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**How effective is community quarantine in the Philippines?
A quasi-experimental analysis**

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Abstract

As the world races to develop a COVID-19 vaccine, non-pharmaceutical interventions such as voluntary social distancing and community quarantine (CQ) have been the first line of defense in breaking the chains of transmission in most countries. The efficacy of a public health measure, however, depends on a myriad of factors including its timing and optimal implementation, the proclivity of individuals in following protocols and information dissemination. We examine whether the different types of CQ imposed at different periods and areas in the Philippines are effective in mitigating the pernicious effects of COVID-19 while controlling for other confounding factors. Our natural experiment (difference-in-differences fixed effects) using panel data that we constructed results in the following. First, a lockdown is effective only in reducing COVID-19 incidence and mortality when combined with health capacity and sociodemographic characteristics that could potentially capture preferences to comply. Second, the efficacy of a CQ persists over time but it is somewhat reduced. Third, heterogeneity in the effectiveness of a quarantine exists across the different types of CQ, with a stricter CQ apparently more effective. Fourth, the number of nurses and other health care workers, urbanity and population matter in improving the health outcomes of areas under quarantine.

Keywords: COVID-19, community quarantine, health policy intervention, quasi-experimental analysis, Philippines

JEL Codes: I12, I15, I18

1. Introduction

1.1. COVID-19 at a glance

The first two decades of the 21st century have been eventful, to say the least, from the epidemiology perspective. They have been marked with two influenza pandemics (the 2009 H1N1 and the 2020 COVID-19) resulting in a health crisis, which in part was triggered by the novelty of the experience and was worsened by governance challenges. COVID-19, declared by the World Health Organization (WHO) as a pandemic on March 11, 2020, is different from the 2009 H1N1 flu pandemic in that, epidemiologically speaking, it is the first flu pandemic caused by a coronavirus (severe acute respiratory syndrome coronavirus 2 or SARS-CoV-2). As of April 18, 2020, there were 213 countries, areas or territories that have been affected by COVID-19 and four months later, global COVID-19 incidence and deaths reached to 20.1 million and 736,000, respectively (WHO, 2020a).

In the Philippines, the first case of COVID-19 was reported by the Department of Health (DOH) on January 30, 2020 followed by two more cases in the first week of February while the first mortality due to this pandemic occurred on February 1, 2020, which interestingly and unfortunately was the first ever recorded mortality outside China (DOH, 2020a). It was not until March 6th, however, when the fourth and fifth cases were confirmed, that the country experienced the beginning of a sharp increase in incidence and mortality (Figure 1 below) and community transmission was officially confirmed on March 7. About eight months later, the number of COVID-19 cases and deaths in the country dramatically rose to about 385,000 and 7,000, respectively (DOH, 2020b).

One of the government's responses to curb COVID-19 transmission was to impose different types of community quarantine (CQ) in different parts of the country at different time periods. Our paper aims to examine whether these CQs, as policy interventions, were able to control the pernicious spread of the virus after accounting for health capacity and sociodemographic characteristics, which could capture the proclivity of a community to comply to quarantine protocols. In particular, we want to determine whether CQs were able to flatten the epidemic curve (reduce COVID-19 incidence and mortality) using quasi-experimental analysis while the world is waiting for a vaccine. In effect, we examine the policy relevance of lockdowns

by integrating into epidemiology and analysis of a public health policy the economic and econometric tools.

