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MOCOS CASE STUDY FOR THE OPENING OF MSU-IIT, ILIGAN CITY, PH

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MOCOS

This report uses the results and code developed by the MOCOS International research group founded in Wrocław in February 2020. The model description can be found in the appendix.

1. Situation in Iligan City

According to the medical doctors and health managers Iligan City has an approximated capacity of 10 ventilators, which can be considered as the capacity of intensive care units to this moment. In the neighboring province Lanao del Sur of the region BARMM, a growing number of possible incidents of COVID-19 is observed. In times without lockdown a fraction of 30% of citizens of Marawi city and surrounding barangays is commuting daily to Iligan City.

2. Problems in Estimating the Situation

Due to a lack of laboratories it is not to expect, that a massive local testing of possible COVID-19 cases is feasible. This directly influences the reported number of COVID-19 cases, which in Iligan City are with few exceptions based on clinical diagnosis and hence not counted as COVID-19 cases. The lack of this data makes it impossible to predict the exact number of COVID-19 cases. Hence we assume in our simulations that the city of Iligan is virus-free. In the scenarios we start with 10 imported cases. We assume no further infectious persons appear in the city throughout the time of simulation. Due to the number of people commuting to Iligan City every day, this is a conservative estimate.

3. Simulated Scenarios

3.1. Opening MSU under mild weakening of the lockdown.

Assumptions:

- Iligan City is virus-free during the lockdown
- Households with older than 65 year old people are set in quarantine.
- The social distancing measures are weakened to 50 % of the contacts before the lockdown. This means **instead of 10 people, one person meets five persons outside the household**. Note that also workspace contacts are included in this number. With this we incorporate that we assume that schools are still closed and hygiene measures are taken. The manufacturing and public life inside of Iligan is restarted. Restaurants, bars, churches and mosques are still closed.

Date: April 21, 2020.

- At the beginning of the simulation 10 imported infectious persons are inside Iligan city. With this we model the effect of imported cases due to the opening of Iligan city.
- The immunity is set to 1%, which means that 7500 persons were infected with COVID-19 before.
- For 11.800 MSU-IIT students the contact rate is set to 60 % of the contacts before the lockdown.
- **In this scenario no imported contacts from other provices are taken into account. This will enhance the speed of the disease spread.**
- **We have not incorporated in our simulations that the exeeding of the ICU threshold leads to a higher mortality rate.**

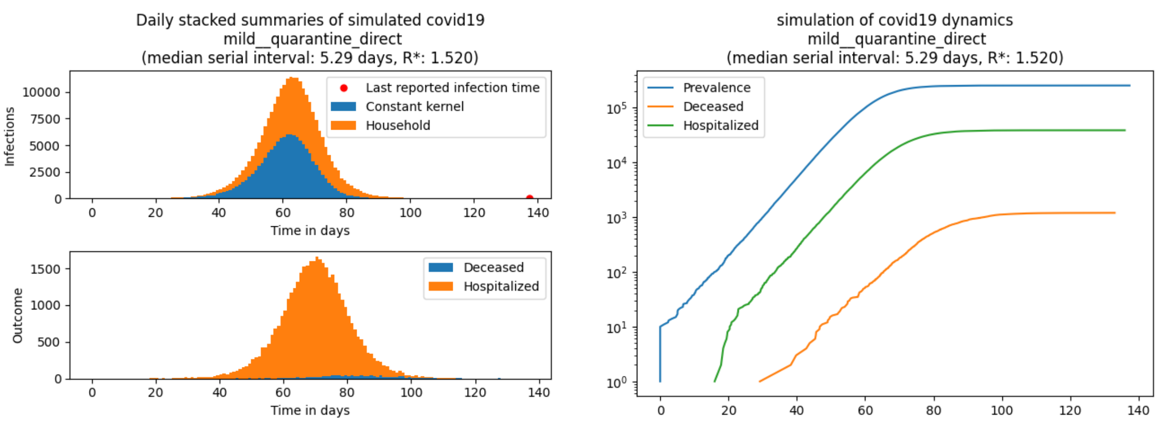
Results:

After	Prevalence	ICU care	Deceased
20 days	$\sim$ 1500	$\sim$ 10	2
50 days	$\sim$ 2400	$\sim$ 600	$\sim$ 80
70 days	$\sim$ 255200	$\sim$ 1500	$\sim$ 1000
120 days	255250	$\sim$ 90	1190

TABLE 1. Outcome for the scenario 'Opening MSU under mild weakening of the lockdown'.

