MAKERERE UNIVERSITY
DEPARTMENT OF MATHEMATICS

PRESS RELEASE: CORONA VIRUS IN UGANDA

9th June 2020

Mathematical modelling of COVID-19 dynamics in Uganda: Using a locally parameterized system to enhance intervention policies.

Introduction

Uganda has a unique set up comprised of resource-constrained economy, social-economic challenges, politically diverse regional neighbourhood and home to refuge crisis that comes from long and protracted conflicts of the great lakes. The devastation of the on-going global pandemic outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is likely to be escalated by these circumstances with expectations of the impact of the disease being severe.

On 21st March 2020, Uganda reported her first case of COVID-19 which was imported. Subsequently, more predominantly imported cases were detected and the government responded by issuing the following guidelines to curb the spread - closure of schools, religious places, non –essential businesses, entertainment places, the stoppage of public transport, the social distancing and stay home – stay safe campaigns. The measures were intended to serve the purpose of; eliminating crowding places that would provide breeding grounds of new cases, limiting introduction of imported cases, limiting the chances of community transmission, and preventing the potential long-distance pathogen spread through vehicle facilitated movement.

The disease was relatively well managed in Uganda with the number of cases only rising after a surge in the number of imported cases. As 4th June 2020, there were 522 cases, 0 deaths and 82 recoveries.

The most worrying challenge for Uganda was on the health system capacity. The indicators of the pandemic from other countries seemed to show that the matter requires and required huge healthcare support – the number of patients would overwhelm the hospital facilities we have in Uganda, the need of intensive care units (ICUs), personal protective equipment (PPE), isolation and quarantine centers, hospital beds and manpower. On the problem of truck drivers, one needs to recall that in order to sustain availability of basic commodity requirements for the population, the Government of Uganda maintained the flow of cargo destined to Uganda and to regional neighbors but this came at a cost of increased reported cases that have increased the demand for testing and hospitalization.

The aim of this study is to develop a mathematical model to study the dynamics of COVID-19 in Uganda and use it to provide comprehensive forecast of the disease trend and give appropriate policy-based support to government on the timing and nature of interventions measures.

The basics and fundamentals of the model and governing dynamics are presented in the diagram shown in Figure 1.

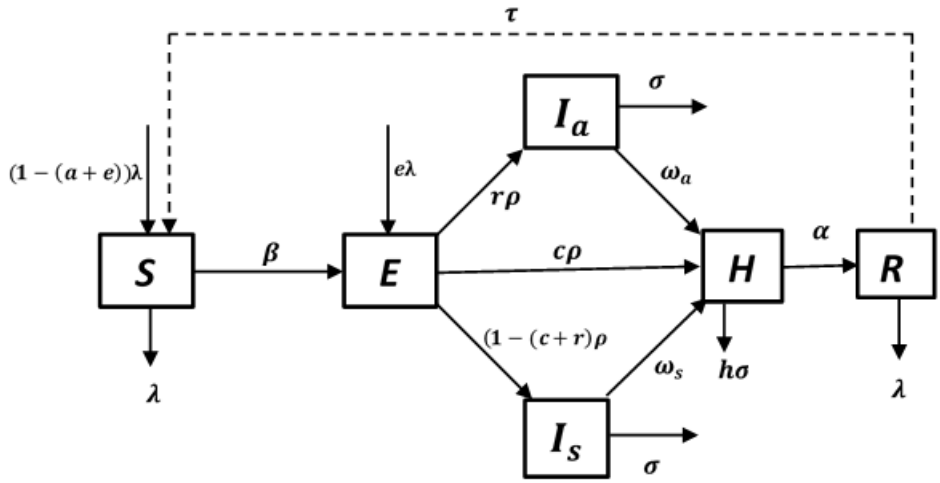

Figure 1. A compartmental model for fatal COVID-19 transmission dynamics that incorporates arrival of infected and susceptible individuals and departure of susceptible and/or recovered individuals and incorporates contact tracing efforts and isolation of susceptible individuals. The underlying descriptions and assumptions are mathematically taken care of in the formulation.

In the analysis, the model is parametrized to suit the initially observed dynamics of COVID-19 in Uganda, and use it to make projections of the disease burden of undetected transmissions, imported cases, hospital demand, quarantine, contact tracing, and timing of easing of lockdowns focusing their impact on two selected disease burden indicators namely, the number of hospitalized and undetected infected cases in the community.

Findings

1. **Lockdown and social distancing:** The immediately implemented measures by the Government of Uganda averted thousands of cases. It is projected that if 50% of the population was out of the lockdowns after 58 days, then the daily COVID-19-related demand for hospital beds would have exceeded Uganda's current capacity of 2000 by 85 days and this daily demand would reach 10,000 within one year. During the same period, the number of undetected infectious individuals on a given day would reach 1400. This is indicated in Figure 2. These undetected daily cases have along with them secondary multiple contacts that they interact with and as numbers grow big, contact racing becomes overwhelming.