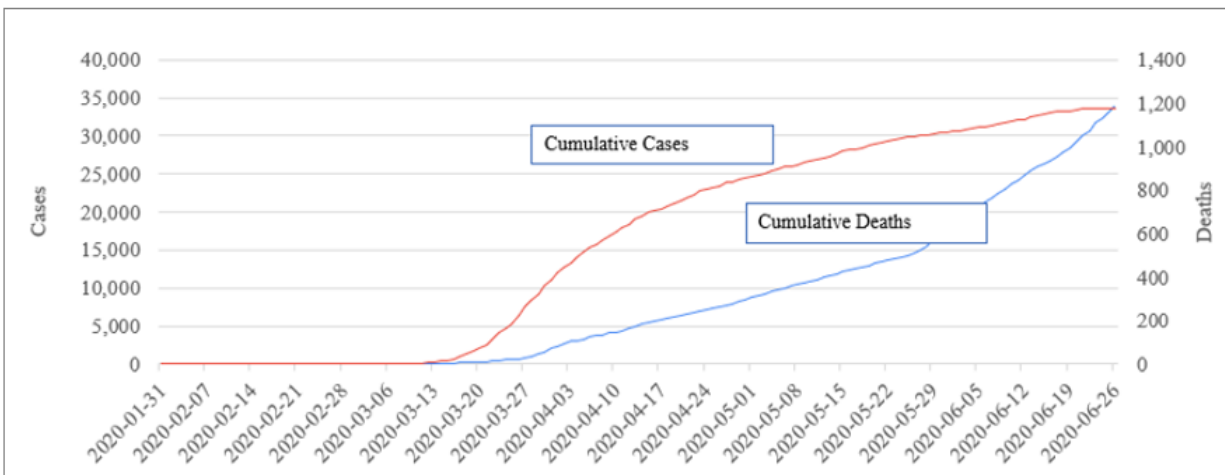


Figure 1. Cumulative COVID-19 Cases and Deaths (Philippines, January 31 – June 26, 2020). *Source:* DOH, 2020 COVID-19 Tracker.

1.2 Motivation of the paper

During a pandemic, non-pharmaceutical interventions (NPIs) such as the use of personal protective equipment (PPE), hand hygiene, school closures and prohibition/limitation of mass gatherings were implemented to reduce caseloads and flatten the epidemic curve.

For example, during the 1918 Spanish flu pandemic, since there were no vaccine and antibiotics available to treat secondary bacterial infections, most efforts were focused on NPIs or public health measures to stem the spread of the virus (Centers for Disease Control and Prevention, 2019). In addition, NPIs are recognized as the first line of defense since they are preventive behaviors that individuals and communities can easily adopt while the world races to develop a vaccine against a new influenza pandemic virus (WHO 2020b; United States Department of Health and Services, 2017).

Although there have been previous studies on the effectiveness of NPIs in breaking the chains of transmission during the last flu pandemic in 2009, there are still a lot to be learned regarding their timing and optimal implementation especially in the face of the current COVID-19 flu pandemic. There are three critical reasons why there is a need to reassess the effectiveness of NPIs.

First, as of this writing, although it has approximately been ten months since the first case of COVID-19 in late December of 2019 in China, a pandemic vaccine that is sufficiently-tested is yet to be approved, mass produced and distributed. As of July 28, 2020, WHO released a list of 164 COVID-19 candidate vaccines, 25 of which are still in clinical evaluation and 139 in preclinical evaluation (WHO, 2020c). Meanwhile, countries rely on NPIs to help distribute the number of COVID-19 cases over a longer period and reduce peak capacity needs.

Second, there is a threat of a second wave (a resurgence of cases), albeit contentious, that could occur during flu season (fall and winter) or earlier due to changes in human behavior (complacency in observing preventive measures). Third, there is paucity in research on NPIs implemented in different countries during COVID-19, which is understandable given that this pandemic is quite recent and that more observations need to be gathered to conduct an evidence-based analysis.

With these three reasons, it becomes more urgent to study the efficacy of NPIs in reducing COVID-19 incidence, morbidity and mortality especially if the findings could help governments in choosing and implementing the right policy interventions.

Our paper is the first to examine the impact of a CQ as a health policy, while controlling for other confounding factors, during the COVID-19 pandemic in the Philippine context. We conducted a natural experimental analysis and used the country's first longitudinal data on quarantine, COVID-19 health outcomes, health capacity and sociodemographic characteristics, which we created using the government's different quarantine pronouncements, official COVID-19 data from DOH and other secondary data from different government agencies. In this study, we were able to take advantage of the spatial and temporal variation in data as well as properly identify the effects of a CQ by examining how health outcomes have evolved among the different groups at different periods.