After	Prevalence	ICU care	Deceased
120 days	254823	$\sim$ 80	1181

TABLE 2. With the same constants but without opening MSU-IIT.



(A) (B)

FIGURE 1. Incidences and Prevalence for the scenario 'Opening MSU under mild weakening of the lockdown'

3.2. **Opening MSU some month after weaker lockdown.**

Assumptions:

- Iligan City is virus-free during the lockdown
- Households with older than 65 year old people are still set in quarantine.
- The social distancing measures are weakened to 75 % of the contacts before the lockdown. This means **instead of 10 people, one person meets seven persons outside the household**. Note that also workspace contacts are included in this number. With this we incorporate that we assume that still there are hygiene measures taken after the lockdown. The manufacturing and public life inside of Iligan is restarted. Restaurants, bars, churches and mosques are open. Schools are slowly opening.
- At the beginning of the simulation 10 imported infectious persons are inside Iligan city. With this we model the effect of imported cases due to the opening of Iligan city.
- The immunity is set to 5%, which means that 37500 persons were infected with COVID-19 before. This a pessimistic estimate compared the the results from the scenario before.
- For 11.800 MSU-IIT students the contact rate is set to 90 % the contacts before the lockdown.
- **In this scenario no imported contacts from other provices are taken into account. This will enhance the speed of the disease spread.**
- **We have not incorporated in our simulations that the exeeding of the ICU threshold leads to a higher mortality rate.**

Results:

After	Prevalence	ICU care	Deceased
20 days	$\sim$ 750	4	0
50 days	$\sim$ 18000	600	8
80 days	$\sim$ 245000	1000	800
120 days	246993	$\sim$ 1150	3447

TABLE 3. Outcome for the scenario 'Opening MSU some month after weaker lockdown'.

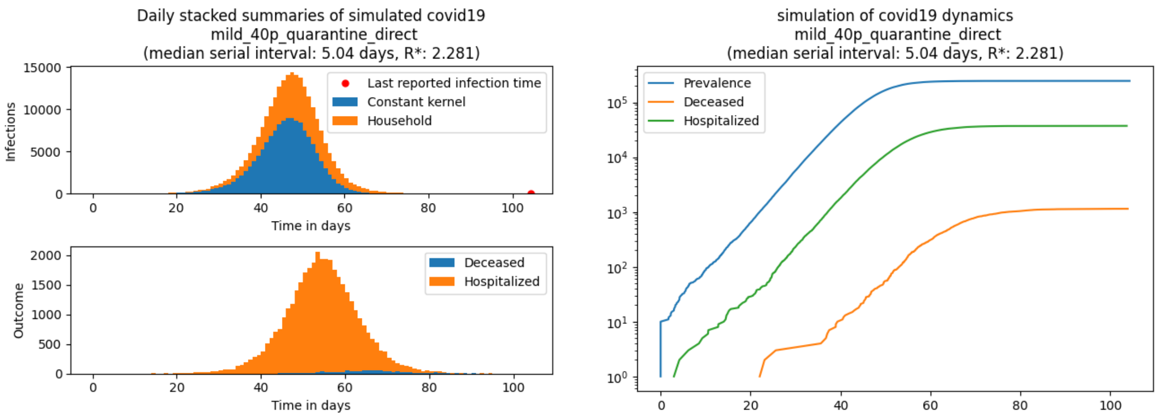
After	Prevalence	ICU care	Deceased
100 days	108052	$\sim$ 600	490

TABLE 4. With the same constants but without opening MSU-IIT.

3.3. **Opening MSU after an overcritical epidemic.**

Assumptions:

- Iligan City was struck by a massive outbreak of COVID-19.
- Households with older than 65 year old people are still set in quarantine.
- The social distancing measures are weakened to 80 % of the contacts before the lockdown. This means **instead of 10 people, one person meets eight persons outside the household**. Note that also workspace contacts are included



(A) (B)

FIGURE 2. Incidences and Prevalence for the scenario 'Opening MSU some month after weaker lockdown'

in this number. With this we incorporate that we assume that still there are hygiene measures taken after the lockdown. The manufacturing and public life inside of Iligan is restarted. Restaurants, bars, churches and mosques are open. Schools are opening.

