APRIL 2020

DISCUSSION PAPER SERIES NO. 2020-15

Projected Disease Transmission, Health System Requirements, and Macroeconomic Impacts of the Coronavirus Disease 2019 (COVID-19) in the Philippines

Michael R.M. Abrigo, Jhanna Uy, Nel Jason Haw, Valerie Gilbert T. Ulep, and Kris Francisco-Abrigo

Philippine Institute for Development Studies

CONTACT US:

RESEARCH INFORMATION DEPARTMENT
Philippine Institute for Development Studies

18th Floor, Three Cyberpod Centris - North Tower
EDSA corner Quezon Avenue, Quezon City, Philippines

publications@mail.pids.gov.ph
(+632) 8877-4000

https://www.pids.gov.ph

Projected Disease Transmission, Health System Requirements, and Macro-economic Impacts of the Coronavirus Disease 2019 (COVID-19) in the Philippines

Michael R.M. Abrigo
Jhanna Uy
Nel Jason Haw
Valerie Gilbert T. Ulep
Kris Francisco-Abrigo

PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

April 2020

Abstract

The novel Coronavirus Disease 2019 (COVID-19) is a global pandemic that has infected at least 1.2 million people and caused more than 67,000 deaths worldwide. The Philippines has recorded 3,764 confirmed cases and 177 deaths as of April 7, 2020 and has implemented an enhanced Luzon-wide enhanced community quarantine (ECQ) from March 17 to April 30 in attempts to limit population movement and curb the spread of the epidemic.

Based on our disease transmission model, we project that **aggressive efforts in the post-ECQ period to isolate at least 70% of infectious cases** through better contact tracing, social distancing, individual or household isolation, and reduced delays in time to seek care for symptomatic cases **are necessary to suppress the outbreak.** Otherwise, lifting the ECQ but maintaining current conditions of delayed time to seek care for symptomatic cases merely delays the progression of the outbreak but still results in around 8% of the population infected.

For all scenarios that do not successfully isolate at least 70% of infectious individuals, demands for health care resources generated by COVID-19 at the peak of the outbreak far exceed available supply in the health sector. For example, assuming no further improvements in the ability to isolate symptomatic cases post-ECQ, the country's health system would require a 1.51 million beds, 456 thousand ICU beds, 246 thousand ventilators, 727 thousand doctors, a million nurses, 91 thousand medical specialists, and 36 million PPE sets on the peak day of the outbreak in August 2020.

The COVID-19 epidemic is expected to affect not only the country's health system, but also the economy. Projections based on a Leontief input-output model suggests that the **Philippine economy may lose between 276.3 billion (best case) and PHP 2.5 trillion (worse case)** due to COVID-19. The transport, storage, and communication sector is expected to suffer substantial losses because of expected declines in tourism (PHP 11.7- to 124.3-billion). Other services (PHP 41.5-356.9 billion), manufacturing (PHP 82.1- to 855.2-billion), and wholesale and retail trade (PHP 93.2- to 724.8-billion) are projected to be substantially negatively affected by weaker global and domestic demand. Extending the ECQ by one more month may potentially cost the Philippine economy at least PHP150 billion due to possible declines in household consumption as workers remain unemployed for longer periods.

Keywords: COVID-19, disease transmission, health system resource requirements, macroeconomic impact, Philippines

Table of Contents

List of Tables

List of Figures

Projected Disease Transmission, Health System Requirements, and Macro-economic Impacts of the Coronavirus Disease 2019 (COVID-19) in the Philippines

Michael R.M. Abrigo[1], Jhanna Uy[1], Nel Jason Haw[2], Valerie Gilbert T. Ulep[1],
Kris Francisco-Abrigo[1]

1. Introduction

The novel Coronavirus Disease 2019 (COVID-19) that caused an outbreak of severe acute respiratory syndrome in Wuhan City, China in December 2019 is now a global pandemic. As of April 8, the World Health Organization (WHO) reports that over 1.4 million people have been infected with more than 82,000 deaths across 184 countries. The number of cases is expected to escalate further in the coming weeks (WHO, 2020).

The Philippine Department of Health (DOH) confirmed its first case of COVID-19 on January 20, 2020, with local transmission identified on March 7, 2020. As of April 7, 2020, the Philippines has recorded 3,870 confirmed cases and 182 deaths (DOH, 2020). To curb the potential exponential spread of the outbreak locally, the Philippine government implemented an enhanced Luzon-wide community quarantine for 30 days (March 17 to April 12) to limit population movement, then extended it until April 30. The enhanced community quarantine (ECQ) has entailed suspension of classes, work-from-home schemes and skeletal workforces, and restriction of the population to their homes. Only essential activities such as health care, food supply, medicines, and banking are operational during the ECQ.

This report aims to contribute to the discussion on the potential impact of the pandemic on the Philippines by estimating the likely trajectory and magnitude of the outbreak in the country under various scenarios. Based on the projected number of COVID-19 cases that require medical intervention, we then calculated the resource requirements needed by the health system to cope with the expected increase in health care demand. We also linked the results from our disease transmission model with a micro-simulation model to assess the potential burden of COVID-19 on the Philippine macroeconomy.

The spread of COVID-19 in the country is expected to pose substantial strain on the country's health system. If left unchecked, the health system is projected to require as much as 1.51 million regular hospital beds, 456 thousand ICU beds, 246 thousand ventilators, 727 thousand doctors, a million nurses, 91 thousand medical specialists, and 36 million sets of personal protective equipment (PPE) for hospitalized COVID-19 cases on the peak day of the outbreak. For reference, the country employed only 52 thousand physicians and 351 thousand nurses in 2015 (PSA 2016 as cited in Abrigo et al. 2019), and has only 61 thousand beds in level 2 and 3 hospitals (DOH-HFDB 2020). The challenge is ensuring that the epidemic remains at manageable levels, if not totally suppressed.

An equally important challenge, however, is designing and implementing interventions necessary to effectively subdue the spread of the disease without imposing strains on society that are greater than the potential negative effects of the outbreak. As shown by the experiences in other countries, responses to epidemics may have unintended consequences, including on food security (Thomas, et al. 2014),

1 Fellow II, Supervising Research Specialist, Fellow I, and Consultant, respectively, at the Philippine Institute for Development Studies
2 Faculty, Health Sciences Program, Ateneo de Manila University

This paper has benefitted from thoughtful discussions by Karla Therese Sy, Vicente B. Paqueo, Aniceto C. Orbeta, Jr., Emmanuel Jimenez, Roehlano Briones, Jose Ramon G. Albert, Connie Bayugan-Dacuycuy, Ramonette Serafica, Francis Mark Quimba, Celia Reyes, Rosemarie Edillon, John Wong, the Ateneo de Manila University FASSSTER team led by Maria Regina Justina Estuar, the Philippine Council for Health Research and Development, the volunteer group from Asian Institute of Management led by Maria Elena B. Herrera, and the Department of Health. All remaining errors are by the authors.

child nutrition (Kamara, et al. 2017), and delivery of non-epidemic-related health services (Brolin, et al. 2016), as resources are diverted towards programs to control the epidemic. Local interventions need to recognize that more than half of Filipinos have limited capacity to subsist beyond one month without additional support.

Depending on the interventions implemented locally and the trajectory of the pandemic in other parts of the world, projections from combined disease transmission, micro-simulation and macroeconomic models suggest that the country's gross value added may decline between PHP123.5 billion to PHP2.5 trillion. Extending the Luzon-wide ECQ is estimated to cost the economy at least PHP150 billion for every month of ECQ, while only delaying the spread of the disease if not combined with more aggressive mitigation measures. With aggressive efforts in the post-ECQ period to isolate at least 70% of infectious cases through better contact tracing, social distancing, enforced individual or household isolation protocols, and reduced delays in time to seek care for symptomatic cases, such losses and resource costs can be drastically reduced or avoided.

The report is organized as follows. In Section 2, we assess the potential trajectory and magnitude of the COVID-19 outbreak by a disease transmission model calibrated using Philippine data. This is then followed, in Section 3, by the implied health system resource requirements needed to respond to the spread of the epidemic. In Section 4, we attempt to quantify the potential burden of the COVID-19 pandemic on the Philippine macro-economy. We also note in this section some potential limitations of various interventions to limit the spread of COVID-19 in the country. Finally, in Section 5, we conclude this report with key insights and recommendations based on our projections.

2. Projected Magnitude of the COVID-19 Outbreak in the Philippines

While modelling the transmission of COVID-19 is challenging due to limited disease surveillance data, estimates of the number of cases, especially severe and critical patients, can inform disease control efforts and resource allocations for the health system.

2.1. Data on Confirmed COVID-19 Cases in the Philippines

We used available data from the DOH-Epidemiology Bureau (EB) on confirmed COVID-19 cases (updated as of April 7, 2020) and literature on the epidemiology of COVID-19 to simulate the virus' spread in the Philippine population. **Table 1** summarizes the basic epidemiological profile of confirmed COVID-19 cases.

It must be emphasized that this may represent only a fraction of the total active cases in the country at the time of reporting. The number of confirmed cases may depend on health seeking behaviors among households and the health system's capacity for laboratory testing to confirm COVID-19 cases. The median age of cases is at 53 years old (interquartile range (IQR): 37 to 65 years old). The median age of deaths is higher at 65 years old (IQR: 58 to 74 years old). Males comprise 58% of all cases and 70% of all deaths. Majority of the confirmed cases (56%) and deaths (62%) are residents of the National Capital Region (NCR). One-hundred and forty (140) cases were considered imported, meaning they traveled from a foreign country with known local transmission within 14 days prior to reported symptoms onset.

2.2. Method for Modelling the Spread of COVID-19 in the Philippines

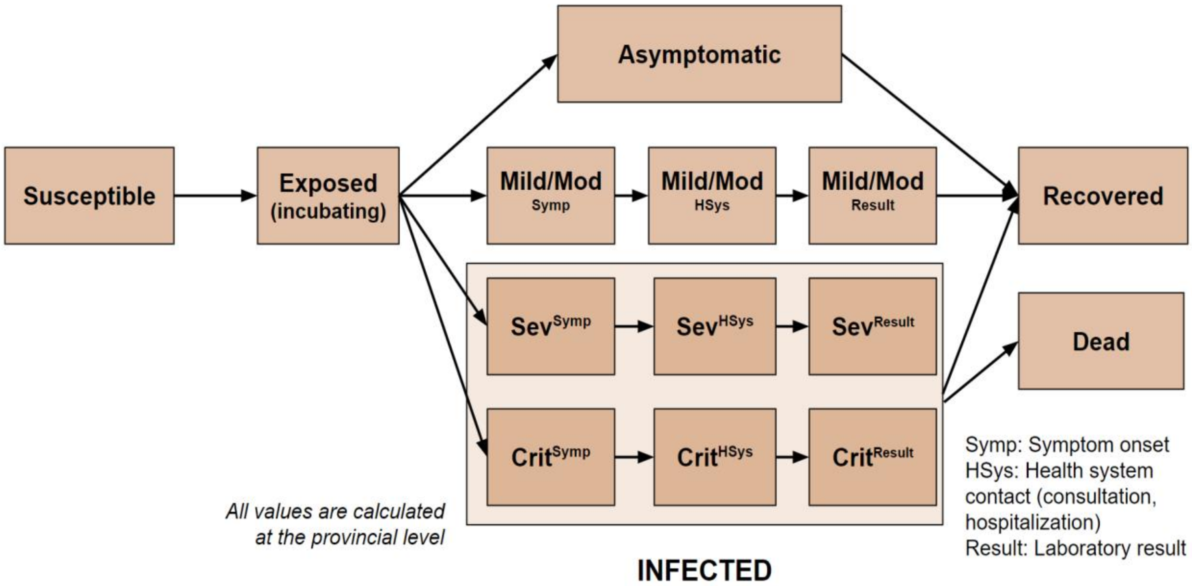
Disease transmission from January 15, 2020 to January 15, 2022 (732 days) was simulated using a discrete-time susceptible-exposed-infected-removed (SEIR) compartmental model stratified by province. Using difference equations that govern that transition of populations across compartments, the SEIR model simulates the rate at which susceptible (S) or healthy people get exposed (E) to the virus, become infected (I), and either recover (R) or die on each day of the outbreak (**see Figure 1**).

