rate. As such I attempt to gain insight in whether such a strategy would be effective in suppressing the jihadist enterprise both in the short-term (18 months, or 540 days) as well in the long-term (22 years, or 8000 days). The model parameters in this analysis are equivalent to those of the previous analysis except the wider range of death rates currently used. Figure 2 shows the disease incidence, or probability of occurrence of a condition in a population within a time period. It can be observed that a death rate 15 times larger than the original one leads to almost a halving of the disease incidence within 18 months. Figure 3 shows the compartiment diagrams associated with this scenario. These diagrams show the compartimentalised population, susceptible and infected, and their population sizes in the rectangular boxes. The arrows indicate flow of individuals to and from these two population compartiments. The upper left arrows of each diagram show the birth rates (b.flow) while the lower left corner shows the death rate of the susceptible individuals (ds.flow). Both of which are deemed negligable for the current analysis and are thus zero. The arrow between the two boxes (si.flow) shows the flow of susceptible individuals who become radicalised and thus turn up as infected. Here, lower numbers indicate that less susceptible individuals become radicalised. The lower right arrows of the diagrams (di.flow) show the death rate of the foreign fighters, or infected individuals in epidemiological terms, wherein higher number indicate higher numbers of deaths in this group. These diagrams neatly show the dynamic interplay between the model parameters as increases in death rates will naturally decrease the flow of susceptible individuals to an infected state. Such an effect is expected as a decreased number of foreign fighters will also negatively affect the organisation's capability of recruiting susceptible individuals through social media.

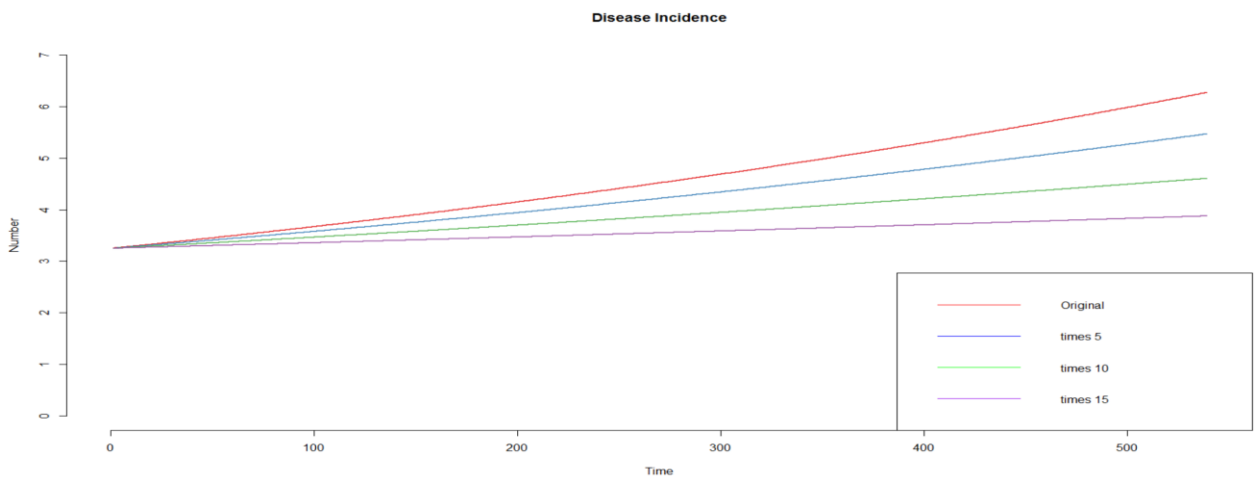


Figure 2: Disease incidence over a 18-month time period with four differing death rates.