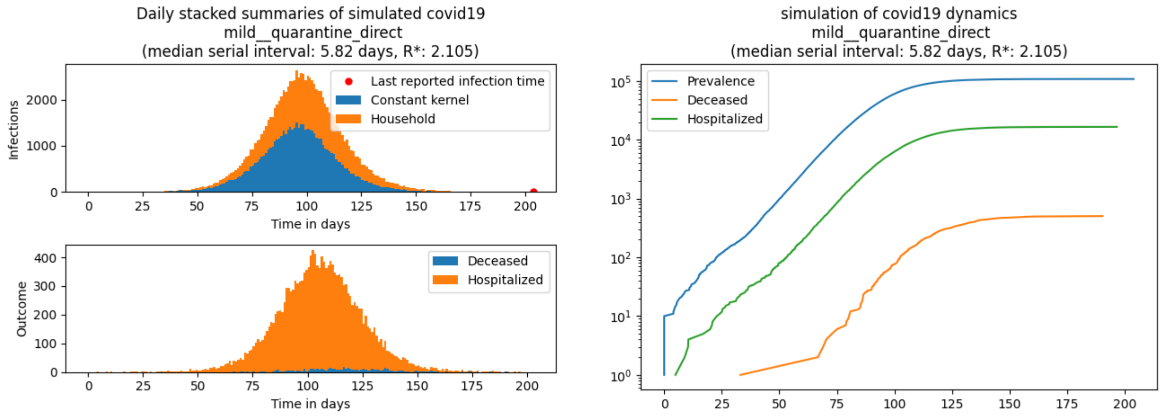
- At the beginning of the simulation 10 imported infectious persons are inside Iligan city. With this we model the effect of imported cases due to the opening of Iligan city.
- The immunity is set to 50%, which means that 190000 persons were infected with COVID-19 before.
- For 11.800 MSU-IIT students the contact rate is set to 90 % the contacts before the lockdown.
- **In this scenario no imported contacts from other provices are taken into account. This will enhance the speed of the disease spread.**
- **We have not incorporated in our simulations that the exeeding of the ICU threshold leads to a higher mortality rate.**

Results:

After	**Prevalence**	**ICU care**	**Deceased**
20 days	25	0	0
50 days	$\sim$ 1000	$\sim$ 10	$\sim$ 10
120 days	$\sim$ 107742	400	800
200 days	107742	0	493

TABLE 5. Outcome for the scenario 'Opening MSU after an over-critical epidemic'.

3.4. **Discussion of the three scenarios.** As our simulations show, all scenarios include a large amount of deaths, however it is not seen directly in the third scenario. The fact



(A) (B)

FIGURE 3. Incidences and Prevalence for the scenario 'Opening MSU after an overcritical epidemic'

there was a massive outbreak before involves many death to achieve a large degree of immunization. Please note that at the end of the first two simulations there are still people infected and moreover there are in both cases - also at the end of the simulation - more intensive care units needed than the city of Iligan can provide.

- Comparing the scenarios we see that the weakening of the lockdown has to be moderate, independently of the situation of MSU-IIT.
- Even a 5 times higher immunity can not prevent a massive outbreak if MSU-IIT students are not practicing hygiene and social distancing measures at university. This can be be seen in the large difference between opening MSU-IIT and keeping MSU-IIT closed in the second scenario. Note that here around 12.000 individuals have almost the full contact rate, which leads to a massive spreading from the students into the city and the households.
- The longer the university stays closed the more one can use the immunity built by the citizens during a weak lockdown. The last example shows that immunity can help also in combination with social distancing measures.

4. Conclusions

The simulations indicate that the opening of MSU-IIT can lead to a super-spreading event, if not combined with strict hygiene and social distancing measures, which reduce the number of secondary infections. It is too expect that the contact rate for students at MSU-IIT is higher than in the rest of the population due to teaching in classrooms and laboratories. Even an augmented immunity does not prevent from a massive outbreak. The more the immunity is built up the less intensive is the increased disease spread from MSU-IIT into the city. We strongly suggest to monitor the progression of COVID-19 during the weakening of the lockdown after April 30, 2020 before opening MSU-IIT. In addition we recommend to take strong social distancing and hygiene measures to milder the disease spread.

Appendix A. Social Distancing Measures

The results in the previous section are just possible in the presence of enough testing. If a massive testing is not possible, due to the lack of laboratories or other capacities, social distancing is a possible non pharmaceutical measure. We assume again the $R^*_{free} = 3$ in the case where we have no social distancing, which is a reasonable value as described before. In this subsection, we assume no quarantine measures. In particular we assume that neither the mild nor the severe cases are detected.

	Observed data	**Intervals of $\mathbf{R}^*$**	
Entity	**Assumed $\mathbf{R}^*_{\mathbf{free}}$**	$\mathbf{R}_{\mathbf{min}}$	$\mathbf{R}_{\mathbf{max}}$
Iligan	3	0.12	0.23

Table 6. Intervals of $R_{min} \leq R^* \leq R_{max}$ for a possible successful overcritical mitigation.