Table 1. Characteristics of confirmed COVID-19 cases as of April 7, 2020

Characteristic	All cases (*n* = 3,781)	All deaths (*n* =177)
Median (IQR) age, years	53 (37 - 65)	65 (58 - 74)
Age group, *n* (%)		
< 15 years old	39 (1.03%)	1 (0.56%)
15 - 44 years old	1,284 (34.0%)	11 (6.2%)
45 - 64 years old	1,476 (39.0%)	68 (38.4%)
≥ 65 years old	981 (25.9%)	97 (54.8%)
Missing	1 (0.03%)	0 (0%)
Sex, *n* (%)		
Males	2195 (58.0%)	126 (69.5%)
Females	1,585 (41.9%)	54 (30.5%)
Missing	1 (0.03%)	0 (0%)
Residence, *n* (%)		
National Capital Region (NCR)	2,114 (55.9%)	109 (61.6%)
Outside of NCR	798 (21.1%)	60 (33.9%)
Missing	869 (23.0%)	8 (4.5%)
Known travel history within 14 days before reported onset of symptoms, *n* (%)		
Foreign country with local transmission	140 (3.7%)	10 (5.7%)
No foreign travel	1,186 (31.4%)	104 (58.8%)
Unknown travel history	2,455 (64.9%)	63 (35.6%)

Source: Authors' calculations based on DOH-EB data.

Figure 1. SEIR Model Schematic for COVID-19 Transmission



We distinguish between Infected individuals who are incubating, asymptomatic, and symptomatic. Symptomatic Infected patients are further subdivided by disease severity, and subphases that reflect periods between a) disease incubation and onset of symptoms, b) onset of symptoms and initial contact with the health system for consultation, testing or hospitalization, and c) contact with the health system and obtaining test results.

On any day in the outbreak, **susceptible** individuals without disease living in different provinces meet infected individuals residing in the same province and in other provinces with a probability determined by a row-standardized social distance matrix. **See Appendix A** for a full description of the equations and **Table 2** for a summary of parameters.

Table 2. Parameters for the COVID-19 Disease Transmission Model

Parameter	Value	Reference
Population	Philippines:108,771,978	Philippine Statistics Authority, 2019
Assumed number of initial Infected cases	140 imported cases as of April 7, 2020	DOH-EB data
Basic reproduction number (R0)	NCR: Uniform(3.2, 3.5) Outside NCR: Uniform(2.0, 2.3)	Calibrated using DOH-EB data on the number of deaths in NCR and non-NCR provinces. Literature suggests that the mean R0 may range from 2.24 to 3.5. (IDM, 2020)
Incubation period	Uniform(5,6) days	Guan WJ et al., 2020 Lauer SA et al., 2020
Case severity distribution at end of illness	Asymptomatic: 25% Mild/Moderate: 55% Severe: 15% Critical: 5%	Various literature suggests that 20% to 30% of infections are asymptomatic. (IDM, 2020) Wu and McGoogan, 2020
Transition times for Infected sub-compartments	From symptom onset to seeking care/testing: • Mild/severe: 6.0 days (SD=5.4) • Critical: 5.9 days (SD=5.3) From seeking care/testing to test confirmation: • Mild/severe: 5.5 days (SD=3.8) • Critical: 5.8 days (SD=3.13) From test confirmation to recovery/discharge or death: • Mild, severe: 9.7 days (SD=5.1) • Critical: 4.4 days (SD=3.9)	Estimated from DOH-EB data.
Case fatality given disease severity	Asymptomatic: 0% Mild/Moderate: 0% Severe: 15% Critical: 55%	Initial estimates for case-fatality was based on literature such as Yang et al., 2020. Literature estimates were adjusted upwards to match DOH-EB data where age-standardized case fatality was 5%.

Infected individuals are able to infect susceptible individuals at a base rate determined by the basic reproduction number (R0). At model initialization, we seeded the Infected compartment with 140 imported confirmed cases. We introduced them into the symptomatic compartment of the model on their day of symptom onset and province of residence or confinement. Accounting for these imported cases, we estimated the *R0* in NCR and non-NCR provinces to be 3.2-3.5 and 2.0-2.3 by calibrating the SEIR model to the history of reported COVID-19 deaths until April 7, 2020. This means that without any interventions, an average non-isolated infectious individual in NCR is able to infect around 3.2 to 3.5 susceptible people, while the rate is 2.0 to 2.3 for non-isolated infectious individuals in other parts of the country.

Exposed individuals have an *average incubation period of five (5) to six (6) days* before developing symptoms. After the incubation period, 25%, 55%, 15% and 5% of the exposed become asymptomatic, mild/moderate, severe, and critical cases. We assume that *asymptomatic individuals do not transmit* the infection at any time while *symptomatic individuals are infectious two (2) days prior to symptom onset* in the terminal phase of incubation (Anderson et al., 2020). Based on DOH-EB data, the average time from symptom onset to health system contact was 6.0 days and 5.9 days for mild/severe and critical cases. Average time from health system contact to test confirmation was 5.5 days and 5.8 days for mild/severe and critical cases. Average time from test confirmation to **recovery or death** was 9.7 days and 4.4 days for mild/severe and critical cases. We assumed that case fatality rates among severe and critical cases are 15% and 55%, respectively.

2.3. Projected Propagation of the COVID-19 Outbreak under different Scenarios

To inform decision makers on potential interventions to suppress the outbreak, the spread of COVID-19 was simulated in the Philippine population under no intervention (S0) and five (5) sets of scenarios for a total of 14 (**Table 3)**. Higher numbered scenario sets (i.e., S2, S3, S4, S5) represent additional interventions on top of ECQ in scenario set 1 (S1). Letter suffixes indicate the length of the ECQ period where "a" assumes ECQ is implemented starting March 17 and ends April 12 while scenario suffixes with "b" and "c" indicate extensions of the ECQ by two (2) and four (4) weeks.

Table 3. COVID-19 Outbreak Scenarios

SCENARIOS			LUZON-WIDE ECQ Duration	LUZON-WIDE ECQ Compliance	Health System contact for Testing and Individual Isolation	Early Isolation at Symptom Onset
S0	**No intervention**		None	n/a	None	n/a
S1	**ECQ**	**a**	Mar 17 - Ap 12	95%	*Time to Test/Care from Symptoms* = ~6 days* *% Following Isolation* During ECQ - 80% Post-ECQ - 50%	n/a
		b	+2 weeks			
		c	+4 weeks			
S2	**ECQ + better testing**	**a**	Mar 17 - Ap 12	95%	*Time to Test/Care from Symptom Onset* ECQ to April 12= ~6 days Extended ECQ = 4days Post-ECQ = 2 days *% Following Isolation* During ECQ - 80% Post-ECQ - 50%	n/a
		b	+2 weeks			
		c	+4 weeks			
S3	**ECQ + better testing + isolate at symptom onset**	**a**	Mar 17 - Ap 12	95%		50%
		b	+2 weeks			
		c	+4 weeks			
S4	**Extended ECQ with partial lifting + better testing + isolate at symptom onset**	**b**	+2 weeks	50% during extension		
		c	+4 weeks			
S5		**b**	+2 weeks			70%
		c	+4 weeks			

***** Author's calculations from DOH-EB data as of April 7, 2020.

Scenario set 1 (S1) approximates current conditions: The Luzon-wide ECQ ends by April 12, 2020 (S1a), April 26, 2020 (S1b), or May 10, 2020 (S1c). Symptomatic cases are isolated when they contact the health system (e.g. going to the hospital emergency room), and majority of individuals follow ECQ guidelines. The ECQ compliance is assumed to be at 95% since the typical family household size is five (5) and only one person per household may leave their homes for essential movement once per week. In the post-ECQ period, everyone is free to move out of their households, but symptomatic cases are still isolated when they contact the health system with a reduced compliance of 50%.

Compared to the S1 set, **scenario set 2 (S2)** models improvements in time from symptom onset to contact with the health system for testing and individual isolation. In the current status quo, time between symptom onset and seeking care is estimated to be six (6) days on average based on DOH-EB data (**Table 2**). Significantly reducing this lag time may be one way to ensure that symptomatic cases have lower chance of infecting other people. Thus, during any extensions of the ECQ, the time from symptom onset is reduced to four (4) days, then finally capped at two (2) days in the post-ECQ period.

Scenario set 3 (S3) describes additional aggressive post-ECQ strategies compared to S2. This involves earlier isolation of at least 50% of symptomatic individuals on the day of symptom onset as opposed to the day they seek care at a health facility. **Scenario set 4 (S4)** is the same in all aspects to S3 except that we reduce ECQ compliance to 50% during the ECQ extension period of 2 weeks (S4b) and 4 weeks (S4c) to simulate partial lifting of ECQ for essential industries such as food and manufacturing. As the expected number of cases is expected to increase with partially lifting the ECQ in S4, we also tried to simulate an increase in intervention efforts to combat this. **Scenario set 5 (S5)** conditions are similar to S4, but now 70% of symptomatic individuals are isolated on the day of symptom onset.

2.3.1. Projection Results

Table 4 summarizes the number of infected people on the *peak day* of the outbreak for different scenarios**. Figure 2** (next page) presents the number of Infected per day until January 15, 2022 of the outbreak.