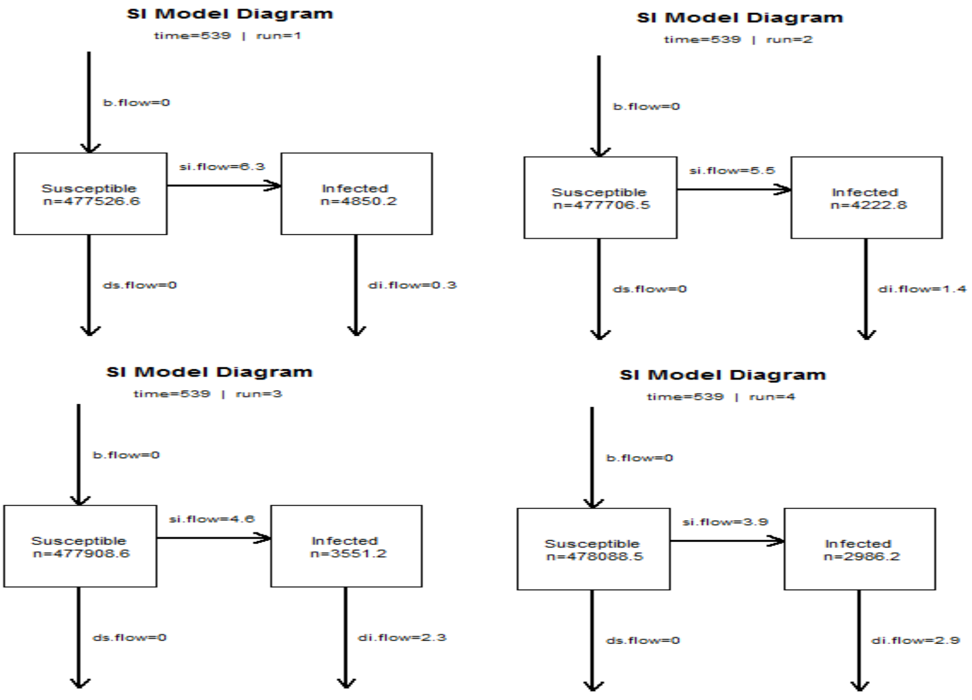


Figure 3: Compartiment diagrams showing (clockwise, starting upper left corner) scenarios for: the original death rate, one 5 times larger, one 10 times larger, and one 15 times larger.

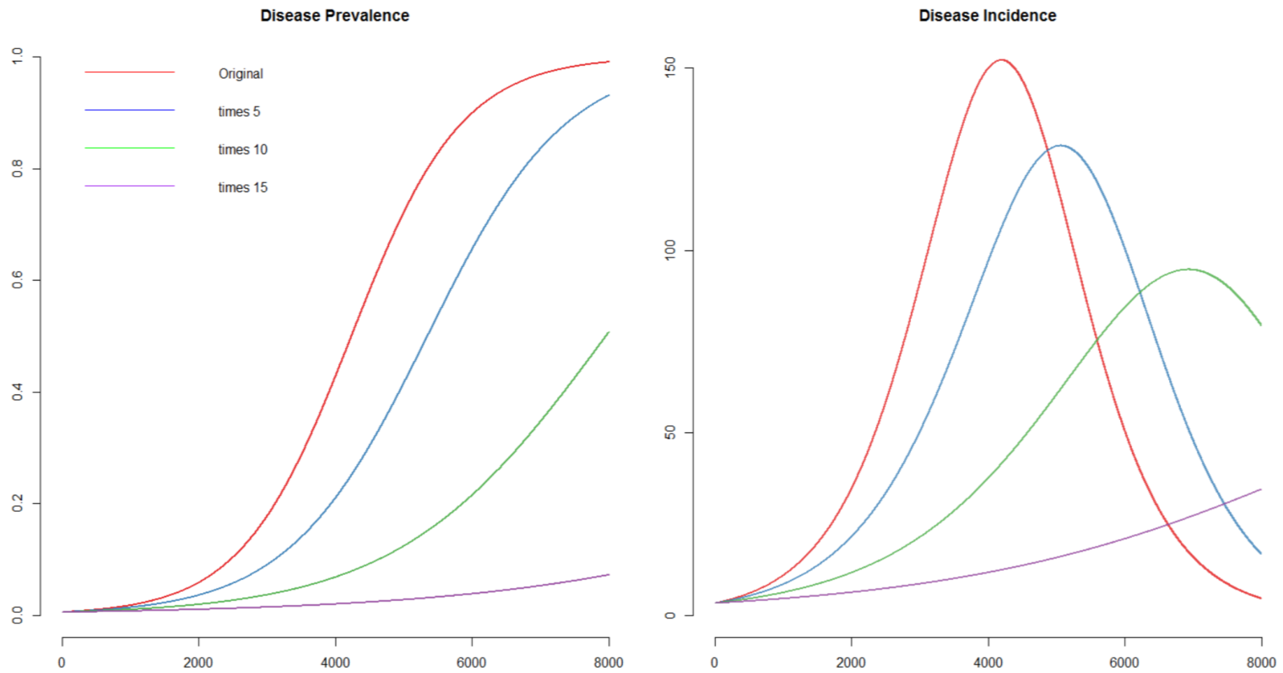


Figure 4:Long-term disease prevalence and incidence with four differing death rates.