Table 6 shows the intervals of $R_{min} \leq R^* \leq R_{max}$ which contain the interval in which a successful overcritical mitigation is possible for the example of the city of Iligan. In other words R_{max} and R_{min} are upper and lower bounds for a successful mitigation. The present value of $R^*_{free} = 3$ was assumed to be 3 in absence of case data . The ICU threshold is again assumed to be 10 units. The upper bound for R^* of those intervals is denoted by R_{max}. This value is transferred into an average per day growth rate of prevalence, as it is reported by most health offices in their daily situation reports. We defined R_{max} as the smallest R^* value for which 10 sample paths surpassed the ICU threshold within 200 days. The critical value R_{min} was defined as the largest $R^* < R_{max}$ for which the daily incidence at day 200 was below 50% of the initial number $N_0 = 10$ of infected . As can be seen from the values in Table 2, the interval for a successful mitigation is below 10% of R^*_{free}.

Appendix B. Model description

We model spread of COVID-19 with an individual based SIR model. This non-Markov stochastic process incorporates the infection probability of susceptible in contact with infected individuals.

Population structure: Our sample population is based on a synthetic reproduction of the microcensus in Iligan City based on the microcensus data in the Demographic and Health survey 2017[9] and involves age and household composition. We omit here more detailed structures like spatial assignment, gender, profession or comorbidity relevant health status.

Disease progression within patients: The disease progression is modeled according to the present medical knowledge. The incubation time is assumed to follow a lognormal distribution with median 3.92 and variance 5.516 [lognormal parameters: shape=0.497, loc=0.0, scale=3.923]. The age dependence of the probability to be hospitalized or to have severe progression or to have critical progression with requirement for ICU treatment is given in Table 1.

The time till hospitalization from the onset of symptoms is assumed to be Gamma distributed with median 1.67 and variance 7.424 [gamma parameters: shape=0.874, loc=0.0, scale=2.915][10] Patients with non severe progression possibly stay at home and the time from onset of symptoms till staying at home is also assumed to be Gamma distributed with median 2.31. and variance 8.365 [gamma parameters: shape=0.497, loc=0.0, scale=3.923].[11]

Symptoms	Age groups			
	0-40	40-50	50-60	60-70
Asymptomatic	0.006	0.006	0.006	0.006
Mild	0.845	0.842	0.826	0.787
Severe	0.144	0.144	0.141	0.134
Critical	0.004	0.008	0.027	0.073

Table 7. Age dependence of the probability to develop a certain level of symptoms. The probability for death was assumed to be 49% within the critical patients.

The maximal duration of the infectious period is assumed to be 14 days.[12]

Contact structure and infection transport: Within the households we assume a clique contact structure. Empirical studies have shown that a large fraction of secondary infections are taking place within households.[13] We hence assumed that the probability of a household member to become infected by an already infected household member, who is infectious within a time interval of length T, scales as $1 - \exp(-T/L)$, where $L + 1$ is the household size. Here, the time T is measured in days. Outside of the households we assume that infected individuals create on average $c \cdot T$ secondary infections, given that all contacts of these individuals are susceptible, where c is an intrinsic parameter. Note the time T being infectious is different for contacts inside and outside the household. The out-reproduction number R^* is defined as the expectation of $c \cdot T$, which is equal to $2.34c$ under our assumptions of disease progression within patients. The actual number of secondary infections of an individual outside the household is assumed to be Poisson distributed with mean $(c \cdot T)$. The total reproduction number R_0 is given by the sum of R^* and the number of secondary infections generated inside the household. The duration of the infectivity time T implicitly depends on age. This is due to the fact that infectivity time is reduced for individuals with severe disease progression, as those patients become hospitalized. Severe progression is in turn more probable for older infected individuals. The outside household contact structure was intentionally chosen to be simple in order to have only one relevant and easily interpretable parameter in the model. We do not consider super-spreading events that could enhance the progression of the epidemic. Such events might have a strong impact at the beginning of an epidemic outbreak but, as the number of cases increases, the mean number of secondary infections R will dominate the evolution.

Testing and quarantine: We included additional model features to study the effect of testing followed by household quarantine in case the testing was positive. We assume that individuals with severe symptoms will always be detected and individuals with mild symptoms will be detected with probability q two days after the onset of symptoms. A detection is followed up by quarantine of the corresponding household with the effect that all out-household contacts by members of those households are stopped. The parameter q can be interpreted as the likelihood that a person with characteristic mild symptoms will be tested for COVID-19.

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