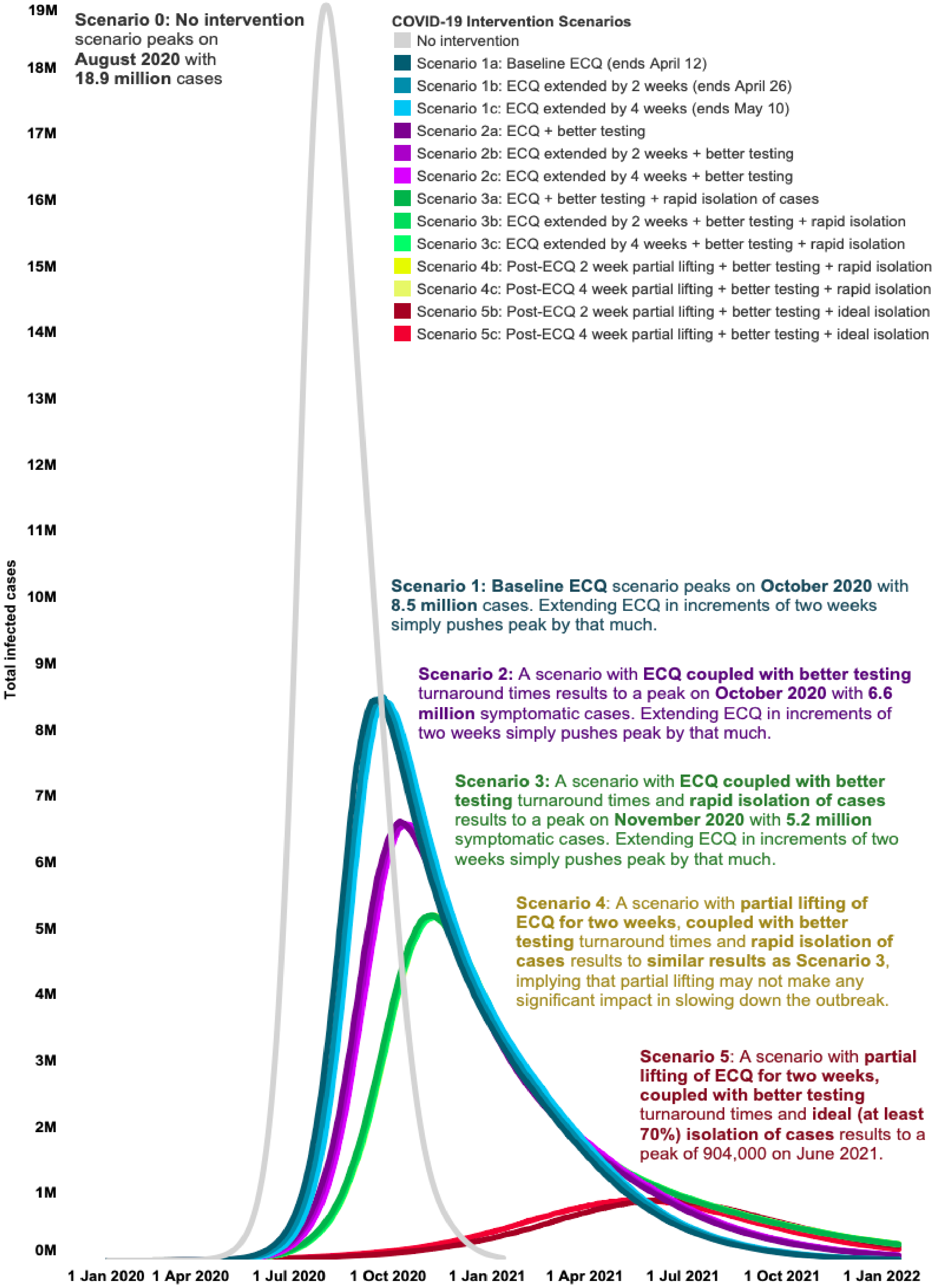
Table 4. Projected Number of COVID-19 cases on the Peak Day of the Outbreak

Scenario	Peak Month	Total Cases	Symptomatic Cases Only			Cumulative Deaths as of Peak Day
			Mild	Severe	Critical	
0	August 2020	18.9 mil	9.88 mil	3.39 mil	1.03 mil	1.66 mil
1a	September 2020	8.46 mil	4.41 mil	1.51 mil	456,000	1.00 mil
1b	September 2020	8.51 mil	4.43 mil	1.52 mil	458,000	1.09 mil
1c	September 2020	8.44 mil	4.40 mil	1.51 mil	454,000	1.02 mil
2a	October 2020	6.63 mil	3.07 mil	1.33 mil	410,000	921,000
2b	October 2020	6.58 mil	3.04 mil	1.32 mil	408,000	947,000
2c	October 2020	6.59 mil	3.04 mil	1.32 mil	408,000	923,000
3a	November 2020	5.21 mil	2.40 mil	1.05 mil	322,000	938,000
3b	November 2020	5.22 mil	2.41 mil	1.05 mil	322,000	874,000
3c	November 2020	5.20 mil	2.40 mil	1.05 mil	321,000	904,000
4b	November 2020	5.20 mil	2.40 mil	1.05 mil	321,000	885,000
4c	November 2020	5.22 mil	2.41 mil	1.05 mil	323,000	885,000
5b	June 2021	904,000	416,000	182,000	55,482	431,000
5c	May 2021	904,000	417,000	182,000	55,617	399,000

Source: Authors' calculations. / mil = million; rounded off to three significant figures

See **Appendix 2** for the number of new cases per month by severity.

Figure 2. Epidemic Curves for the projected number of COVID-19 Cases from January 15, 2020 up to January 15, 2022.



Source: Authors' calculations.

The results of our preliminary simulations imply the following:

- **Without intervention (S0),** the peak of the COVID-19 outbreak in the Philippines would occur in the month of August 2020 with approximately 18% of the whole Philippine population (18.9 million) infected with COVID-19.
- **Under ECQ or ECQ extensions (S1)** following current conditions (i.e., 6 days on average time to testing and isolation), the peak of the outbreak is both delayed by the same amount of time as the ECQ duration and the number of cases at peak is reduced by 44% (18.9 million to 8.5 million) compared to S0.
- **Moderately aggressive efforts in the ECQ extension and post-ECQ period (S2)** to reduce delays in time from symptom onset to testing and isolation further delays the peak of the outbreak by one (1) month and decreases the number of active infections on the peak day by 22% (5.2 million) compared to S1.
- **Additional aggressive efforts in the post-ECQ period (S3)** that immediately starts on the day ECQ ends to isolate 50% of all cases on day of symptom onset again slows the outbreak by another month and decreases the number of cases at the peak by 21% compared to S2 (5.2 million).
- **Partial lifting of the ECQ during any extensions (S4b and S4c)** does not accelerate or increase the peak number of cases compared to S3 **-** with the caveat that *the health system is able to isolate at least 50% of symptomatic cases on the day of symptom onset and cap the time from symptom onset to testing/isolation at two (2) days.*
- **Being able to isolate 70% of symptomatic cases (S5),** even with the partial lifting of ECQ, is able to drastically reduce the number of infected cases on the peak day to only 900,000 cases with the peak predicted to occur much later in May or June 2021.

To summarize, **extending the ECQ without other mitigation measures merely delays** the progression of the outbreak and still results in a large number of cases. **Aggressive efforts** to implement early testing and, more importantly, **earlier isolation of the majority of symptomatic cases** to prevent them from infecting other susceptible individuals will be **crucial to suppress the outbreak.**

3. Resource Requirements for Hospitalized COVID-19 Patients

COVID-19 patients generate massive demands for health system resources in the form of **hospital beds, intensive care unit (ICU) beds, ventilators, frontline health workers, personal protective equipment (PPE).** Moreover, the Philippine Health Insurance Corporation **(PhilHealth),** the national health insurer of the country with a central role of funding Universal Health Care, has proposed case rates to cover **medical charges for hospitalization of COVID-19 cases** (PhilHealth, 2020). It is crucial to take stock of the current supply of and projected demand for resources and costs to the public payer system to be able to address gaps, especially for critical patients who will need them the most.

3.1. Methods and Assumptions in Calculating Resources Requirements

Using the projected number of cases from our SEIR models, **we estimate the resource requirements for COVID-19 cases *that require medical intervention at health care facilities.*** To do this, we assume that all symptomatic COVID-19 cases will first present on an outpatient basis at a health facility primarily at the emergency room (ER). These COVID-19 cases will then be triaged for case severity. We assume only severe or critical cases are hospitalized, as mild/moderate cases who are stable are discharged to be taken cared of at home. Severe cases who present with severe pneumonia are hospitalized in an isolated room or ward while critical cases are admitted to the ICU unit. Approximately 54% of critical cases who are in acute respiratory distress syndrome (ARDS) will need a mechanical ventilator (Guan et al., 2020; Zhou et al., 2020; Arentz et al., 2020).

Throughout these events, teams of frontline health professionals with proper PPE provide care to COVID-19 patients. A full PPE set for protection against airborne, contact, and droplet transmission contains an n95 mask, hair cap, goggles, gown, face shield, gloves, and shoe covers. Assumptions for human resources and PPE consumption may be found in Table 5.

Table 5. Human resources and PPE needs per setting for a 24-hour period

Setting	Ratio of staff to patients (Liwanag & Ayaay, 2020)	PPE sets per Patient Type per day
Outpatient Triage Team	At maximum, 120 patients can be seen in the emergency room: ● Physicians - 4:120 (2 Residents, 1 Consultant, 1 Fellow) ● Nurses - 3:120 ● Auxiliary staff - 4:120 ● Cleaner - 1:120 ● Guard - 1:120	0.217 per symptomatic case (Calculated from Ratio of staff to patients in outpatient triage team)
Inpatient wards	● Doctor - 1:6 ● Nurse - 1:3	15 per severe case per day (DOH estimates in consultation with UP-PGH)
Intensive Care Unit	● Doctor - 1:1 ● Nurse - 1:1 ● Intesivist - 1:5 ● Pulmonologist - 1:5 ● Infectious disease specialist - 1:5 ● Mechanical ventilator technician - 1:5	30 per severe case per day (DOH estimates in consultation with UP-PGH)

3.2. COVID-19 Health System Resource Requirements

Table 6 and Table 7 (next page) show the resource requirement for hospital beds, critical care, PPE, and human resources for the projected number of cases on the peak day of the outbreak by scenario

For all scenarios, demands for health care generated by COVID-19 at the peak of the outbreak far exceed *current* supply in the health sector. Looking at the best case scenario of S5b and S5c, the country's health system would require a staggering 182,000 beds, 55.5 thousand ICU beds, 30 thousand ventilators, 88 thousand doctors, 118 thousand nurses, 11 thousand medical specialists, and 4.41 million PPE sets by May/June 2021.

Meanwhile, there are only 61,459 beds total across all level 2 (L2) and 3 (L3) hospitals in the Philippines (DOH-HFDB, 2020). Among hospitals reporting supply censuses to DOH (36.4% response rate) as of April 8, 2020, there were 1,921 ICU beds and 2,088 ventilators nationwide dedicated to COVID-patients (DOH-HFDB, 2020). Meanwhile, there are only 52 thousand physicians and 351 thousand nurses in the country (Abrigo et al., 2019). We also cannot assume that all ward beds, ICU beds, ventilators, and human resources can be allotted for COVID-19 patients as there will be other patients with illnesses (e.g. cancer, heart failure, kidney failure, stroke) who will require these resources. We also do not factor in that some health care workers will develop COVID-19 or need to be quarantined, effectively removing them from the frontlines.