The Philippines is an interesting country to analyze since there have been dozens of CQs imposed on different cities and provinces at different periods. For example, the Metro Manila (or National Capital Region [NCR]) alone has been under four CQs – general CQ or GCQ from March 15, enhanced CQ or ECQ (March 17–May 15), modified ECQ or MECQ (May 16–May 31) and GCQ (June 1–June 15). We want to examine whether the myriad of CQs imposed were helpful in combatting COVID-19 or whether they led to public confusion and a worsening of health outcomes.

Second, the Philippines is among the countries in the ASEAN region with a high COVID-19 incidence and mortality during our analysis despite the varied lockdown measures imposed, which can be attributed to the following. First is the late uptake of action of the government. For example, the government only imposed a *cordon sanitaire* about two months after the first case of COVID-19 in the country. Second is the relatively weak health system, which, understandably, got overwhelmed, thus, contributing further to the increase in incidence and mortality. Third is the untimely or premature lifting or easing of lockdown in the country. However, as in other countries, the government struggles between the apparent tradeoff between public health and economic recovery.

2. Review of related literature

In this section, we briefly review the relevant literature on social distancing as a health policy. We also discuss how this NPI is being implemented in the Philippines during COVID-19 pandemic.

2.1 Social distancing in the literature

Although there is a dearth of evidence-based studies on NPIs, the findings and experts' opinion, thus far, suggest of their efficacy in curtailing the disease spread (Ferguson et al., 2005; Aledort, et al. 2007; Stern and Markel 2009; Chen, et al. 2020 to name a few). Social distancing whether voluntary or otherwise (school closures, bans on public gatherings and *cordon sanitaire*, to cite a few) when combined with other NPIs (personal hygiene techniques, and patient and provider use of masks and other PPE, for example) and sufficient health capacity become an effective tool in stemming the spread of the virus (Earn et al., 2012; Fung et al., 2015; Ahmed et al., 2018).

Specifically, during the 2009 H1N1 flu pandemic the younger people were more affected and therefore school closures in Canada and the US became an important intervention in stemming the human-to-human transmission of the virus. In Canada, school closures reduced the transmission by more than 50% among the school-age children (Earn et al., 2012) while in the US

in a pandemic scenario, every week of school closure, which could last to 12 weeks, with a 30% attack rate scenario, epidemic peak would be delayed by approximately 5 days (Fung et al., 2015).

Ahmed et al. (2018) found that non-healthcare workplace social distancing measures decreased and delayed the peak influenza attack rate and that the decrease was more pronounced when combined with other NPIs or pharmaceutical interventions. In addition, they found that workplace social distancing measures are less effective when there was a delay in their triggering or lower compliance.

Although the NPIs are low-cost health technologies that can improve the health outcomes and even save lives, they are not without weaknesses. Aside from the costs associated with endorsing and implementing them, some NPIs have direct economic, social and political costs. For example, the mandatory use of PPE, *cordon sanitaire*, and school and mass transit closures can lead to business shutdowns, PPE price inflation and unemployment. In some cases, the costs of the proposed public health interventions may be higher than the costs of the disease.

In addition, the efficacy of NPIs relies heavily on behavioral adaptation – the response and decision of the public to comply and follow the protocols and guidelines about the implementation and use of these NPIs. For example, the full benefits of social distancing are not realized when an economic agent is only concerned with his own utility and own risk of infection and disregards the fact that his/her response and decision affect the common good (or public health).

Therefore, the role of behavioral-based public health interventions in addressing infectious diseases can be tricky. For one, if we integrate economics into epidemics, the role of incentives cannot be ignored. Clearly, individuals are heterogenous and their response to infection risk as well as their incentives to comply to health interventions vary. Generally, economic models have shown that individuals, when left on their own, tend to underinvest in prevention and control of a disease. For example, individuals tend to underinvest in vaccines, which can be crudely attributed to the classic externalities problem. In such cases, public interventions are necessary and in the case of vaccination, a simple (yet costly) subsidy can incentivize individuals.