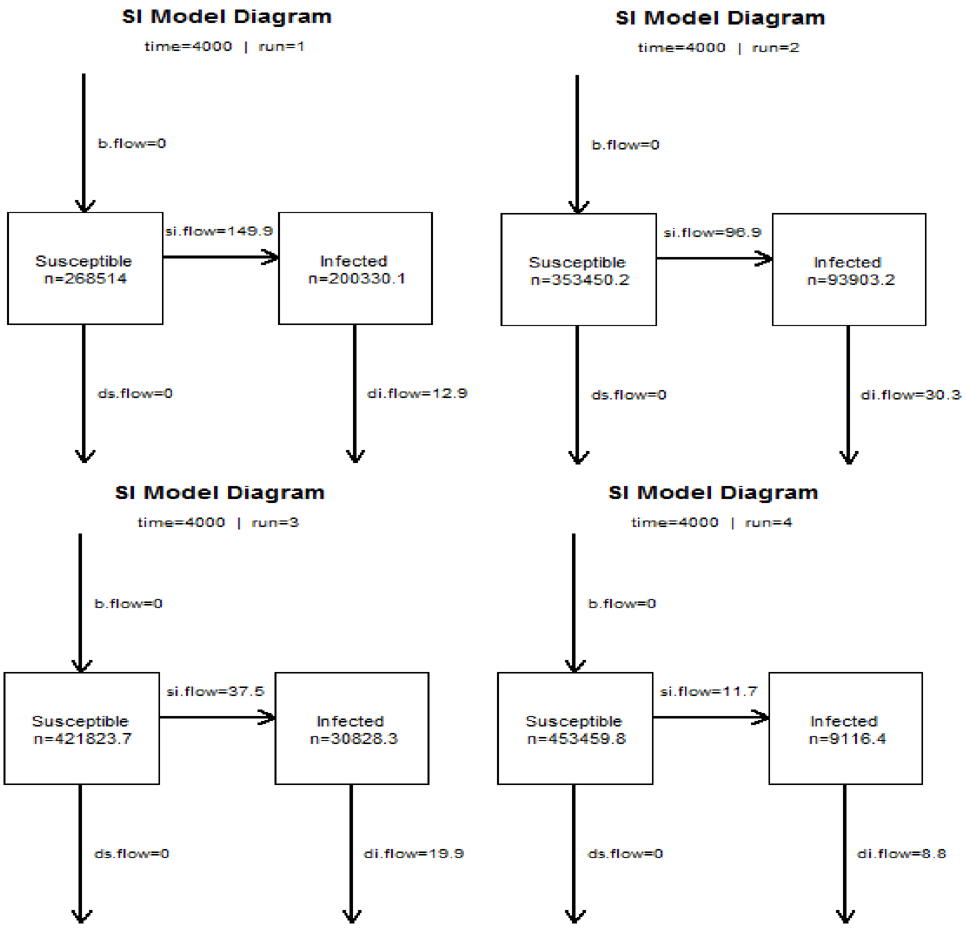


Figure 5: Compartiment diagrams showing (clockwise, starting upper left corner) scenarios for: the original death rate, one 5 times larger, one 10 times larger, and one 15 times larger.

Figure 4, on the other hand, shows both disease prevalence and incidence for the 8000-days time period. These plots show the clear divergence of the four death rates. The disease incidence of the original death rate peaks around day 4000, which is akin to the results of study 1 wherein around day 4000 the number of foreigh fighters surpassed the number of susceptible individuals. Disease prevalence and incidence both progressively decrease when the death rate is increased. While the incidence peak of 5 times the current death rate occurs only slightly later than the original rate, the most extreme death rate does not even peak within the allotted time frame. The differences in death rate and fighter recruitment between these four scenarios can be seen in figure 5. These compartiment diagrams show system's flow at day 4000. Increasing the death rate 5 times is suggested to lead to half of the number of foreign fighters at day 4000 than the original death rate. Even more so, a death rate 15 times higher might lead to only 5% of the number of fighters at day 4000 than the original rate. Such large differences can be explained by the dynamical interplay of the system wherein increased casualties not only drain manpower, but also hamper recruitment efforts.

The second strategy I will investigate is decreasing the number of transmissible acts per time unit. That is reducing the number of tweets from the extremist organisation that is allowed to reach susceptible individuals. I therefore investigate the current transmissible act rate and transmissible act rates 5, 10, and 15 times lower than the original one. Results are again given for both the short- and long-term. Model parameters, apart from the transmissible act rate, are kept equivalent to the previous studies. Figure 6 shows the disease incidences four all four transmissible act rates in the 18-month period. There is a notable difference with the short-term incidence rates of the death oriented strategy. Whereas this previous strategy showed incidence rates that were quite alike albeit progressively lower, the current incidence rates show a remarkable difference between the original transmissible act rate and the alternative rates. Such a difference can be explained by the more direct effects of the current strategy. Instead of allowing susceptible individuals to become radicalised, having them travel to Syria, and then try to eliminate them, this strategy focusses on preventing susceptible individuals to become radicalised in the first place. Preventing the growth of the original number of foreign fighters will also confine their ability to grow. For example, the compartiment diagrams in Figure 7 show that even a transmissible act rate 5 times lower than the current one will stifle growth. Here the number of foreign fighters after 18 months totals 2777, a very minor growth from the 2,500 fighters the organisation started the 18-month period with. Such a growth also stands in stark contrast with the explosive growth of foreign fighters observed in the 18-month period between June 2014 and December 2015.

