A Mathematical Model to Evaluate Strategies for Improving Pandemic Preparedness in Cambodia

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Partners:

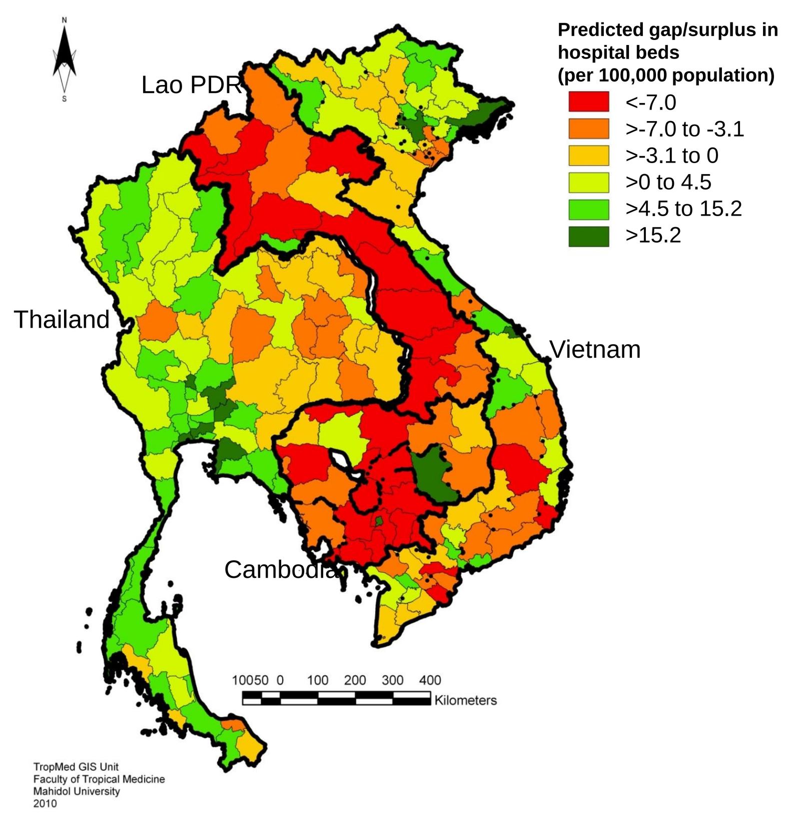
Funders:

Background

Resource poor countries are likely to suffer disproportionally in influenza pandemics.

A previous analysis across Southeast Asian countries suggests that Cambodia will experience particularly severe shortages of healthcare resources, which in turn could result in substantially higher excess mortality rates (Fig 1).†

Figure 1 – Estimated hospital bed shortages for a modelled pandemic scenario†



In order to improve pandemic preparedness and mitigation in such countries, evidence to inform allocation of scarce resources is crucial.

We are developing a mathematical model of pandemic influenza transmission that can inform pandemic investment options in Cambodia.