Fenichel (2013) incorporated individual's economic behavioral response into the S-I-R (susceptible-infected-recovered) compartmental epidemiological modeling framework to show how the efficacy of a public health policy such as social distancing during an epidemic can be affected by behavioral incentives. He found that health policy interventions can enhance the welfare of the public.

Public health state can also be modeled as an impure public good in which individuals may have partial ownership of it even if they have no regard for it as in the case of vulnerable individuals who choose to voluntarily avoid infection for their own well-being (Bell and Gersbach, 2009). In effect, when an individual tries to avoid infection for his/her own welfare, other individuals also benefit, due to positive externalities, and consequently, the risk of infection also decreases.

In this paper, we study how effective the epidemiological interventions (different quarantine measures) imposed by the Philippine government in curbing COVID-19 incidence and mortality given the country's health capacity and sociodemographic characteristics. Although individuals' incentives to comply are inherent in the types of quarantine imposed, there are cases when individuals are given more freedom to self-distance. In which case, we indirectly control for these incentives using urbanity and poverty incidence since the findings in the literature suggest that individuals with low income and those in rural areas tend to engage less in self-protective behaviors such as wearing a face mask correctly and social distancing (Haischer, et al. 2020; Machida, et al. 2020; Papageorge, et al. 2020)

2.2 Social distancing in the Philippines during COVID

This section briefly reviews the myriad of directives on CQs in the Philippines.¹ The Philippine government implemented different mitigation strategies to combat local COVID-19 transmission including a CQ, which was first imposed on Metro Manila on March 15. Since then, different parts of the country were placed under different types of CQs (Table 1).

On March 17, the entire island of Luzon, which is composed of eight administrative regions including NCR and home to more than half of the country's population, was placed under total lockdown (ECQ) from March 17 until April 12, which was later extended to April 30 and eventually extended again until May 15 through executive order (EO) 112. Meanwhile, provinces outside Luzon, or those in Visayas and Mindanao, also adopted similar social distancing protocols and were placed under ECQ (such as Iloilo, Cebu, Negros Occidental and Davao, to name a few).

On May 15, the Inter-Agency Task Force (IATF) for the Management of Emerging Infectious Diseases issued Resolution No. 37, which puts various areas in the country under different forms of CQ until May 31 (Official Gazette, 2020a). For example, all highly urbanized

¹ Appendix 1 discusses in more detail the many, and often confusing, quarantine measures imposed in the country.

cities in the NCR and other transitioning high-risk areas were placed under MECQ, which is a transition phase between the strictest type of CQ (ECQ) and GCQ, until May 31 (Official Gazette, 2020b). All other local government units (LGUs) in the country were placed under GCQ.

On May 29, the IATF issued Resolution No. 41 which set the CQ guidelines for the entire country from June 1 to 15, 2020 (Official Gazette, 2020c). For this period, only two kinds of CQs were imposed, namely, MGCQ and GCQ.

Table 1. Definitions CQs in the Philippines from March 15, 2020 to June 15, 2020, arranged chronologically

	Description	Months
GCQ	General CQ = {1,0}; implementation of CQ protocols (limiting movement and transportation, regulation of operating industries, and presence of uniformed personnel).	March 15– June 15
CQ	Community quarantine = {1,0}; the restriction of movement to mitigate the transmission of COVID-19 virus.	March 16– April 30
ECQ	Enhanced CQ = {1,0}; stricter definition than GCQ (stringent limitation on movement and transportation, strict regulation of industries and provision of food and essentials, and heightened presence of uniformed personnel).	March 17– May 31
MECQ	Modified ECQ = {1,0}; transition phase between ECQ and GCQ.	May 16–May 31
MGCQ	Modified GCQ = {1,0}; transition phase between GCQ and the New Normal.	June 1–June 15

Notes: Source: News, EOs, resolutions and IATF Omnibus Guidelines.