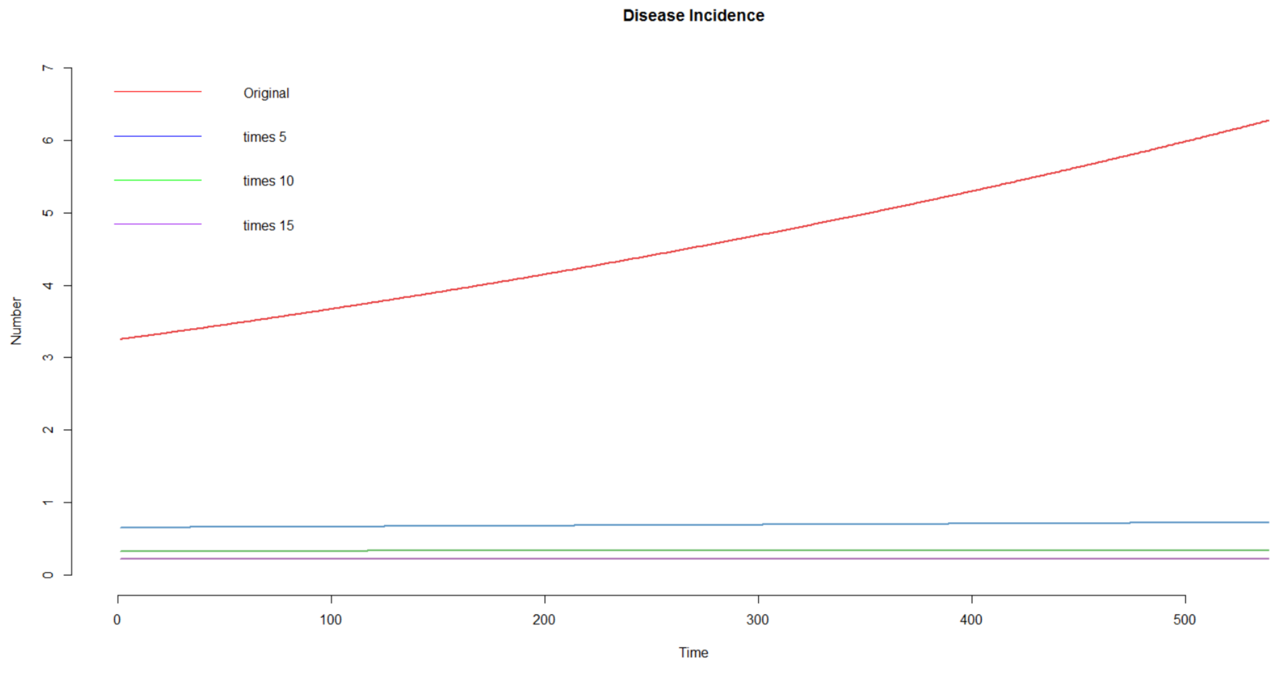


Figure 6: Disease incidence over a 18-month time period with four differing transmissible act rates.

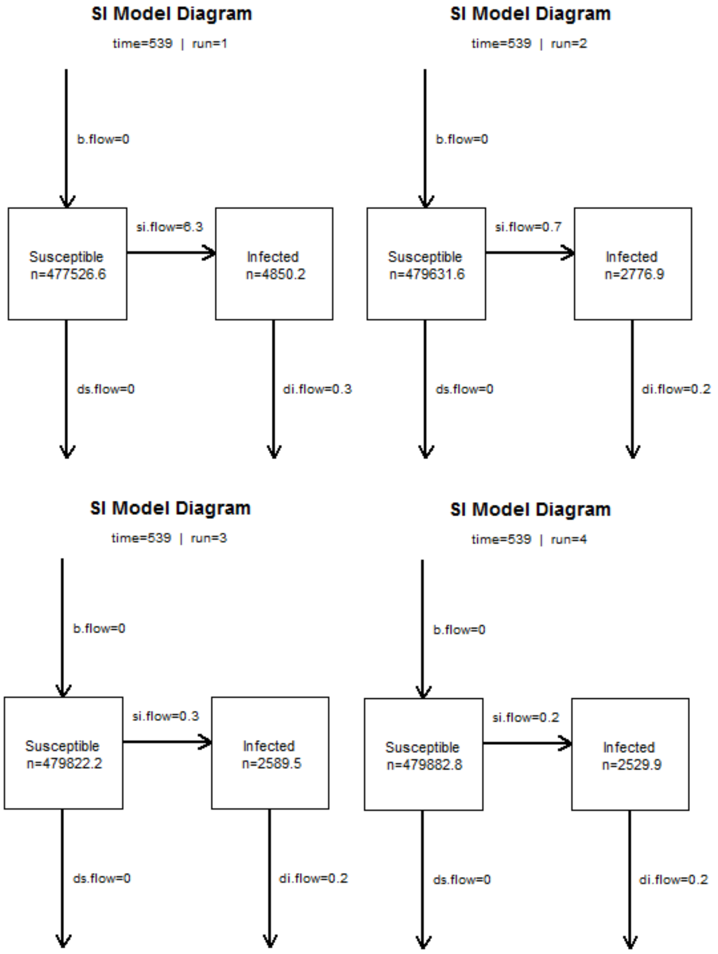


Figure 7: Compartiment diagrams showing (clockwise, starting upper left corner) scenarios for: the original transmissible rate, one 5 times larger, one 10 times larger, and one 15 times larger.