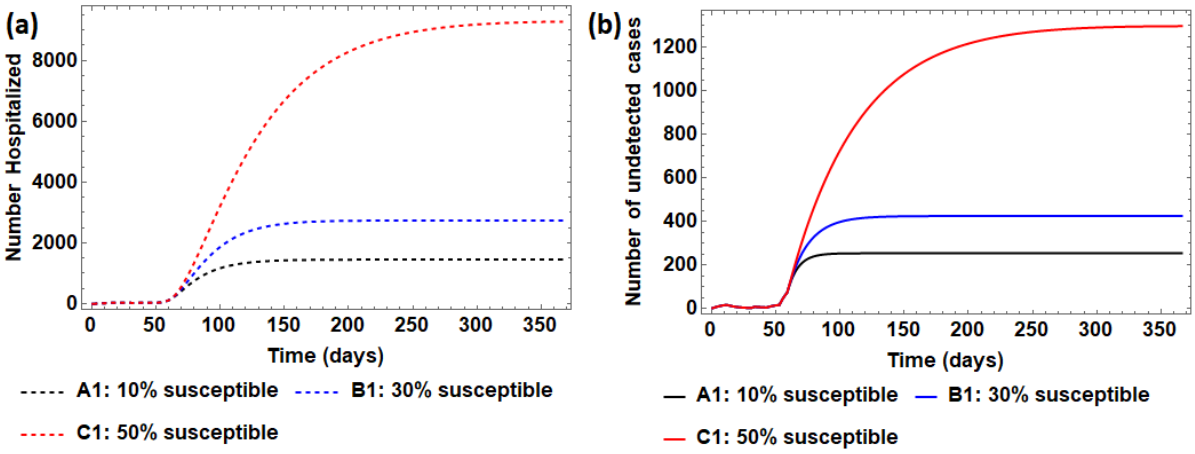

Figure 2. The effect of reducing the proportion of susceptible population after 58 days since the reporting of the first confirmed COVID-19 case in Uganda. Scenario A1 involves maintaining the 10% level while the alternative scenarios investigated are B1 involving 30% and C1 involving 50% of the national population of 43 million being susceptible.

2. **On imported cases:** Model results reveal that the disease will remain endemic in Uganda for as long as we still have imported cases no matter how few. Even more worrying is the fact that the endemic level would be higher at bigger levels of susceptibility. Within one year, the only scenario in which the disease would be wiped out is when there were no more imported cases beyond the first 58 days and this would be achieved after 200 days if all other measures in place are strictly observed. These results are presented in Figure 3.

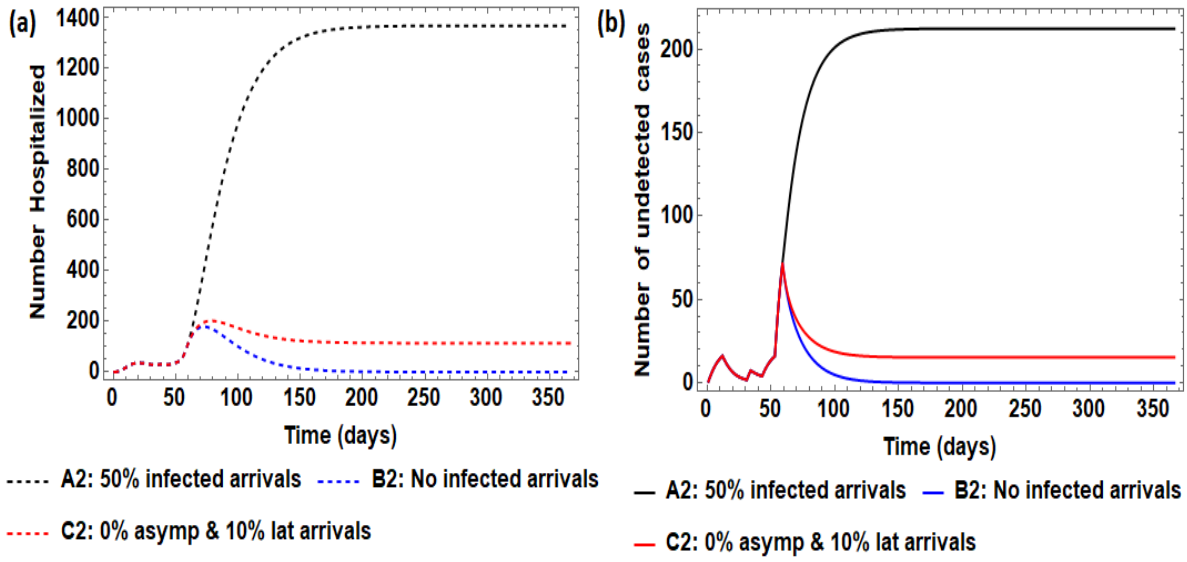

Figure 3. The effect of reducing the number of imported COVID-19 cases and latently infected individuals by 50% in Scenario A2, are completely eliminated in Scenario B2 and in Scenario C2 there are no asymptomatic infectious and there are only 10% latently infected individuals that are granted entry after 58 days since of the reporting of the case in Uganda.