3. Methodology

To properly identify the impact of the epidemiological interventions (lockdowns) on COVID-19 cases and deaths in the Philippines, we use a natural experiment on the panel data that we constructed.

In a natural experiment, or quasi-experiment, researchers compare the response of the treatment group (exposed to the intervention) to a certain treatment/intervention that is assigned randomly with that of the control group (not exposed to the intervention).

Using our panel data, we can compare the health outcomes between the treatment group (provinces under quarantine) and control group (provinces not under the same quarantine measure) and also compare across time, that is, before and after the quarantine was imposed. Another way of putting it is that we aim to estimate how the health outcomes in these two groups evolve before

and after the pronouncement of a quarantine. The most apt methodology is difference-in-differences (DID), which is considered as a quasi-experiment.

3.1 DID and fixed effects (FE)

Our first model considers the impact of ECQ, which has been imposed in most province-daily observations (27% of them), on health outcomes.

The base model that we want to estimate initially is the following:

$$Y_{hpt} = \alpha_p + \beta_t + \delta ECQ_{pt} + \varepsilon_{pt} \quad (1)$$

where $h=1,2,3,\dots,15$ is the index for health outcomes (Y_{hpt}) considered in this paper. The first eight health outcomes pertain to daily new cases (total, male, proportion of male cases to daily new cases, vulnerable cases for those aged 0-4 or 60 and above, proportion of vulnerable cases to daily new cases and incidence rate defined as new cases at time t in proportion to the cumulative daily cases at time t) and deaths (crude mortality and mortality rate defined as daily deaths in proportion to the daily new cases). The second seven health outcomes are just the daily cumulative version of the daily new COVID-19 cases and deaths.

$p=1,2,\dots,85$ is the index for provinces and districts while $t=1,2,\dots,138$ is the index for time (daily) from January 30, 2020 to June 15, 2020.

ECQ_{pt} is a discrete variable for ECQ, which is the policy intervention imposed on province p at time t , or the treatment.

Without initially controlling for other factors that could affect the health outcomes in a province, the coefficient δ (Equation 1) is basically the DID estimate or the average treatment effect (ATE) or intuitively, it measures the effect of the policy (ECQ) on health outcomes. The DID estimator can be expressed as follows, using COVID-19 mortality (C19_M) as the health outcome (h) of interest:

$$\tilde{\delta} = \left(\overline{C19_M}_{pre-ECQ,tg} - \overline{C19_M}_{pre-ECQ,cg} \right) - \left(\overline{C19_M}_{post-ECQ,tg} - \overline{C19_M}_{post-ECQ,cg} \right) \quad (2)$$

where *pre-ECQ* pertains to the period before the imposition of ECQ and *post-ECQ* denotes the period after ECQ was imposed while *tg* refers to treatment group (provinces under treatment or ECQ) and *cg* corresponds to control group (provinces not under ECQ).

In effect $\tilde{\delta}$ is the difference over time in the average difference of COVID-19 mortality in the two treatment regimes. Our null hypothesis simply tests whether $\delta=0$. The DID estimate essentially measures whether ECQ is efficacious in mitigating deaths attributed to COVID-19. To properly identify δ , certain conditions like random assignment, consistency and confounding assumption need to be satisfied (Appendix 2). One could derive the causal relationship between the treatment and the health outcome and ascertain the efficacy of the treatment using the DID methodology work given certain strong assumptions.

Our base model (equation 1) is made complicated by the fact that the ECQ was imposed in different provinces at different time periods. Therefore, our analysis goes beyond the canonical 2x2 (two-period, two-groups) DID methodology. A generalized DID analysis is more apt with multiple time periods ($t=1, \dots, T_0$ for pre-ECQ and $t= T_0 + 1, \dots, T$ for post-ECQ imposition).