Table 6. Hospital bed, intensive care unit (ICU) bed, ventilator, and PPE needs on the peak of the outbreak

Scenario	Peak Month	Hospital Bed	ICU beds	Ventilators	PPE sets
0	August 2020	3.39 mil	1.03 mil	557,000	82.0 mil
1a	September 2020	1.51 mil	456,000	246,000	36.5 mil
1b	September 2020	1.52 mil	458,000	247,000	36.7 mil
1c	September 2020	1.51 mil	454,000	245,000	36.4 mil
2a	October 2020	1.33 mil	410,000	222,000	32.3 mil
2b	October 2020	1.32 mil	408,000	220,000	32.1 mil
2c	October 2020	1.32 mil	408,000	220,000	32.2 mil
3a	November 2020	1.05 mil	322,000	174,000	25.5 mil
3b	November 2020	1.05 mil	322,000	174,000	25.5 mil
3c	November 2020	1.04 mil	321,000	174,000	25.4 mil
4b	November 2020	1.04 mil	321,000	174,000	25.4 mil
4c	November 2020	1.04 mil	323,000	174,000	25.5 mil
5b	June 2021	182,000	55,500	30,000	4.41 mil
5c	May 2021	182,000	55,600	30,000	4.41 mil

Source: Authors' calculations; mil = million; rounded off to three significant figures

Table 7. Health workforce needs at peak of the outbreak

Scenario	Doctors	Nurses	Infectious Disease Specialists	Pulmonologists	Respiratory Specialist
0	1.64 mil	2.19 mil	206,113	206,113	111,000
1a	727,000	975,000	91,300	91,300	49,300
1b	730,000	979,000	91,600	91,600	49,500
1c	725,000	971,000	91,800	91,800	49,000
2a	646,000	864,000	82,000	82,000	44,300
2b	642,000	859,000	82,500	82,500	44,000
2c	643,000	860,000	81,600	81,600	44,100
3a	508,000	680,000	64,500	64,500	34,800
3b	508,000	680,000	64,400	64,400	34,800
3c	507,000	678,000	64,300	64,300	34,700
4b	507,000	678,000	64,300	64,300	34700
4c	509,000	681,000	64,600	64,600	34,900
5b	88,000	118,000	11,100	11,100	5,990
5c	88,000	118,000	11,100	11,100	6,000

Source: Authors' calculations; mil = million; rounded off to three significant figures

Only S5 presents a manageable timeline to scale up health system capacity within a year to a reasonable level that the health system can sustain and benefit from even after the COVID-19 outbreak**.** For example, should the gaps in hospital beds be addressed, the Philippine health system would actually end up with 1.7 L2 and L3 beds per 1,000 population compared to the current supply of 0.57 L2 and L3 beds per 1,000.

Table 8. Projected total PhilHealth reimbursements for COVID-19 cases

Scenario	Reimbursements in PHP (Billions)
0	9,520
1a	6,430
1b	6,340
1c	6,250
2a	4,970
2b	4,920
2c	4,860
3a	3,800
3b	3,760
3c	3,740
4b	3,760
4c	3,740
5b	206
5c	268

Source: Authors' calculation

We also calculated the **public payer costs to PhilHealth** of reimbursing severe and critical hospitalized COVID-19 cases with the **proposed case rates** of PHP 333,519.00 for severe cases and PHP 786,384.00 for critical cases for the year 2020 (PhilHealth 2020).

In S5 where the most extensive mitigation interventions are implemented to reduce the total number of COVID-19 cases as much as possible, total predicted reimbursements for PhilHealth for severe and critical COVID-19 cases would be PHP 206 to PHP 268 billion. In 2019, PhilHealth only had a corporate budget of PHP 175 billion (PhilHealth, 2019).

This does not include case rates for costs of testing, community isolation, and hospitalization of mild cases with comorbidities/elderly. Likewise, these calculations assume that the case rates will not be revised (e.g. to a lower amount) for April 14, 2020 onwards and that all COVID-19 cases will avail of PhilHealth benefits.

As a caveat, estimates are based on the modelled scenarios. Should the health system become even much more aggressive and efficient in identifying and quarantining infected individuals, this would change the progression of the outbreak and may decrease the maximum number of cases and resource consumptions.

4. Projected Economy-Wide Impacts of COVID-19

The COVID-19 outbreak is expected to affect not only local health systems, but also local economies. Arguably, the most direct impact could be observed on the **ability of workers to participate in the labor market**. Aside from direct effects of excess morbidity on the labor force participation of infected individuals, household and community interventions (e.g. self-isolation and community quarantines) may **induce greater exit from the workforce**. This has important implications on a) household incomes and consumption, especially when social protection systems are limited, b) market production that affects the supply of goods and services available in the market, and c) government revenues and its ability to provide public services.

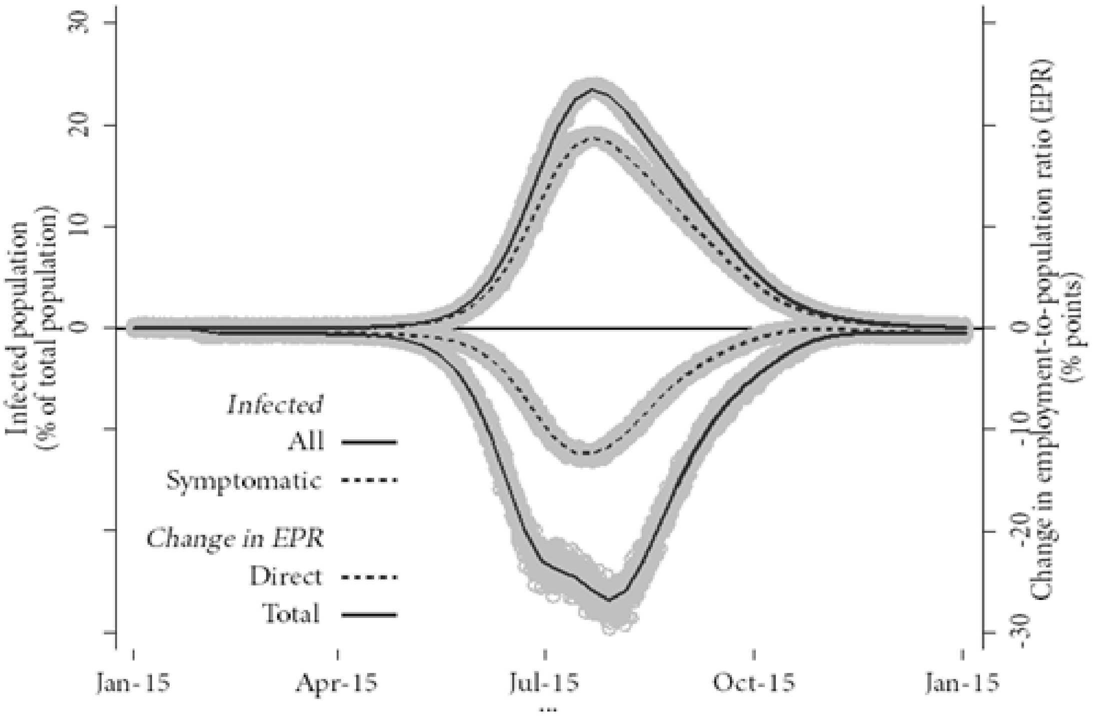
4.1. Projected Impact on Employment

To assess the potential impact of the COVID-19 outbreak on labor force participation among households, we linked the population-level SEIR model to an individual-level micro-simulation model. Under a no intervention scenario (S0), the projected number of symptomatic individuals may reach as high as a fifth of the Philippine population at the peak of the epidemic. Consequently, **self-isolation and quarantine rules on infected individuals and their household may delay the re-entry of**

workers to the labor force as reflected by the slower descent in the change in employment-to-population ratios (EPR) in Figure 3.

The **country's EPR may decline by as much as 12 percentage points under S0 as a direct result** of workers becoming symptomatic COVID-19 cases. Accounting for possible household responses (e.g. taking leaves to care for the sick, voluntary household isolation), however, the **reduction in EPR could reach almost 30 percentage points**. With the Philippines' current EPR of 60%, this poses a **potential 50% reduction in the country's number of workers at the peak of the epidemic** should it be realized. The reduction could be **much more pronounced if community-wide quarantines are imposed**.

Figure 3. Projected Infected cases and EPR change for a No intervention scenario (S0)



4.2. On the Potential Negative Impacts of Interventions

While arresting the spread of COVID-19 is paramount, **government interventions may need to account for the ability of households to cope with any indirect negative impacts** of these interventions. For example, community quarantines may effectively limit the income sources among households, especially those with non-permanent jobs. **Table 9** presents key household characteristics based on the 2015 Family Income and Expenditure Survey (PSA 2016), and using the income class typology proposed by Albert, et al. (2015, 2018). We converted the proposed per capita income ranges into a hypothetical number of months that a household may live on one average monthly income when consuming the bundle of goods and services used to calculate the 2015 national poverty threshold. Based on the distribution of household incomes in 2015, the table suggests that about three (3) in every five (5) Filipinos have limited capacity to subsist without additional support if community quarantines are extended beyond one month.

Table 9. Selected household characteristics by income class, Philippines 2015

	Poor	Low income, not poor	Middle income			Upper income, not rich	Rich
			Lower	Middle	Upper		
Subsistence capacity (months)	<1	1	2- 3	4 -6	7-11	12-19	20+
Share of population (%)	22	37	26	10	4	<1	<1
Labor and employment							
Labor force participation rate (%)	61	62	64	66	68	71	76
Employment rate (%)	95	94	93	95	96	98	98
Nature of employment (%)							
Permanent job	62	66	76	85	90	91	92
Short term	30	28	22	14	10	8	8
Different employer	8	6	2	1	<1	<1	<1
Age distribution							
Average family size	5.9	4.9	4.3	3.8	3.5	3.0	2.8
Median age (years)	17	23	28	32	35	39	40
Share of children aged 15 & below (%)	42	29	20	15	12	8	7
Total dependency ratio (%)	104	62	39	29	22	15	13
Housing and household amenities							
Household amenities[1] (%)							
Motorcycle	11	21	31	35	33	28	27
Car	<1	1	4	16	36	57	70
Landline	<1	1	4	16	31	43	53
Mobile phone	69	83	90	93	95	96	96
Computer	1	6	27	54	70	77	78
Refrigerator	6	22	52	77	88	91	95
Housing tenure (%)							
Home or owner-like possession	63	67	72	75	83	88	88
Rented house or lot	3	6	10	13	10	7	9
Others	34	27	18	12	7	5	3
Remittance recipient (%)	11	21	34	43	46	47	39

Source: Philippine Statistics Authority (2016) as presented in Albert, et al (2018).
Calculated from PSA (2016) based on the typology by Albert, et al (2018)

Although it can be argued that households may **rely on alternative sources of income**, such as financial incentives from employers, direct loans from banks, government social security agencies, and international remittances, these options **are not available equally among households**. Estimates from the 2016 Annual Poverty Indicators Survey (PSA 2017a) show that only two (2) in every five (5) households have at least one family member with Social Security System (SSS) or Government Service Insurance System (GSIS) coverage. This **proportion is expected to be lower among poorer households** who are less likely to have formal employment compared to richer households.