3. **Enhanced surveillance and contact tracing**: Contract tracing helps to remove latently infected individual from the community before they become infectious. Enhanced contact tracing would increase the proportion of latently infected individuals removed from the community. By ensuring that after 58 days twice as many latently infected individuals are traced and all other infectious individuals are traced within one day (as was subsequently done for truck drivers), then 52% and 83% of peak hospitalization needs and undetected cases would be averted. These results are presented in Figure 4.

4. **Hospital acquired infections:** The earlier mitigation of hospital acquired infections may have averted thousands of subsequent hospitalizations. Introducing hospital acquired infections at a mere 12% rate compared with the undetected infectious after 58 days would increase the maximum number of hospitalizations and undetected cases to close to 10,000 and 2000 respectively. This study notes that even with a reduced transmissibility of only 12% within hospital settings, the resulting disease spill-over to the community would increase the maximum demand for hospital beds by 260% in a period of one year, while doubling of imported cases leads to 100% increase in the demand due to the associated secondary infections These results are presented in Figure 4

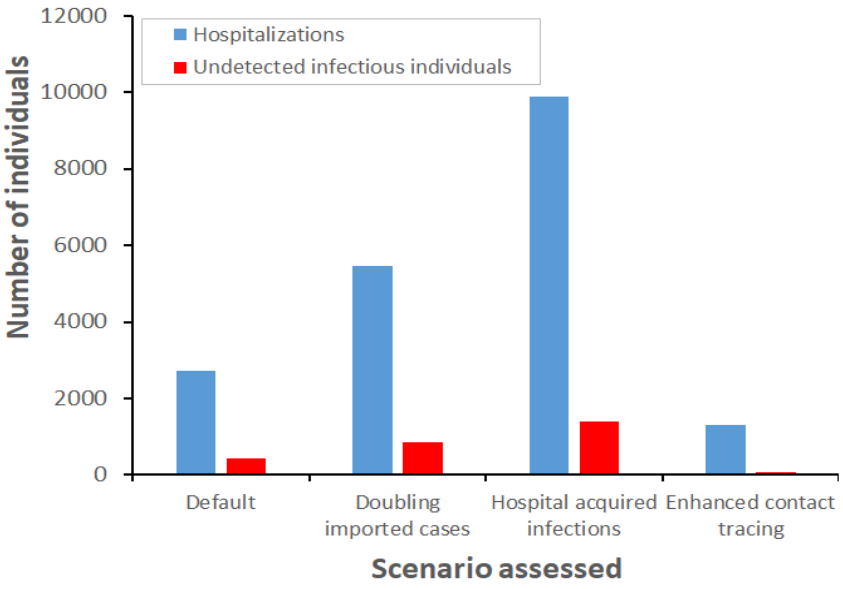

Figure 4. Outcomes of selected scenario analyses on the effect of varying the high impact parameters as identified by sensitivity analysis on COVID-19 burden. The numbers presented are maximum values attained over the simulated period of one year.

5. **Second wave of infection**: Even in an ideal situation with no new arrivals of imported cases nor occurrence of hospital acquired infections after 58 days, 75% of population can only be effectively released from lockdown after 210 days (around October 2020) if the possibility of having a second wave of infection is to be mitigated. Easing lockdown from 10% to 30% after 58 days followed by 75% susceptible after 150 days of lockdown (translating to around August 2020 – a case of too many and too soon) the reaming infected individuals are enough to initiate an even bigger second wave of infection. Results are presented in Figure 5.