In practice, fixed effects (FE) regression model has been used as an estimator in DID to estimate the effect of a treatment/policy on outcomes of interest (Wing, et al., 2018; Zeldow and Hatfield, 2019; de Chaisemartin and D'Haultfoeuille, 2020). In our paper, we also use FE regression and DID approach since we want to control for unmeasured time-invariant confounders in determining the efficacy of ECQ in reducing COVID-19 cases and mortality. In Equation (1), α_p is the unobserved time-invariant provincial characteristics or fixed-effects (FE) that we want to control for. For example, one province may have social distancing measure already ingrained in its culture compared to another province.

We also want to control for time effect (β_t in Equation 1) that does not vary across provinces such as the initial price inflation of PPE (face masks and face shields) when the national government required their use in public places.

We extend Equation (1) to include other control variables that could affect COVID-19 health outcomes.

$$Y_{hpt} = \mu_p + \vartheta_t + \phi ECQ_{pt} + \gamma X_{pt} + \theta V_p * ECQ_{pt} + \psi_{pt} \quad (3)$$

$$X_{pt} = X_{pt}\{COVID_test_{pt}, PPE_{pt}\} \quad (4)$$

$$V_p = V_p\{socio_dem_p, health_cap_p\} \quad (5)$$

where X_{pt} is a vector of time-variant (daily) provincial COVID-19 health capacity variables that can potentially affect provincial health outcomes, which includes testing capacity ($COVID_test_{pt}$) and personal protective equipment (PPE_{pt}).

V_p pertains to a vector of time-invariant provincial sociodemographic characteristics ($socio_dem_p$), which include population, poverty incidence and urbanity, and health capacity ($health_cap_p$), such as number of doctors, other health workers, hospitals and beds.

$V_p * ECQ_{pt}$ captures the impact of time-invariant provincial characteristics conditional on whether the province is under ECQ or not.

The rest of the variables are similar to those specified for Equation (1). In addition, we also estimate Equation (3) using fixed effects (FE) model.

Based on the literature and on health guidelines, the purpose of a strict social distancing measure, while waiting for the development of a new pandemic vaccine, is to limit and control for the spread of the pandemic virus. Therefore, we want to test whether ECQ actually decreased COVID-19 incidence and mortality and so our null hypothesis is that ECQ is not effective as a policy intervention:

$$\frac{\partial Y_{hpt}}{\partial ECQ_{pt}} = \phi + \theta V_p = 0 \quad (6)$$

In addition, we also want to control for health capacity and predict that a stronger health system can improve the health outcomes ($\gamma < 0$).

We likewise test whether the impact of the different time-invariant provincial characteristics – like sociodemographic and health capacity before COVID-19 – is heterogenous between the different treatment and control groups.

$$\left. \frac{\partial y}{\partial x} \right|_{ECQ=1} - \left. \frac{\partial y}{\partial x} \right|_{ECQ=0} = \theta = 0 \quad (7)$$

In our second model, we change our health policy intervention to a discrete variable that is equal to 1 if a province is under any type of CQ and 0, otherwise to examine the difference in health response between a province that was under any form of a lockdown and a province that was not.

In our third model, we have a multi-treatment, multi-group and multi-period scenario where each treatment group can serve as a control group to every other treatment group (de Chaisemartin and D'Haultfoeuille, 2020). This is to account for the fact that a province can be under several types of CQs at different time periods as in the case of Metro Manila that was under a total of three different CQs from March 15 to June 15.

In this case, we use a general DID in our analysis to compare the treatment group (provinces under quarantine i) with the control group (provinces not under the same quarantine type i) before and after the imposition of the quarantine measure. We also use FE analysis to account for the provincial fixed effects ξ_p :

$$Y_{hpt} = \xi_p + o_t + \sum_{i=1}^5 \pi_i \text{Quarantine}_{ipt} + \varpi X_{pt} + \sum_{i=1}^5 \rho_i V_p * \text{Quarantine}_{ipt} + v_{pt} \quad (8)$$

where Quarantine_{ipt} is the i th quarantine measure (as a discrete variable) experienced by province p at time t . $i=1,2,\dots,5$ is the index for quarantine $\{i=1$ for ECQ, $i=2$ for MECQ, $i=3$ for GCQ, $i=4$ for MGCQ, and $i=5$ for CQ $\}$. The rest of the variables are similar to those described in equations (1) and (3–5).