The Model

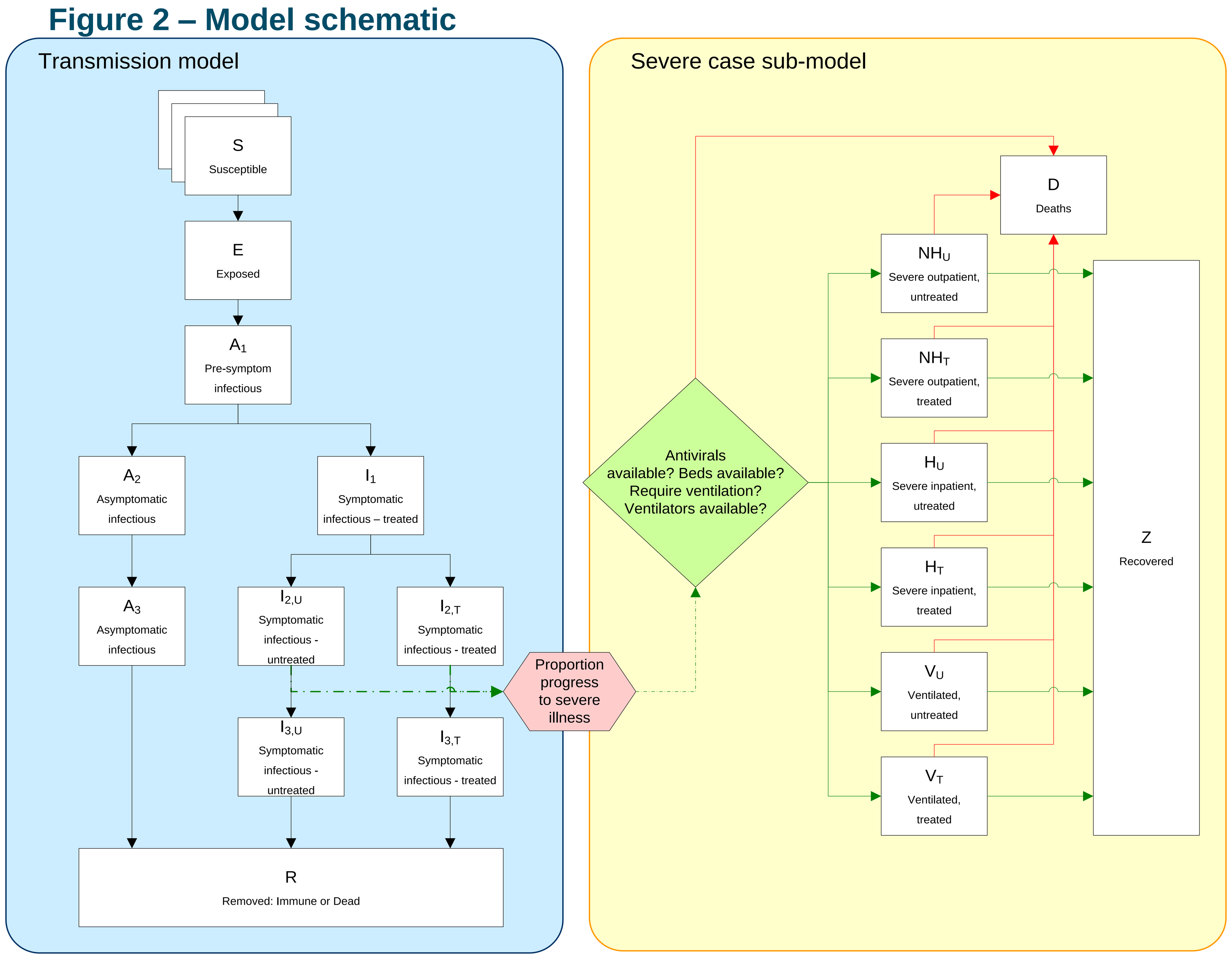
The model¤ is an age-structured, deterministic compartmental system of differential equations, with two main components (Fig 2):

1. A **transmission model,** based on the classic "SEIR" (Susceptible-Exposed-Infectious-Removed) model. Early treatment of outpatients in this model can reduce duration and level of infectiousness, and risk of progressing to severe illness.
2. A **severe case sub-model**, to track the availability of hospital resources over the course of the outbreak, which in turn affects outcomes (length of stay and risk of death) of severe cases.

The model system is designed to allow investigation of a wide range of intervention scenarios including:

- Antiviral stockpiling and distribution strategies
- Increasing hospital surge capacity
- Contact reduction (e.g. school closure)

Figure 2 – Model schematic



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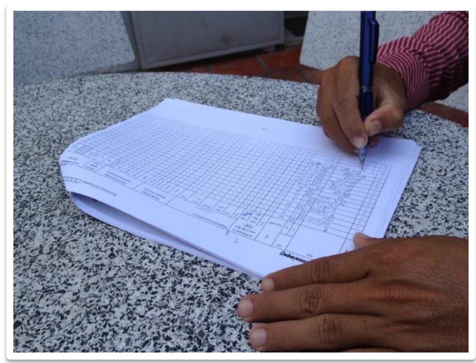
†Rudge JW *et al.* (2012) *PlosONE* 7(2):e318
¤ The model builds on previous work including Krumkamp *et al*. (2011) *Epidemiol Infect* 39(1):59-67
§Since the analyses of contact patterns data from Cambodia is ongoing, the preliminary simulations used a contact matrix from Vietnam, provided in Boni M *et al*. (2010) *BMC Medicine* 7: 43.

Data and Parameterisation

Data to inform the model were collected though:



- A survey of 2000 humans across 3 provinces in Cambodia to measure social mixing patterns and healthcare seeking behaviour
- A survey of hospitals and health offices across Cambodia to map resource availability
- A review of secondary data on previous pandemics and severe influenza cases.