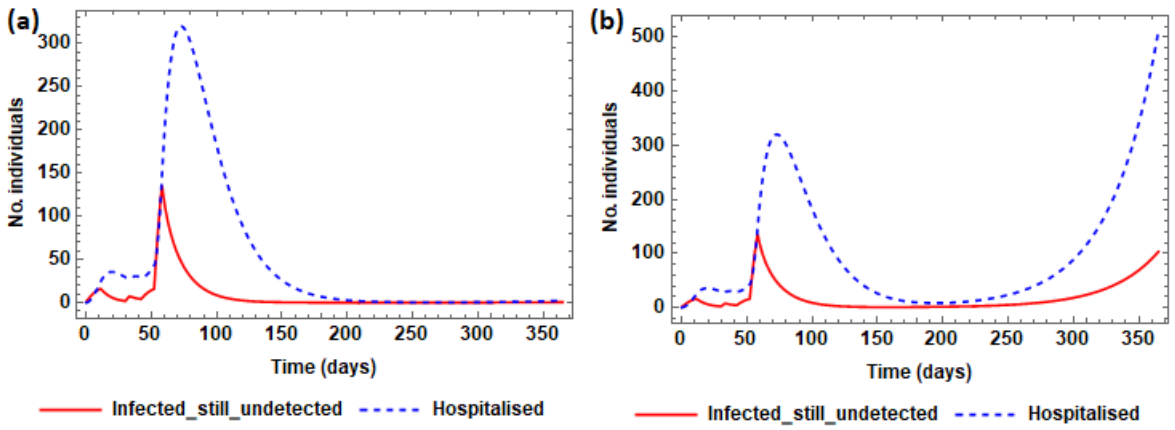

Figure 5. The possibility of having a second wave of COVID-19 infections upon easing lockdown measures with no hospital acquired infections and after 58 days, there is assumed to be an initial 30% ease in the lockdowns and no more imported cases.

Conclusion

Findings of this study show that the immediately implemented measures by the Government of Uganda averted thousands of cases that would have overstretched the health system within a couple of months. Without significantly altering the current situation, measures on partial lockdowns and use of masks are insufficient to stop COVID-19 and as such the disease will remain endemic in the population. In all the assessed scenarios the disease would be wiped out in the case where there are no infected arrivals beyond the first 58 days and in this case the disease would be wiped out within 200 days.

With the worrying situation of increased reported cases in our neighbouring countries, the impact of Uganda's interventions would be greatly affected as results show that doubling the imported cases would almost triple both the maximum number of hospitalized individuals and the number of undetected cases.

Screening of truck drivers faces a challenge of reagent limitation, imperfect test accuracy, arrival of asymptomatic and latently infected individuals that may pass as false negatives during screening as well as the porosity of some of the national borders. Thus, adoption of alternative less-risky means of essential cargo delivery (e.g., by rail and ship services) combined with quarantining of all entrants for a duration not shorter than the incubation period should be enforced.

Amidst challenges of social-economic impact of COVID-19, agitation of lifting lockdown may downplay the impact of intervention measures and the study findings highlight the importance of optimal timing and magnitude of lockdown easing. Effectively phased-out ease of lockdown needs to be well studied and executed to avoid the possibility of a second wave.

Recommendations

1. It is not advisable to eased lockdown by releasing 50% of susceptible population for the Ugandan situation with current 3200 hospital beds and not all are of ICU-like capacity, because within 100 days the COVID-19 related hospitalization demand would have already overwhelmed the current resources.

2. Since the consequences of hospital acquired infections go beyond merely increasing the number of cases, their mitigation should be given high priority.
3. Lifted to a 75% level, the yet-to-be detected cases in the community have potential to start a second and more disastrous epidemic wave. However with enhanced surveillance and contact tracing, gradual easing by releasing smaller percentages of susceptible individuals from lockdown can still be safely executed sooner than the optimum 210 days for up to 75% susceptible level.
4. The issue of handling truck drivers mingling at service and testing centres at border crossings should be reinforced – preferably, government should set up treatment and isolation facilities as close as possible to the testing border points not to overwhelmed the existing regional facilities, optimize scarce handling resources and also to minimize stigma and community discontent. This would in addition reduce the time frontline workers are exposed to the risk of infection amidst lack of well equipped ambulances
5. Since latently infected individuals can only be detected after latent period, effort should be put on obtaining information on where the drivers have been few days before arrival to understand the risk of admitting persons from high risk regions of neighbouring countries. The risk of imported cases is not only posed by those who test positive but also due to false negatives and latently infected individuals.

Project Team

The study was led by Prof. Joseph Y.T. Mugisha (Department of Mathematics, Makerere University) as Principal Investigator along with the following Co-Investigators: Dr. Amos Ssematimba (Department of Mathematics, Gulu University), Dr. Juliet Nakakawa Nsumba (Department of Mathematics, Makerere University), Dr. Joseph Ssebuliba (Department of Mathematics, Makerere University), and Dr. Cliff Richard Kikawa (Department of Economics and Statistics, Kabale University) as collaborator.

Acknowledgement

We thank the Government of Uganda through Makerere University Research and Innovation Fund on COVID 19 for the grant to carry out this study, and Ministry of Health for the data on COVID-19.