While the inflow of cash remittances from international migrant workers, an important resource among a significant number of households, have been documented (e.g. Orbeta 2008) to be countercyclical, i.e., increasing (decreasing) in economic downturns (upturns), **international migrant workers' jobs overseas may also be at risk with the spread of COVID-19 in their respective host countries**. In particular, seafaring jobs are at high risk with the mass grounding of cruise ships to limit the spread of COVID-19 infections, and of cargo ships as a result of slowing global demand. Land-based overseas workers are also at risk of losing employment as a result of contracting economies, especially among countries more greatly affected by COVID-19.

The experiences of many countries with community-wide quarantines suggest that large scale **telecommuting arrangements** among workers and online classes among students may be possible. However, these strategies assume that the **facilities necessary to implement such arrangements are available, accessible, and affordable** to all households; this may not necessarily be the case in the Philippines. Data shows that among households in 2015, **only 1% and 6% of poor and low income households, respectively, own a computer**. Moreover, **not all occupations** (e.g. plant machine operators, etc.) and education courses (e.g. those with laboratory components) **can be done remotely**.

Finally, while severely limiting travel as part of physical distancing may arguably be critical in slowing down if not totally arresting the spread of infections, it may have a **negative impact on the social and economic welfare of households**. As shown in **Table 4.1, ownership of personal vehicles**, including motorcycles and cars, **are limited** among all household types. Extended ECQ where public transportation is discontinued may thereby effectively constrain the ability of consumers to access, and producers to deliver essential market resources. It may be **detrimental to patients with non-COVID-related medical conditions** such as cancer, kidney disease **who need to access health care facilities for treatment.**

4.3. Projected Macroeconomic Impacts

Estimating the potential impact of COVID-19 on the Philippine economy is challenging, but necessary to provide indications that any potential response to arrest the spread of the disease are not worse than the negative impacts of the disease itself. Responses to epidemics may have unintended consequences on other material measures of well-being, including food security (Thomas, et al. 2014), child nutrition (Kamara, et al. 2017), and delivery of non-epidemic-related health services (Brolin, et al. 2016) as resources are diverted from established programs to initiatives aimed at hindering the spread of epidemics.

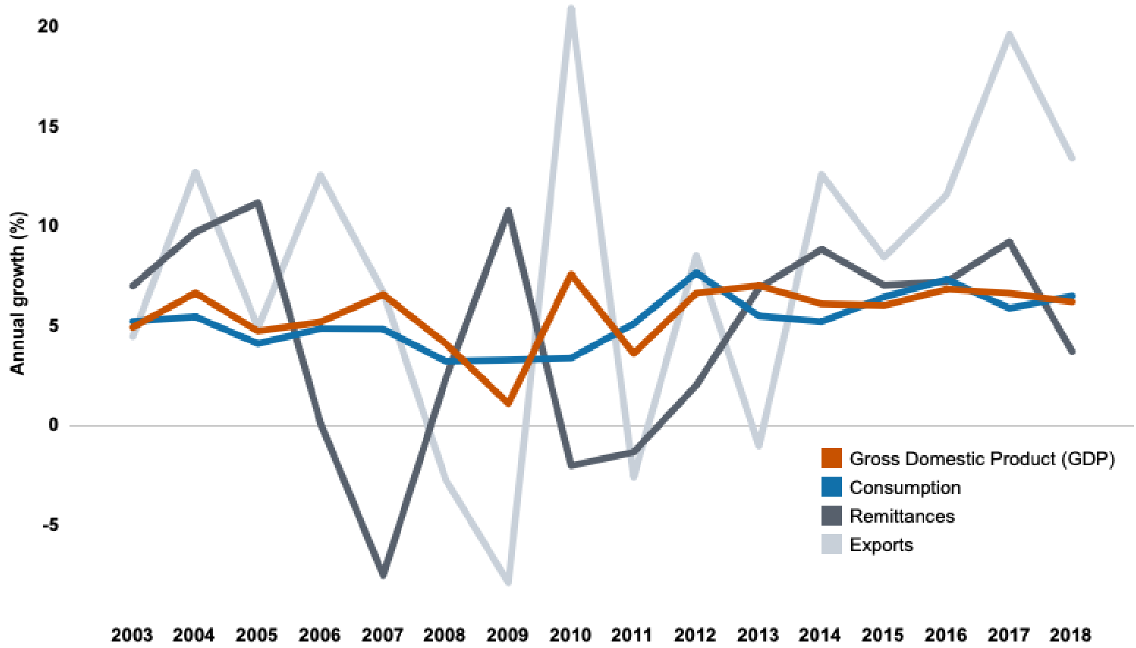
4.3.1. Challenges in estimating the potential macroeconomic impact of COVID-19

The **first** challenge lies in that the Philippines has not experienced an epidemic of similar proportions in recent history that allows direct comparison of costs and benefits. While the country has experienced a number of disease outbreaks (e.g. measles, malaria, and dengue), in the recent past, these do not compare to the potential magnitude of spread and impact of COVID-19. Disease outbreaks in other parts of the world, such as the 2002 to 2004 severe acute respiratory syndrome in China, Hong Kong, Taiwan, Singapore and Canada, the 2009 to 2010 global H1N1/09 influenza pandemic, and the 2013 to 2016 Ebola virus epidemic mainly in West Africa, appear to have limited impact on the Philippines based on aggregate income and consumption growth in the country in these period (**Figure 4** in the next page).

Second, COVID-19 is a novel disease; hence, its characteristics are not yet well understood. As such, projecting epidemic curves that may be included as part of the basis of economic impact estimates are being updated as new data arrives.

Third, while the transmission channels of the economic impacts of COVID-19 may be mapped out and linked with different policy options, the relevant elasticities required to convert the extent of interventions to its projected impact are not readily available or may need to be estimated based on other proximal measures.

Figure 4. Annual growth (%) in selected macroeconomic indicators: 2003-2018



Source: World Bank (2020) World Development Indicators**.**

4.3.2. Current Macroeconomic Trends amidst the COVID-19 Pandemic

Recent trends in some macro-economic indicators appear to be **very similar to those of the 2009 global financial crisis**. Over the course of the pandemic, the world has seen a significant decline in the price of crude oil in the first quarter of 2020 as demand has slowed among countries taking extreme measures against COVID-19, including border closures and community-wide quarantines. Brent crude prices declined by more than 50% from about USD 70 per barrel in March 2019 to less than USD 30 per barrel in March 2020 – even cheaper than the USD 36 per barrel during the peak of the 2009 world crisis. Stock market composite indices also declined considerably among major trade partners of the Philippines (Table 10), suggesting declining market confidence. If this current trend continues, it may directly impact the country's prospects for export growth in the near term.

Unlike the 2009 global financial crisis, however, the intentional contraction or "freezing" of economies in response to COVID-19 may limit the capacity of overseas Filipino workers (OFWs) to send cash remittances as they are at high risk of losing their employment. As shown in **Figure 4**, the substantial increase in international remittances during the 2009 global financial crisis counter-balanced the considerable decline in Philippine exports and allowed aggregate consumption and income to grow albeit at a much slower pace.

Another unique feature of this global pandemic is the intended tightening of borders across local communities. In the Philippines, for example, while the continuous and unimpeded flow of critical supplies (e.g. agricultural products) are guaranteed by the national government, the experience in the immediate weeks of the Luzon-wide community quarantine show that **additional documentary rules and misinformed local government prerogatives may effectively limit the cross-border movement of supplies.** Disruptions in both local and global supply chains are expected to negatively affect the delivery of final goods for consumption and the production of other goods and services that rely on intermediate inputs.

Table 10. COVID-19 cases and stock index decline in major Philippine export partners

Export partners	Exports, 2017[1]		Confirmed COVID-19 cases[2]	Stock index decline[3]	
	Value (USD B)	Share (%)		October 2008	March 2020
United States of America	11.5	16.3	35,530	~30%	~25%
Japan	10.6	15.1	1,101	~30%	~25%
China, Hong Kong SAR	9.6	13.7	356	~30%	~15%
China, People's Republic of	9.6	13.7	81,496	~5%	~10%
Singapore	3.8	5.4	509	~20%	~30%
Korea, Republic of	3.2	4.6	8,961	..	~25%
Thailand	3.0	4.2	721	..	~30%
Germany	2.7	3.9	27,546	~20%	~30%
Taiwan	2.2	3.2	195	~15%	~20%
Malaysia	1.8	2.6	1,518	~15%	~15%

1 Exports data are from PSA (2020) Foreign Trade Statistics.
2 Data as of March 23, 2020 from Johns Hopkins University (coronavirus.jhu.edu/map.html).
3 Stock index refers to the primary composite index in each country's stock market. Figures reflect the rate of decline relative to the prior month. Figures for 2020 are as of March 24, 2020.

4.4. Methods for Macroeconomic Projections

Based on these trends in the global and local economy and COVID-19 spread, we explored a number of scenarios as described in Table 11**.** The scenarios are broadly based on our disease transmission and employment microsimulation models and assumptions about the Philippine export market. These scenarios provide indications of the potential magnitude of loss of economic activity from COVID-19 and COVID-19 interventions.

It is important to emphasize the following:

- The **estimates are only indicative**; they are based on specific assumptions on perceived likely trajectory of the epidemic and consumption patterns. They may not capture all of the economic impacts of the disease (e.g. lives lost, foregone human capital investments, supply chain disruptions, etc.).

- We exclude the potential increase in health care demand. For example, demand for PPE and for hospital care are expected to increase as COVID-19 spreads. However, this may be tempered by lower demand for other health care services by households taking precautionary actions against being infected. The net effect is difficult to assess at this point.

- Overall, we intentionally err on using **conservative projection assumptions** to provide a **lower limit to the potential economic losses** that the country may experience from the pandemic.

The macro-economic projections are based on an application of the **Leontief input-output analysis** that has also been employed elsewhere (e.g. Abiad, et. al. 2020). Using the 2012 Philippine input-output table (PSA, 2017b), which captures the forward and backward linkages among industries in the economy, we calculated the implied matrix of technical coefficients, which captures the inputs necessary to produce one unit of output in each sector assuming Leontief production technology. Based on the projected change in final demand, it can be shown that the changes in gross output may be calculated, from which changes in gross value added (GVA) may be derived.

Table 11. Macroeconomic projection scenarios

Scenarios	Consumption/Employment[1]	Exports
Worse case Scenario S1B; The pandemic is not contained around the world, and the global economy slows down into a recession.	5.3% reduction in household consumption as a result of 19.7% drop in annual average labor supply, and 20% net reduction in average incomes among displaced workers.	Philippine exports of goods decline by 80 percent of 2009 Global Financial Crisis rates for agriculture, forestry and fishing (5%), mining and quarrying (20%), and manufacturing (24%). Consumption from transportation, storage and communication, and other services export decline by 20%.
Moderate case Scenario S3B; The pandemic is effectively contained around the world by end of 2020Q3.	3.7% reduction in household consumption as a result of 14.4% drop in annual average labor supply, and 20% net reduction in average incomes among displaced workers.	50% of worse-case scenario.
Best case Scenario S5B; The pandemic is effectively contained around the world by end of 2020Q2.	0.7% reduction in household consumption as a result of 7.4% drop in annual average labor supply, and 20% net reduction in average incomes among displaced workers.	10% of worse-case scenario.