3.3. Time-variant treatment effects

In empirical literature, treatment effects can vary over time (Wing, et al., 2018) therefore, we consider both the real-time or contemporaneous effect, and the lagged or delayed effect of a CQ on health outcomes. The two sources of the lagged effect (delay in DOH reporting and in individual reporting) led us to also examine the impact of a CQ one to three weeks later.^{2 3}

4. Data description

The longitudinal dataset employed in this research covers 81 provinces and 4 districts of Metro Manila, and spans from January 30 to June 15, 2020. We are able to construct a total of

² Daily COVID-19 health outcomes, as reported by DOH, may include cases 14 days prior (DOH, 2020c).

³ DOH (2020d), citing WHO, reports that COVID-19 virus has an incubation period that ranges from 1 day to 12.5 days.

11,730 daily observations at the provincial/district level by merging seven individual panel datasets. A panel dataset is more apt than other types of datasets since it addresses both spatial and time variations as well as the time-invariant unobserved heterogeneity.

4.1 COVID-19 incidence and mortality dataset

Our fifteen daily COVID-19 health outcomes, summarized in Table 2 below, are all derived and generated using the daily COVID-19 updates from the DOH and assigned to 85 provinces and districts, which are, in turn, derived from the Philippine Standard Geographic Codes of the Philippine Statistics Authority (PSA) as of March 31, 2020.

The Eastern Manila district (or the second district), composed of the cities of Quezon, Mandaluyong, Marikina, Pasig, and San Juan, recorded the highest number of confirmed daily cases among the vulnerable group (104) and total number of daily deaths (21) last March 31 and April 29, respectively, while Cebu had the highest total daily cases (324) and male cases (175) last June 3.

Table 2. Summary statistics of health outcomes

<i>Daily COVID-19 cases and deaths</i>	Mean	SD	Max
Crude mortality	0.09	0.68	21
Mortality rate	0.01	0.06	1
New cases	1.56	9.27	324
Male cases	0.84	5.22	175
Prop of male cases	0.07	0.23	1
Vulnerable cases (age <=4 age>=60)	0.33	2.36	104
Prop of vulnerable cases	0.03	0.13	1
Incidence rate	0.02	0.10	1
<i>Cumulative daily COVID-19 cases and deaths</i>			
Cumulative crude mortality	4.21	24.39	359
Cumulative mortality rate	0.05	0.13	1
Cumulative cases	65.53	346.18	4,636
Cumulative male cases	35.72	185.73	2,399
Prop of cumulative male cases	0.27	0.35	1
Cumulative vulnerable cases	16.90	92.59	1,232
Prop of cumulative vulnerable cases	0.15	0.25	1

Notes: N=11,730 for all except for mortality rate (N=11,666). Minimum = 0 for all.

The average provincial total daily deaths attributed to COVID-19 is about four while the incidence rate and cumulative mortality rate are about 2% and 5%, respectively.

4. 2 Lockdown dataset

Our main policy variables are the five types of CQ that were imposed by the national government and LGUs from March 15, 2020 to June 15, 2020. We constructed the first CQ panel dataset (11,730 province-daily observations) using EOs, news outlets, government pronouncements and resolutions from the IATF.

The most stringent quarantine type is ECQ followed by MECQ, GCQ, MGCQ and CQ. We also included a binary variable “*lockdown*”, which is equal to 1 if a province is under any of the five types of community quarantine and 0 otherwise.

About 64% of the observations were under lockdown (27% were under ECQ and 26% were under GCQ while about 10% were under CQ, MECQ and MGCQ (Table 3).