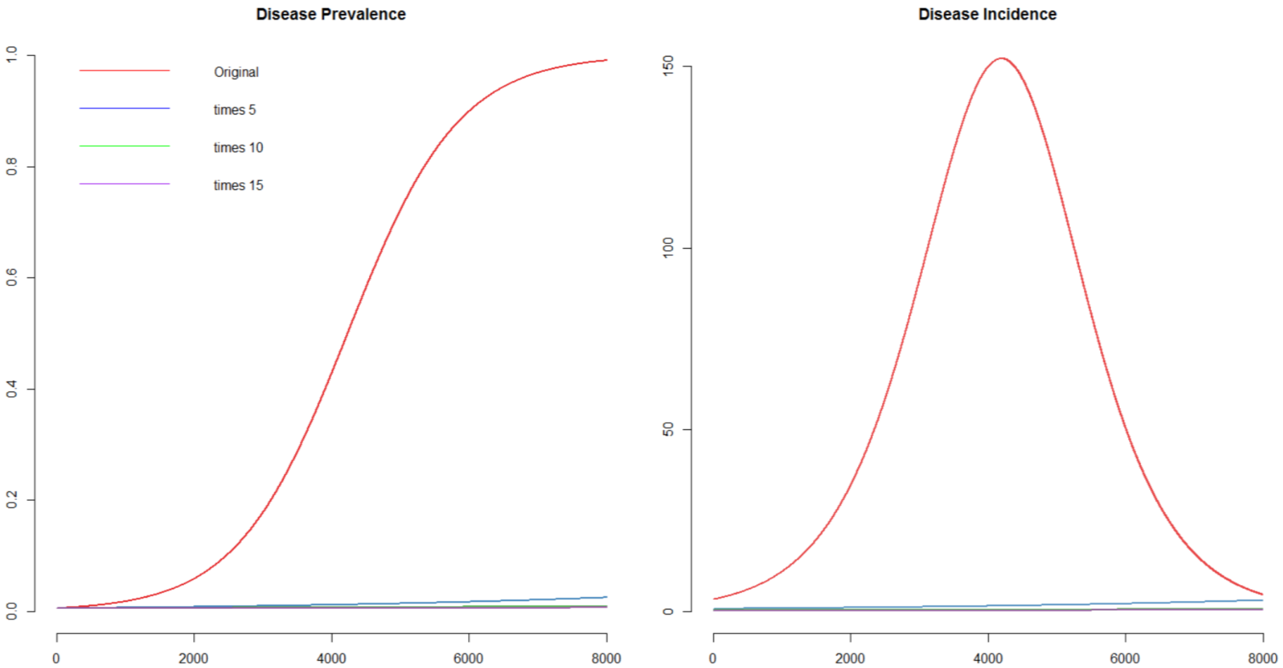


Figure 8: Long-term disease prevalence and incidence with four differing transmissible act rates.