Note: Authors' assumptions.

1 Commodity-specific income elasticities of demand are calculated based on aggregate data from PSA. See Appendix 3 for the calculation of the change in employment by scenario.

4.5. Results of Macroeconomic Projections

Table 12 summarizes the projected decline in gross value added by sector based on the scenarios in Table 11. **The Philippine economy may lose between 276.3 billion (best case) and PHP 2.5 trillion (worst case)** due to COVID-19. While the transport, storage and communication sector is expected to suffer substantial losses because of expected declines in tourism (PHP 11.7- to 124.3-billion), other sectors, particularly other services (PHP 41.5- to 356.9- billion), manufacturing (PHP 82.1- to 855.2-billion), and wholesale and retail trade (PHP 93.2- to 724.8-billion) are projected to also be significantly negatively affected as a result of weaker global and domestic demand.

We also estimated the potential macroeconomic impact of different non-medical mitigation measures summarized in Table 3. Unlike the estimates for the scenarios however, the results summarized in **Table 13** only captures the contribution of weaker household final demand on gross value added. The potential contributions of declining exports are excluded. Further, the estimates are based on a multi-regional input-output (MRIO) model to capture the inter-linkages among major island groups. The MRIO model is based on three regions (NCR, rest of Luzon, Visayas, and Mindanao) and the same ten industry groups in Table 12.

Table 12. Projected decline in sectoral gross value added

	Level (PHP Billions)			Share of 2019 Gross Value Added (%)		
	Best	Moderate	Worse	Best	Moderate	Worse
Agriculture, forestry and fishing	9.4	50.5	110.3	0.5	2.9	6.4
Mining and quarrying	1.7	8.6	26.9	1.1	5.3	16.7
Manufacturing	82.1	421.8	855.2	2.3	11.7	23.8
Construction	1.7	9.0	19.3	0.1	0.5	1.2
Electricity, gas and water	5.7	30.5	44.3	0.9	5.0	7.3
Transportation, storage and communication	11.7	61.6	124.3	1.1	5.6	11.3
Wholesale and retail trade	93.2	497.7	724.8	2.6	13.9	20.3
Financial intermediation	18.5	98.9	141.3	1.1	6.0	8.6
Real estate, renting and business activities	10.7	56.8	79.7	0.4	2.4	3.3
Other services	41.5	221.0	356.9	1.5	7.8	12.6
All sectors	276.3	1,456.3	2,482.9	1.4	7.6	12.9

Source: Authors' calculations.

Table 13. Projected macro-economic impact of NMI

	Mitigation measures			ECQ Extension		
	ECQ	Better testing	Isolation at onset	No extension	+2 weeks	+ 4 weeks
A. Level (PhP Billion)						
S1	Yes; 95%	No	No	1,417.9	1,475.7	1,573.3
S2	Yes; 95%	Yes	No	1,230.4	1,323.7	1,415.7
S3	Yes; 95%	Yes	Yes; 50%	1,043.6	1,141.5	1,241.2
S4	Yes; 50%	Yes	Yes; 50%	…	980.7	1,029.8
S5	Yes; 50%	Yes	Yes; 70%	…	213.4	283.7
B. Share of 2019 GVA (%)						
S1	Yes; 95%	No	No	7.4	7.7	8.2
S2	Yes; 95%	Yes	No	6.4	6.9	7.4
S3	Yes; 95%	Yes	Yes; 50%	5.4	5.9	6.4
S4	Yes; 50%	Yes	Yes; 50%	…	5.1	5.3
S5	Yes; 50%	Yes	Yes; 70%	…	1.1	1.5

*No intervention: PhP1,980B; 10.2% of 2019 GVA

The results suggest that imposing community-wide quarantines alone may not be enough to sufficiently flatten the epidemic curve to avert substantial economic losses. It also suggests that **extending community-wide quarantines may increase these economic losses given the same non-medical mitigation measure implemented**. Extending the Luzon-wide community quarantine by one month is projected to result in at least **PHP150 billion-worth in foregone economic activity based on our projection assumptions.**

The cost of inaction may be larger, however. In a no-intervention scenario (S0), the MRIO model suggests that the Philippines may lose about PHP 2 trillion in foregone gross value added as a result of weaker household demand as more workers are unemployed for extended periods of time.

5. Recommendations Moving forward

The COVID-19 pandemic is not merely a public health issue but an economic and social one as well. The enhanced community quarantine (ECQ) is a step towards managing the health system's limited resources, and buying time to buttress hospital and laboratory testing capacity, and equipping healthcare workers with proper protection. However, setting the economy on "freeze" for a longer period may cause unintended consequences.

As our model suggests, the ECQ may have provided the health system some time to prepare but in itself not sufficient to contain the outbreak. In the absence of more aggressive public health interventions, a successive wave of infections could rise months after the ECQ. Hence, the government should not be complacent, and should be strategic in containing the outbreak.

The post-ECQ strategy must be designed to maintain a low level of virus transmission, but economically sustainable. We therefore recommend a gradual and calibrated transition to a risk-based strategy that combines relaxation of economic restriction while controlling the spread of the virus. As the economy reopens, the government should continuously expand its capacity to perform the following:

- Detect and isolate individual cases, and identify close contacts.
- Protect high risk population groups, including healthcare workers.
- Continuously implement public health measures, such as physical distancing and handwashing.
- Treat many patients as possible, particularly severe and critical cases.

To implement these requires a whole-of-government approach: bringing together the resources of different government agencies and harnessing the expertise of the private sector. The general strategy should not be hospital centric. **Efforts to control the transmission of the virus should start in local communities, and hospitals shall serve as the last line of defense.** The **role of local governments** to implement public health programs and surveillance are critical.

The following are specific recommendations covering the four action points:

- **Continue scaling up testing capacity to reduce turnaround times with laboratory results.** As of April 13, 2020, the testing capacity of the country using RT-PCR is at 2,000 tests per day across fifteen (15) laboratories, with more than 30 laboratories at different stages of accreditation by the Research Institute of Tropical Medicine (RITM). Efforts should continue in rapidly accrediting these laboratories to remove bottlenecks in receiving laboratory confirmation. Efforts by local government units (LGUs) and the private sector in scaling up these laboratories should be encouraged by the national government. The goal is to reduce turnaround times from around 10 days to the ideal of 24 to 48 hours to ensure that confirmed cases are isolated, and their close contacts quarantined as soon as possible. Moreover, being able to remove negative cases quickly from quarantine reduces the burden on the health system in terms of isolation beds, and allows the provision of more appropriate interventions. To be successful,

In addition to RT-PCR, the government should ready to scale up rapid serology tests to know who has already been infected with the coronavirus and has antibodies. However, serologic testing should not be used as the sole basis in making clinical management decisions.

- **Rapidly increase contact tracing capabilities.** The DOH should increase the number of contact tracers coordinating with epidemiology surveillance units (ESUs) at the central and regional level, and provide the necessary support for ESUs in the LGUs. Two relevant DOH issuances have already been publicly circulated and need to be strengthened. First, nurses deployed under the Nurse Deployment Program (NDP) should be seconded to become contact tracers in their respective LGUs, regardless of the discretion previously provided to the DOH regional directors, but notwithstanding more urgent needs such as COVID-19 case management. Second, DOH should mandate, and not merely provide guidance on, hospital and subnational laboratory cooperation for all DOH and LGU efforts related to epidemiological surveillance. Finally, DOH should enlist the cooperation of the public by clearly communicating the importance of contact tracing, and what the public can do to improve epidemiological surveillance.

- **Decongest health facilities by expanding isolation and quarantine facilities outside of hospitals for mild cases or suspected cases presenting with mild symptoms.** LGUs should continue building isolation and quarantine facilities for these cases to avoid intra-household transmission. The use of non-essential public spaces and partnering with lodging facilities like hotels are an important start. Furthermore, the Department of Education (DepEd) should consider allowing LGUs to use schools as quarantine facilities, at least until the end of May, with proper attention to strict decontamination protocols assuming classes resume in June.

- **Provide a more humane approach for enforcing quarantine and isolation for suspected and confirmed cases.** The national government, through the Department of Social Welfare and Development (DSWD), the Department of Labor and Employment (DOLE), GSIS, and SSS, must develop a joint policy providing financial incentives for suspected and confirmed cases for fully complying with isolation and quarantine guidelines. These may be in the form of recovering lost daily wages based on the regional minimum wage or GSIS or SSS monthly salary credit, or conditional cash transfers for those in the informal sector. At the same time, the national government must provide a more measured approach for quarantine violations, such as the withholding of these financial incentives or imposing a fine, rather than arresting or inflicting any violence for any reason whatsoever.

- **Provide wide-range of support and protection to healthcare workers.** As evidence suggests, the risk of infection among healthcare workers during outbreaks increases because of the following reasons: 1.) delayed recognition of symptoms and limited experience in dealing with the respiratory disease; 2.) burn-out due to exposure to a large number of patients; 3.) lack of personal protective equipment (PPEs); and 4.) lack of measures to prevent the spread in the hospitals.

To address these issues, we recommend the following: 1.) provide constant training to healthcare workers about the novel disease through interactive training and mentoring; 2.) improve access to PPEs, 3.) provide psycho-social support to reduce burn-out and depression. Burnout is associated with negative outcomes such as lower quality of care. If health workers are taking on long shifts without break, they might be less vigilant when using personal protective equipment and abiding to infection control protocols; and 4.) strengthen the hospital surveillance system.

- **Remove all possible bottlenecks on the production and importation of PPEs.** To rapidly scale up availability of PPEs, the national government must rely on both expanding local manufacturing capacity and increasing imports. Through whatever means necessary, the national government, led by the Department of Trade and Industry (DTI), must enlist the support of textile, plastic, and paper factories, and distilleries, to repurpose their production lines to produce PPEs and other critical medical supplies. The national government may then engage with these companies through negotiated contracts to purchase 100% of the inventory produced, and distribute equitably to all health facilities in need. With regards to importation, the national government must strictly enforce policies enacted related to trade liberalization of PPEs, such as relaxing Food and Drug Administration (FDA) requirements and allowing provisional goods declaration by the Bureau of Customs (BOC). Daily updates on total PPE production and shipments must be reported publicly for transparency purposes.

The goal of the government should not be solely confined to "flattening" the epidemic curve, but also to **limit prolonged disruptions in the economy.** A key step towards this direction, of course, is to control the spread of the epidemic. Even during epidemics, the government should ensure that critical goods and services remain available, affordable, and accessible.

- **The national government should be ready to deploy a massive safety nets program to ensure that households have access to food and other basic necessities.** However, the interventions do not need to be confined to the poor, displaced workers and other at-risk population, but also to firms, particularly micro-, small- and medium-sized enterprises. Safety nets programs may be used to ensure that households are not unnecessarily induced to continue working for their sustenance during epidemics. It may also be used to limit the spread of the disease by isolating susceptible and infected populations by limiting contact across the general population. Based on current infection rates and costs of treatment, it may be more cost-effective to incentivize people to stay at home.