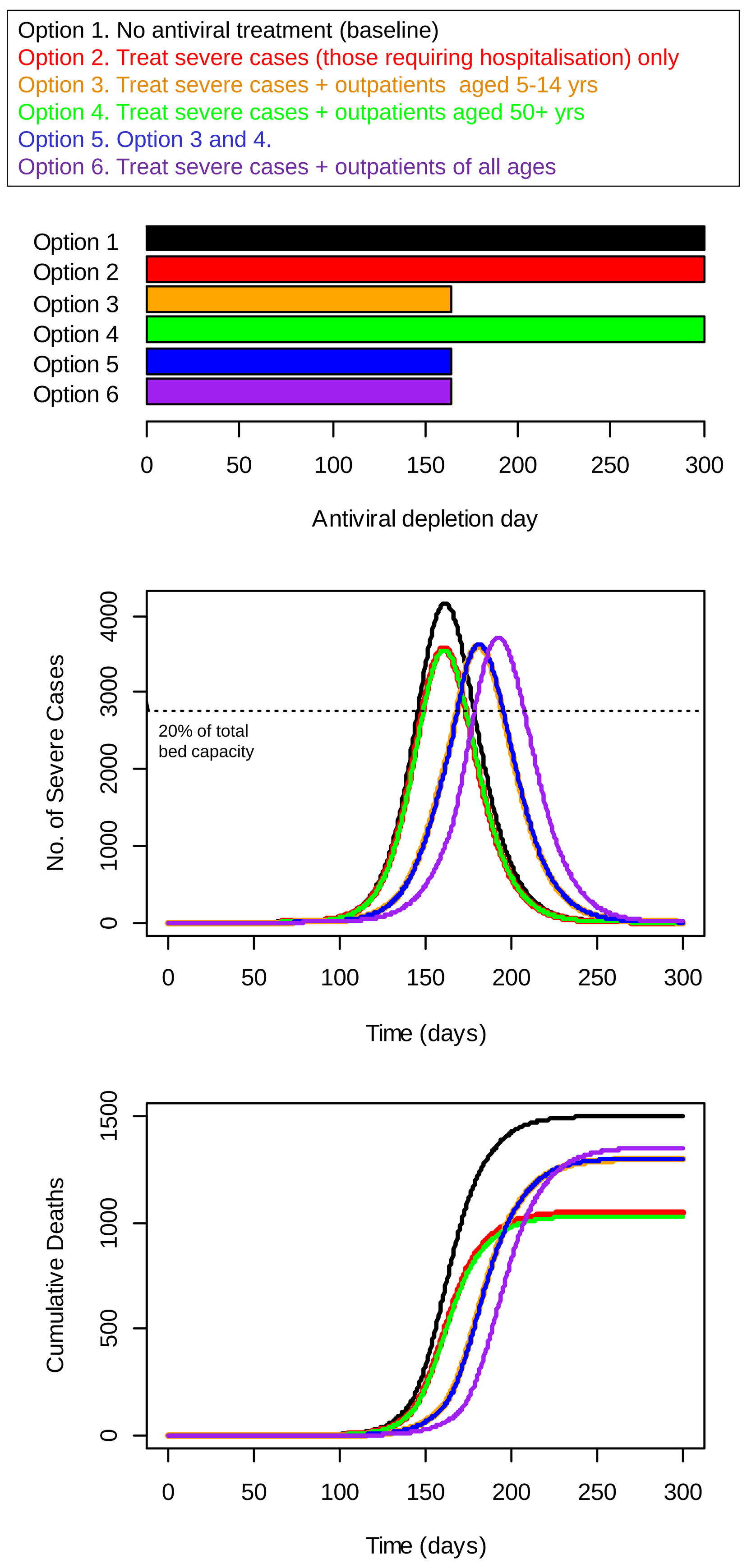
Preliminary Results

Simulations were run for a pandemic H1N1(2009)-like scenario in Cambodia§, comparing different antiviral drug administration strategies (Fig 3).

Assuming a stockpile of **100,000 antiviral treatment courses,** the model predicts that:

- Restricting treatment to severe cases would reduce the total number of deaths by around 30%.
- Treating outpatients presenting with mild illness, in addition to severe cases, could reduce transmission and delay the pandemic peak. However, depletion of the stockpile results in more deaths overall.
- Targeted treatment of specific age-groups has different impacts, depending their contribution to transmission (highest for ages 5-14), and risk of progressing to severe illness (highest for those aged 50+).

Figure 3 – Model simulations comparing antiviral administration strategies



Conclusions and Future Work

We have developed a mathematical model to investigate a diverse range strategies for improving pandemic preparedness and mitigation.

The model will be extended to allow for spatial heterogeneity in transmission and resource availability. Importantly, given the unpredictability of future pandemic scenarios, parameter values will be sampled from plausible distributions using Monte Carlo simulations.

Ultimately, the model will be linked to a costing model for economic evaluation of investment options.

Although parameterised specifically for Cambodia in this study, the model system can be applied to other settings.