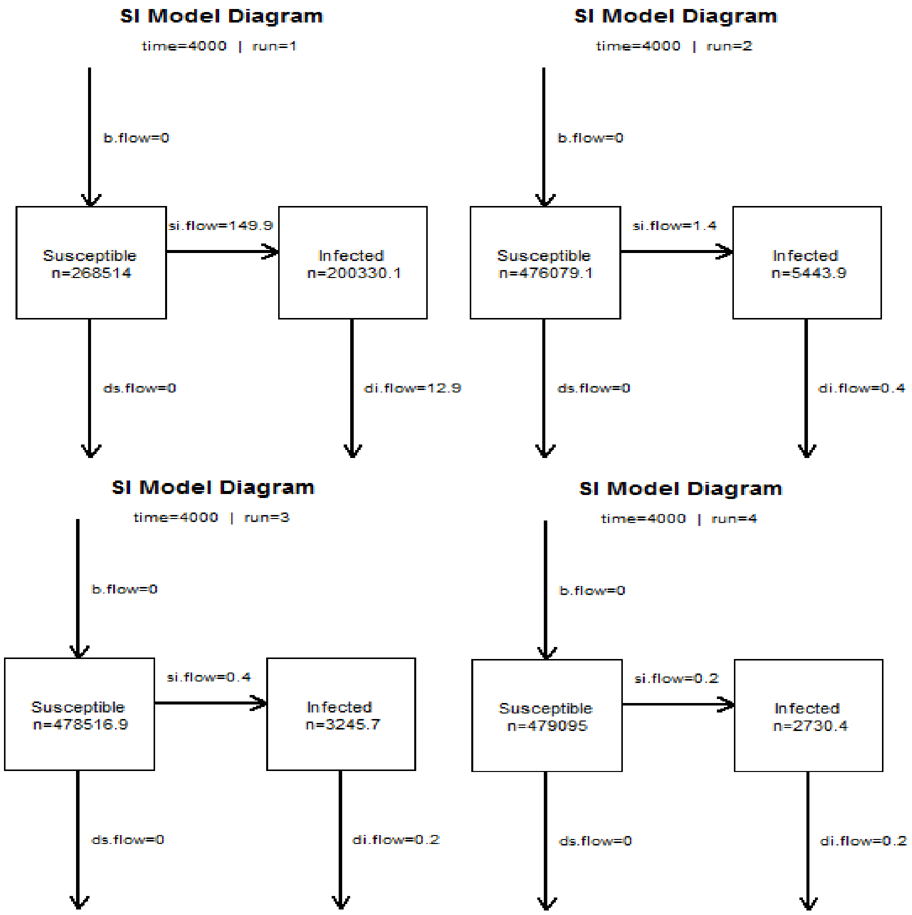
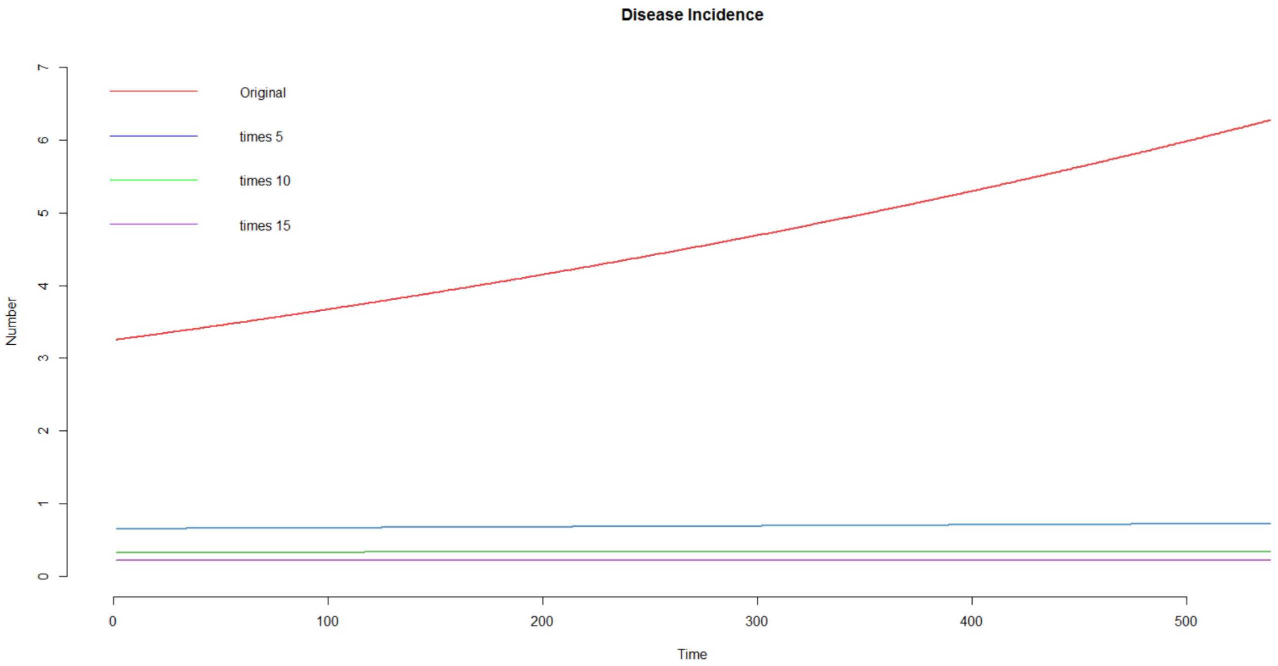


Figure 9: Compartiment diagrams showing (clockwise, starting upper left corner) scenarios for: the original transmissible rate, one 5 times larger, one 10 times larger, and one 15 times larger.

When we look at the long-term effects of decreasing the transmissible act rate, we observe similar results. Whereas disease incidence of the original rate peaks around day 4000, the alternative rates prohibit the influx of foreign fighters from peaking within the 8000-day time period, or even showing a noticable increase. The compartiment diagrams in figure 9 show that with a transmissible act rate 5 times smaller than the original one, it takes 4000 days (or about 11 years) for the number of foreign fighters to grow beyond 5,000. This is a strong difference with the original situation wherein such an increase could be realised within 540 days (or 18 months). Such a result suggests that undermining the transmissible act rate would be more effective than trying to increase the death rates.

Lastly, I will investigate the strategy of decreasing the infection probability. That is attempting to reduce the effectiveness of radicalising messages that reach susceptible individuals. I therefore investigate the current infection probability and infection probabilities 5, 10, and 15 times lower than the original one. Results are reported for both the short- and long-term. Model parameters, apart from the infection probabilities, are again equivalent to the previous studies. Figure 10 shows the disease incidences of the four infection probabilities on a 18-month timeline, whereas Figure 11 shows the associated compartiment diagrams. The results are similar to those of reducing the transmissible act rate, and this pattern is replicated for the long-term. Such a result can be explained through the notion that these two factors interact to form the process that could convince susceptible individuals to become radicalised. As such, an identical decrease in either of these factors will lead to similar results. As their result are identical, choices between these two



strategies could be based on other considerations such as cost and feasability.

Figure 10: Disease incidence over a 18-month time period with four differing infection probabilities.