- **The national government must also prioritize revitalizing economic activity without endangering public safety.** Keeping every person at home may freeze the economy. Economic activity needs to be encouraged wherever it is safe and possible to allow the production of goods and services to be consumed in other areas. It also ensures that households have a continuous source of incomes, the greatest safety net of all. As mentioned, some businesses may be repurposed to help in the interventions against COVID-19, e.g. garments factories to produce PPEs, distilleries to alcohol production, etc. Other businesses may need to be developed, e.g. research, digital platform deliveries, manufacturing, etc., to supply goods and services that cannot be readily sourced from the international market.

The national government must also allow public transportation to partially operate, subject to strict physical distancing guidelines, to facilitate the movement of essential economic transactions. The government may opt to directly hire drivers or operators in a cash-for-work program to effectively control public transportation.

- **The national government must ensure supply chains remain operational.** Ensuring the continuous and unencumbered flow of goods and services is crucial during these times. While social distancing measures are necessary, it need not be counter to ensuring that necessary supplies are delivered. Fast lanes for food, health personnel, medical supplies, and many others need to be established and safeguarded. Safety protocols may be built in to ensure that COVID-19 are not spread through the supply chain.

Efforts to contain disease outbreaks are important public goods: its potential impacts cut across age groups, socio-economic class, and geographic boundaries. It necessarily requires concerted action across sectors – a whole-of-government, whole-of-society approach – to contain the spread of the disease. After all, the success of the various initiatives implemented may only be measured by the success of the "weakest link" in the network of communities.

6. Bibliography

Abiad, A., M. Arao, B. Ferrarini, I. Noy, P. Osewe, J. Pagaduan, D. Park, and R. Platitas (2020). *The economic impact of the COVID-19 outbreak on Developing Asia*. ADB Briefs No. 128. Mandaluyong City: Asian Development Bank.

Abrigo, M.R.M. and D.A.P. Ortiz (2019). Who are the health workers and where are they? Revealed preferences in location decision among health care professionals in the Philippines. PIDS Discussion Paper No. 2019-32. Quezon City: Philippine Institute for Development Studies.

Albert, J.R.G., A.G.F. Santos, and J.F.V. Vizmanos (2018). *Profile and determinants of the middle-income class in the Philippines.* PIDS Discussion Paper Series No. 2018-20. Quezon City: Philippine Institute for Development Studies.

Albert, J.RG., J.C. Dumagan, and A. Jr. Martinez (2015). I*nequalities in income, labor and education: The challenge of inclusive growt*h. PIDS Discussion Paper Series No. 2015-01. Makati City: Philippine Institute for Development Studies.

Anderson, R. M., Heesterbeek, H., Klinkenberg, D., & Hollingsworth, T. D. (2020). How will country-based mitigation measures influence the course of the COVID-19 epidemic? The Lancet, 395(10228), 931–934. https://doi.org/10.1016/S0140-6736(20)30567-5

Arentz, M., Yim, E., Klaff, L., Lokhandwala, S., Riedo, F. X., Chong, M., & Lee, M. (2020). Characteristics and Outcomes of 21 Critically Ill Patients With COVID-19 in Washington State. JAMA. https://doi.org/10.1001/jama.2020.4326

Brolin Ribacke, R.K.J., D.D. Saulnier, A. Eriksson, and J. von Schreeb (2016). Effects of the West Africa Ebola virus disease on health-care utilization – A systematic review. *Frontiers in Public Health*, 4:222.

Department of Health (2020). Department Memorandum 2020-0114: Advisory on Deployment of Nurses under the Nurse Deployment Program to DOH Hospitals and LGU Hospitals in Response to COVID19 Health Event. March 14, 2020

Department of Health (2020). Department Memorandum 2020-0152: Guidance to All Public and Private Healthcare Facilities and Other Concerned Establishments to Assist Surveillance Officers in the Epidemiologic Investigation on the Coronavirus Disease 2019 (COVID-19). March 18, 2020.

Department of Health (2020). *DOH COVID-19 Case bulletin #024*.

Guan, W., Ni, Z., Hu, Y., Liang, W., Ou, C., He, J., Liu, L., Shan, H., Lei, C., Hui, D. S. C., Du, B., Li, L., Zeng, G., Yuen, K.-Y., Chen, R., Tang, C., Wang, T., Chen, P., Xiang, J., … Zhong, N. (2020). Clinical Characteristics of Coronavirus Disease 2019 in China. New England Journal of Medicine, 0(0), null. https://doi.org/10.1056/NEJMoa2002032

Institute for Disease Modelling (2020. IDM Coronavirus InfoHub: *Epidemiological Parameters Table*. Online database. Accessed on March 26, 2020 from https://covid.idmod.org/#/

Kamara, M.H., R. Najjemba, J. van Griensven, D. Yorpoi, A.S. Jimissa, A.K. Chan, and S. Mishra (2017). *Increase in acute malnutrition in children following the 2014-2015 Ebola outbreak in rural Sierra Leone*. *Public Health Action*, 7(Supplement 1), S27-S33.

Linton, N. M., Kobayashi, T., Yang, Y., Hayashi, K., Akhmetzhanov, A. R., Jung, S., Yuan, B., Kinoshita, R., & Nishiura, H. (2020). Incubation Period and Other Epidemiological Characteristics of 2019 Novel Coronavirus Infections with Right Truncation: A Statistical Analysis of Publicly Available Case Data. Journal of Clinical Medicine, 9(2), 538. https://doi.org/10.3390/jcm9020538

Liwanag H.J. and Mark John Ayaay (2020). *Preliminary Projections for Health Workforce Requirements in the ER, wards, and ICU settings for the Philippines using selected scenarios for the COVID-19 pandemic.* Unpublished manuscript, Department of Health - Health Human Resource Development Bureau, Manila, Philippines.

Muyrong, M.S. (2020). #StayAtHome #Bayanihan: Understanding the profile of displaced workers due to ECQ. Policy Brief No. 2020-03. Quezon City: Ateneo de Manila University Department of Economics, and Ateneo Center for Economic Research and Development.

Orbeta, A.C. Jr. (2008). Economic impact of international migration and remittances on Philippine households: What we thought we knew, what we need to know. In M.M.B. Asis and F. Baggio, Eds., *Moving out, back and up: International migration and development prospects in the Philippines*. Quezon City: Scalabrini Migration Center.

Philippine Health Insurance Corporation (2019). Corporate Operating Budget 2019. Online. Accessed on April 8, 2020 from: https://www.philhealth.gov.ph/about_us/transparency/COB_CY2019.pdf

Philippine Health Insurance Corporation (2020). *Benefit packages for inpatient care of probable and confirmed COVID-19 developing severe illness/outcomes*. Accessed April 14, 2020 from: https://www.philhealth.gov.ph/circulars/2020/circ2020-0009.pdf

Philippine Statistics Authority (2016). Census of Population 2015. Public-use file. Quezon City, Philippines: Philippine Statistics Authority.

Philippine Statistics Authority (2016). *2015 Family Income and Expenditure Survey*. Quezon City: Philippine Statistics Authority.

Philippine Statistics Authority (2017a). *APIS 2016: Annual Poverty Indicators Final Report*. Quezon City: Philippine Statistics Authority.

Philippine Statistics Authority (2017b). *Benchmark 2012 Input-Output Accounts of the Philippines*. Quezon City: Philippine Statistics Authority. Accessed on March 26, 2020 from https://psa.gov.ph/content/psa-releases-65x65-2012-input-output-tables-0.

Philippine Statistics Authority (2019). Updated Population Projections Based on the Results of 2015 POPCEN. Online database. Accessed on March 26, 2020 from https://psa.gov.ph/statistics/census/projected-population .

Philippine Statistics Authority (2019). Preliminary results of the 2019 Annual Estimates of the Labor Force Survey (LFS). Online database. Accessed on March 26, 2020 from http://www.psa. gov.ph/content/preliminary-results-2019-annual-estimates-labor-force-survey-lfs

Philippine Statistics Authority (2020). Highlights of the Philippine export and import statistics: December 2019. Quezon City: Philippine Statistics Authority. Accessed on March 24, 2020 from http://www.psa.gov.ph/content/highlights-philippine-export-and-import-statistics-december-2019

Thomas, A.-C., T. Nkunzimana, A. Perez Hoyos, and F. Kayitakire (2014). *Impact of the West African Ebola virus disease outbreak on food security*. Science and Policy Report. Ispra, Italy: Joint Research Centre, Institute for Environment and Sustainability, European Commission.

Weiss, P., & Murdoch, D. R. (2020). Clinical course and mortality risk of severe COVID-19. The Lancet, 395(10229), 1014–1015. https://doi.org/10.1016/S0140-6736(20)30633-4

World Health Organization (2020). Coronavirus disease 2019 (COVID-19) Situation Report - 77. Online. Accessed on April 7,2020 from https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200406-sitrep-77-covid-19.pdf?sfvrsn=21d1e632_2

World Bank (2020).World Development Indicators. Online Database. Accessed on March 26, 2020 from https://databank.worldbank.org/source/world-development-indicators.

Wu Z, McGoogan JM (2020). Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. JAMA. Published online February 24, 2020. doi:10.1001/jama.2020.2648

Yang, X., Yu, Y., Xu, J., Shu, H., Xia, J., Liu, H., Wu, Y., Zhang, L., Yu, Z., Fang, M., Yu, T., Wang, Y., Pan, S., Zou, X., Yuan, S., & Shang, Y. (2020). Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: A single-centered, retrospective, observational study. The Lancet Respiratory Medicine, 0(0). https://doi.org/10.1016/S2213-2600(20)30079-5

Zhou F, Yu T, Du R, et al. (2020). *Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study*. The Lancet. 2020

Appendix A. SEIR Model Description

This note discusses the key features of a SEIR model developed to simulate the potential spread of COVID-19 in the Philippines population from January 15, 2020 to January 15, 2021.The model compartments are illustrated in the schematic below (Figure A.1)