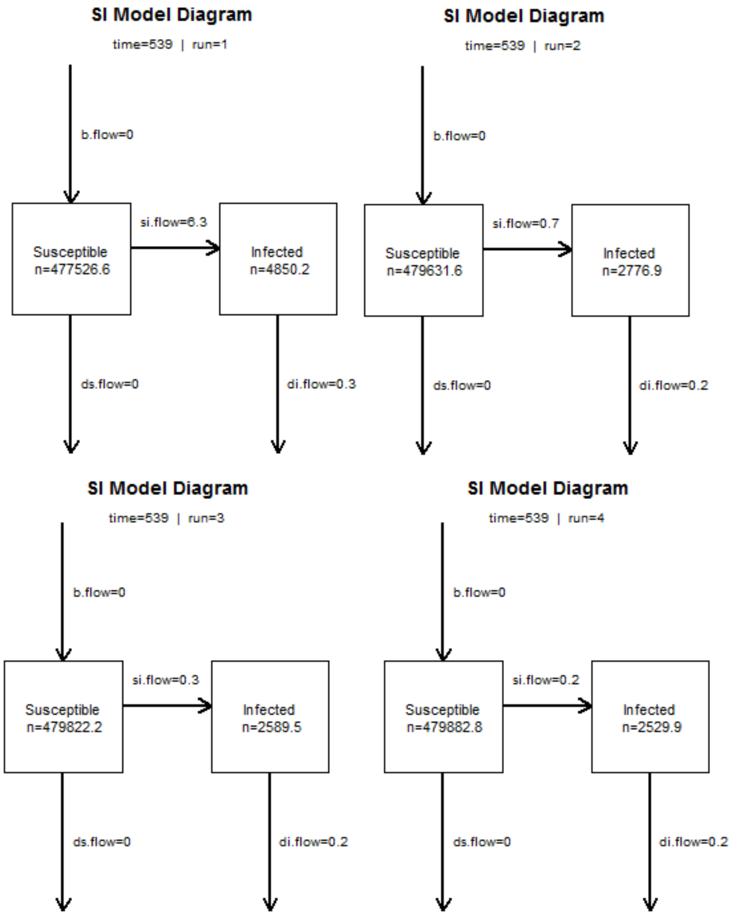


Figure 11: Compartiment diagrams showing (clockwise, starting upper left corner) scenarios for: the original infection probability, one 5 times larger, one 10 times larger, and one 15 times larger.

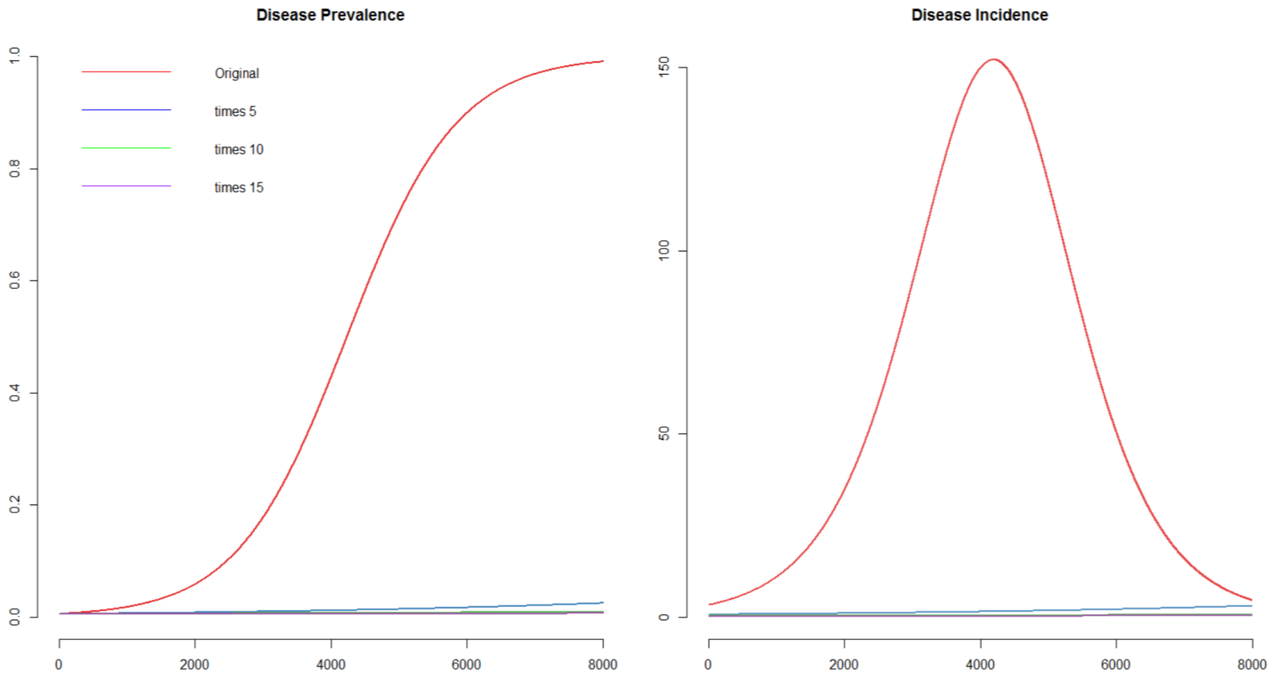


Figure 12: Long-term disease prevalence and incidence with four differing infection probabilities.

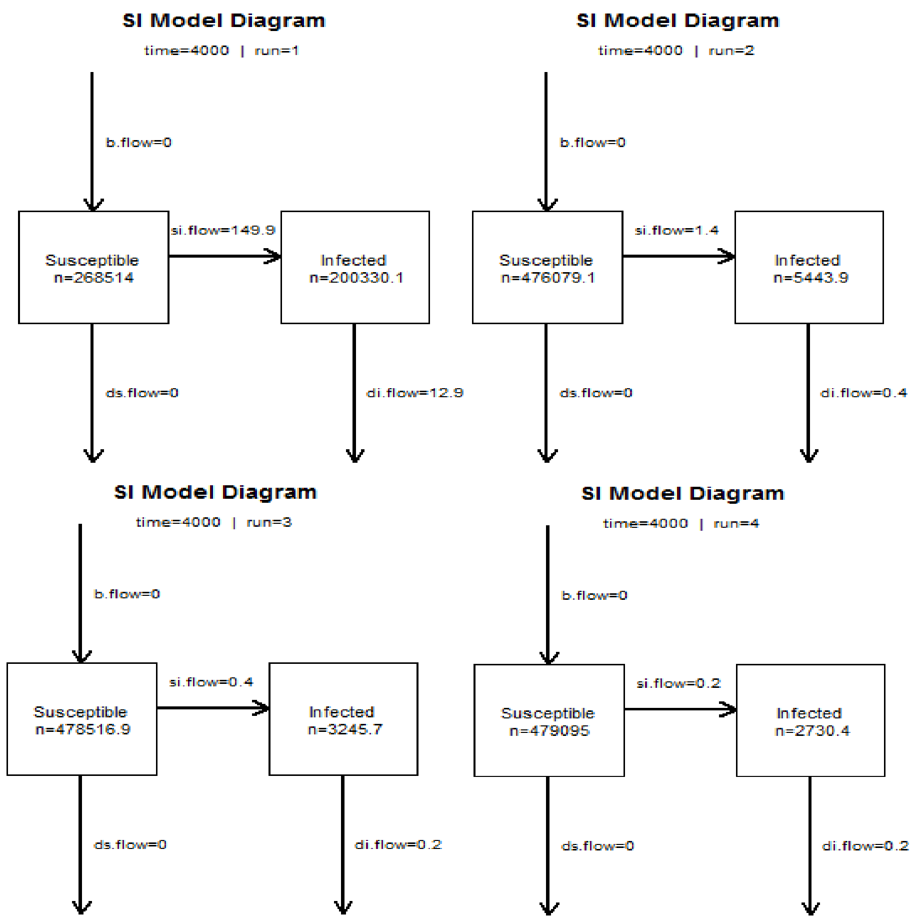


Figure 13: Compartiment diagrams showing (clockwise, starting upper left corner) scenarios for: the original infection probability, one 5 times larger, one 10 times larger, and one 15 times larger.

Conclusions and discussion

In the current paper, I proposed to use a novel approach in modeling the jihadist enterprise as an epidemic spread of infectious disease throughout social networks. In the first study I presented a proof of concept which showed that an epidemic model of the jihadist enterprise could indeed predict the staggering increase in foreign fighters in Syria for the period between June 2014 and December 2015. Additionally, the model was shown capable of accurately predicting the number of expected casualties for the same period. In the second study I investigated three strategies for suppressing the number of foreign fighters in Syria. It was shown that increasing the number of casualties among foreign fighters was not as effective as reducing the number of radicalising messages or reducing their effectiveness in convincing susceptible individuals. Such a result can be explained by the directness of the strategies, as the latter two strategies become effective early in the recruitment effort, whereas the death oriented strategy is more of a reactive effort. As both contact oriented processes produced the same results, any preference for one or the other could be based on secondary considerations. Here, interventions in the transmissible act rates seem most feasible as decreasing the number of social media outlets can be more easily attained than trying to undermine the effectiveness of such messages. In the light of these results the current endeavour to keep closing jihadist linked social media accounts seems the most effective strategy for decreasing the number of susceptible individuals that become radicalised. This would hamper the influx of new fighters into Syria, which in turn decreases the manpower available to recruit additional fighters.

However, the current study does suffer from a number of limitations. For example, the parameters of the epidemic model are based on the scare information available on, e.g., number of deaths among foreign fighters, the number of radical social media outlets, and their effectiveness in persuading susceptible individuals. Improvements in the availability of such information could lead to more precise estimations and predictions, which could lead to better informed choices on which strategy is the most effective. Furthermore, the current analyses and conceptualisations are based on a Susceptible/Infected (SI) model, whereas the use of a Susceptible/Infected/Susceptible (SIS) seems more plausible, as foreign fighters can return back to their European countries of origin. While such individuals could return without any plans to commit violent acts, they remain susceptible to any radical ideas or any calls for violence. As such, information on these persons could enhance the current conceptualisation of the model while investigating strategies that increase return rates would also become possible.

The current research can therefore serve as a stepping stone for further studies into the conceptualisation of the jihadist enterprise as an infectious disease. This research can benefit governments and security minded institutions by presenting a viable approach to test differing interventions aimed to suppress the radicalisation of susceptible individuals and their possible journey to conflict ridden areas of the world.

Words: 4165

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