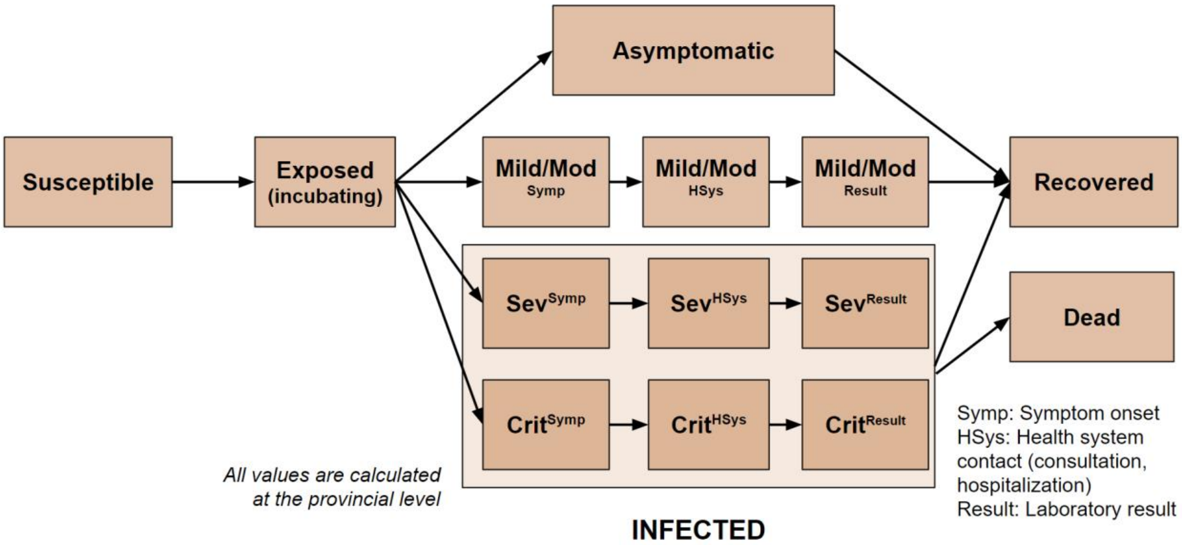


Figure A.1. SEIR Model Schematic for COVID-19 Transmission

Susceptible

Susceptible people are healthy people without disease. In any period t= {1,2,...}, susceptible population S_{it} living in provinces indexed by i={1,2,...} meet infected individuals living in their own area and in other areas with probability σ_{it-1}. Provinces are linked with each other through a row-standardized social distance matrix with elements w_{ij}.

$$\Delta S_{it} = -\beta \cdot \sigma_{it-1} \cdot S_{it-1}$$

$$\sigma_{it-1} = \frac{\sum_j w_{ij} \left(\sum_k \psi^{0k} I^{0k}_{j(t-1)} + \sum_k \psi^{1k} I^{1k}_{j(t-1)} + \psi^{21} I^{21}_{j(t-1)} \right)}{S_{it-1} + I_{i(t-1)} + R_{i(t-1)}}$$

$$w_{ij} = \frac{N^j_{i0}}{N_{i0}} \cdot Q(q_{ij} = 1)$$

Each infected individual is able to infect others at a base rate of β per day. Infected persons at different sub-phases of infection and of different disease expression are assumed to have different relative infection rates, captured by ψ^{vk}.

Various experiments may be introduced in the model through the indicator variable $Q(q_{ij}=1)$ that takes on a value of 1 if areas *i* and *j* are connected, and zero if otherwise, (e.g. school closure, area-based quarantine, etc). Other parameters, including transition times between Infection substates and basic reproduction number, may also be adjusted for experiments.

Exposed

Exposed or infected individuals who do not yet exhibit symptoms are not infectious until G days representing the average incubation period of COVID-19. We assume G is drawn from an exponential distribution with mean$1/\gamma$ and that the probability of transitioning to an Infected state in the next day is approaches γ as $1/\gamma$grows.

$$\Delta E_{it} = \beta \cdot \sigma_{it-1} \cdot S_{it-1} - \gamma E_{it-1}$$

Infected

The infected phase ${I_{it}}^{vk}$has three sub-phases indexed by v={0,1,2}, and four states indexed by k={0,1,2,3}. The states refer to levels of disease expression among individuals: asymptomatic (k=0), mild (k=1), severe (k=2), and critical (k=3). Waiting times (implying transition rates) across sub-phases vary with the level of disease expression.The sub-phases reflect the period between disease incubation and onset of symptoms among symptomatic cases (v=0); between onset of symptoms and initial contact with health care professionals (v=1); and when some are hospitalized or isolated (v=2).

$$\Delta I_{it}^{0k} = \alpha_k \gamma E_{it-1} - \theta_k I_{it-1}^{0k}$$

$$\Delta I_{it}^{1k} = \theta_k I_{it-1}^{0k} - \phi_k I_{it-1}^{1k}$$

$$\Delta I_{it}^{2k} = \phi_k I_{it-1}^{1k} - \mu_k[\zeta_k + (1 - \zeta_k)] I_{it-1}^{2k}$$

Recovered/Dead

For the last transition, infected individuals transition either into recovery (R) or death (D), with severity-specific case fatality rate ζ_{k}.

$$\Delta R_{it} = \sum_k \mu_k (1 - \zeta_k) I_{it-1}^{2k}$$

$$\Delta D_{it} = \sum_k \mu_k \zeta_k I_{it-1}^{2k}$$

Appendix B. SEIR Model Results per Month

The table below presents the total number of new COVID-19 cases per month and the total cumulative number of deaths as of month's end for each scenario.

Table B.1. Projected number of new cases and total cumulative deaths per month (thousands)

Scenario	April 2020				May 2020				June 2020			
	Mild	Severe	Critical	Cumulative Deaths	Mild	Severe	Critical	Cumulative Deaths	Mild	Severe	Critical	Cumulative Deaths
0	5.90	1.5	0.49	1.6	69	17.3	5.8	21.2	490	123	40.9	219
1a	0.87	0.22	0.07	0.55	7	1.68	0.56	3.22	36.4	9.1	3.0	20.1
1b	0.45	0.11	0.04	0.54	5	1.14	0.38	2.36	26.8	6.7	2.2	14.6
1c	0.48	0.12	0.04	0.54	3	0.75	0.25	1.83	20.7	5.2	1.7	10.5
2a	0.79	0.20	0.07	0.49	4	0.99	0.33	2.48	17.6	4.4	1.5	12.1
2b	0.43	0.11	0.04	0.52	3	0.83	0.28	2.02	16.3	4.1	1.4	10.2
2c	0.44	0.11	0.04	0.54	3	0.73	0.24	1.68	13.3	3.3	1.1	8.1
3a	0.64	0.16	0.05	0.51	2.7	0.68	0.23	2.16	9.3	2.3	0.8	8.4
3b	0.47	0.12	0.04	0.52	2.3	0.56	0.19	1.84	8.9	2.2	0.7	7.4
3c	0.46	0.12	0.04	0.53	2.0	0.51	0.17	1.64	8.0	2.0	0.7	6.5
4b	0.50	0.13	0.04	0.52	2.6	0.64	0.21	1.90	8.5	2.1	0.7	7.4
4c	0.51	0.13	0.04	0.55	2.3	0.57	0.19	1.82	8.0	2.0	0.7	7.0
5b	0.53	0.13	0.04	0.52	0.77	0.19	0.06	1.55	1.3	0.3	0.1	3.4
5c	0.52	0.13	0.04	0.53	1.0	0.26	0.09	1.69	1.7	0.4	0.1	4.2

Scenario	July 2020				August 2020				September 2020			
	Mild	Severe	Critical	Cumulative Deaths	Mild	Severe	Critical	Cumulative Deaths	Mild	Severe	Critical	Cumulative Deaths
0	793	198	66.10	1,409	465	116	38.7	3,333	191	47.7	15.9	4,572
1a	174	43.4	14.50	120	356	89	29.7	539	311	77.6	25.9	1,347
1b	139	34.8	11.60	90.7	340	85.1	28.4	440	323	80.6	26.9	1,208
1c	112	27.9	9.32	68.8	312	78.1	26.0	358	344	85.9	28.6	1,077
2a	77.5	19.4	6.46	58.3	215	53.8	17.9	240	281	70.2	23.4	695
2b	70.6	17.7	5.89	50.8	193	48.4	16.1	215	268	66.9	22.3	641
2c	61.5	15.4	5.12	41.8	191	47.8	15.9	185	277	69.3	23.1	582
3a	32.9	8.23	2.74	31.5	94.2	23.6	7.85	109	175	43.8	14.6	317
3b	31.1	7.76	2.59	28.8	86.3	21.6	7.19	102	182	45.6	15.2	301
3c	27.6	6.89	2.30	26.4	86.9	21.7	7.24	95.8	184	46.1	15.4	287
4b	30.6	7.66	2.55	28.4	91.7	22.9	7.64	100	181	45.3	15.1	296
4c	29.2	7.29	2.43	27.0	85.8	21.5	7.15	96.0	167	41.8	13.9	286
5b	2.11	0.53	0.18	6.6	3.07	0.77	0.26	11.0	4.9	1.2	0.4	19.1
5c	2.68	0.67	0.22	8.46	4.35	1.09	0.36	15.0	6.8	1.7	0.6	25.4

Scenario	October 2020				November 2020				December 2020			
	Mild	Severe	Critical	Cumulative Deaths	Mild	Severe	Critical	Cumulative Deaths	Mild	Severe	Critical	Cumulative Deaths
0	41	10	3.4	5,139	10.6	2.7	0.9	5,283	1.5	0.36	0.12	5,319
1a	227	57	18.9	2,158	172	43.0	14.3	2,751	137	34.3	11.4	3,215
1b	240	60	20.0	2,044	181	45.1	15.0	2,666	141	35.2	11.7	3,149
1c	252	63	21.0	1,931	190	47.5	15.8	2,580	146	36.5	12.2	3,083
2a	222	56	18.5	1,352	168	42.0	14.0	1,926	124	31.0	10.3	2,382
2b	227	57	18.9	1,291	171	42.7	14.2	1,873	127	31.8	10.6	2,340
2c	228	57	19.0	1,225	173	43.2	14.4	1,81	133	33.3	11.1	2,298
3a	218	54	18.1	737	175	43.7	14.6	1,243	131	32.7	10.9	1,706
3b	214	54	17.9	709	177	44.2	14.7	1,213	132	33.0	11.0	1,681
3c	210	53	17.5	689	181	45.2	15.1	1,192	134	33.4	11.1	1,665
4b	206	52	17.2	703	174	43.4	14.5	1,207	135	33.8	11.3	1,676
4c	219	55	18.3	686	179	44.8	14.9	1,191	135	33.6	11.2	1,664
5b	7.3	1.8	0.6	31	10.4	2.6	0.9	47.3	14.6	3.6	1.2	72.6
5c	9.3	2.3	0.8	41	13.8	3.5	1.2	63.1	18.9	4.7	1.6	96.1

Appendix C. Estimating projected labor supply change

The overall change in labor supply is calculated by combining the projected exit from the labor market as a result of (1) excess mortality or morbidity, including household-level isolation or other mitigation measures, from the spread of COVID-19, and (2) the displacement of workers as a result of community-wide quarantines. The contribution of excess mortality or morbidity, and household-level mitigation measures on labor market exit is estimated based on the projected prevalence of the disease from the disease transmission (i.e., SEIR) model, which we linked with the individual-level micro-simulation model. The contribution of the Luzon-wide community quarantine on labor supply displacement is based on estimates by Muyrong (2020). These estimates are then used to calculate the projected change in household final consumption expenditure in the Leontief input-output model.

Table C.1. Projected change in labor supply by cause (% change)

	Excess mortality/ morbidity	Community quarantine	Total effect
Best case	-2.9	-4.4	-7.4
Moderate case	-5.2	-4.4	-14.4
Worse case	-15.2	-4.4	-19.7