Table 3 Summary statistics of health capacity and sociodemographic characteristics

Variable	Mean	SD	Min	Max
<i>Lockdown</i>				
GCQ	0.26	0.44		
CQ	0.02	0.15		
ECQ	0.27	0.44		
MECQ	0.01	0.12		
MGCQ	0.07	0.26		
Lockdown	0.64	0.48		
<i>Sociodemographic characteristics</i>				
Population (in ‘000)	1,188	1,056	17.2	4,651
Poverty	28.25	14.87	2.63	65.01
Urbanity	0.18	0.22	0	1
<i>Time-invariant health capacity</i>				
Doctors	663	1,141	8	7,119
Other health staff	1,403	1,737	85	10,872
Hospitals	14	11	4	43
Beds (in ‘000)	1.2	1.5	0.2	7.4
<i>COVID-19 tests</i>				
Number of testing facility	0.34	1.19		13
Samples tested	79	402		6,441
Unique individuals tested	73	379		6,361
Available tests (in ‘000)	6	43		661

Table 3 Summary statistics of health capacity and sociodemographic characteristics

Variable	Mean	SD	Min	Max
Backlogs	14	138		2,910
<i>COVID-19 PPE (available) (in '000)</i>				
Gowns	0.8	2.2		20.4
Gloves	22	75		1,635
Head covers	6	18		126
Goggles	0.5	1.5		14.4
Coveralls	1	2.8		23.1
Shoe covers	1.7	6.6		81.3
Face shields	0.9	3.1		34.5
Surgical masks	16	49		446
N95 masks	1.3	3.8		32.4

Notes: N=11,730 for sociodemographic characteristics and health capacity prior to COVID-19 (time-invariant). N=6,290 for all COVID-19 tests. N=5,440 for all COVID-19 PPE. min = 0 for all COVID-19 tests and PPE.

4.3 Health capacity dataset

The health capacity of a country during pandemic affects how fast the virus is transmitted and how equipped a country is in handling the surge in capacity. We include two sets of variables to account for provincial health capacity: (1) time-invariant variables available prior to COVID-19 (number of doctors, other health workers, hospitals and beds), derived from DOH's Health Facilities and Services Regulation Bureau (2016) and Health Human Resources Development (2017); and (2) time-variant health capacity variables available during COVID-19 (testing capacity and PPE available), taken from DOH Data Drop as reported by the different health facilities that conduct COVID-19 tests and/or have COVID-19 patients.

Table 3 shows a skewed distribution of health workers (and health capacity) across the country. The second district of Metro Manila had the most number of doctors (about 7,000) and other health workers (about 11,000), which translates to about 15 doctors and 23 other health workers per 10,000 population, while the island province of Siquijor had the least number of doctors (8) and other health workers (85).⁴ NCR, on the other hand, had the most number of hospital beds (7,431) or 23 beds per 10,000 population satisfying the WHO requirement of 20 beds per 10,000 population (DOH, 2012). Autonomous Region of Muslim Mindanao, meanwhile, only had 183 hospital beds.

⁴ The second district's population was about 4.6 million.

Metro Manila, again, had the most number of health facilities for testing COVID-19 and the most number of individuals tested, which can be attributed to the high incidence in the region and a better health capacity.⁵ It also had had the highest number of available PPE at different periods (about 1.6 million gloves, 450,000 surgical masks and 32,000 N95 masks).⁶

4.4 Sociodemographic characteristics dataset

Next, we constructed a time-invariant provincial dataset containing the control variables for poverty, urbanity, and population, which we hypothesized could also affect the COVID-19 health outcomes.

In the literature, poverty is found to be positively correlated with the transmission of infectious diseases such as COVID-19. For example, lack or poor access to safe water and sanitation as well as inadequate housing may lead to an efficient spread of infection (Alsan et al., 2011). Furthermore, Bargain and Aminjonov (2020) examined the link between poverty and COVID-19 cases among developing countries using DID. They found that poverty is associated with an increase in COVID-19 cases through regional mobility to work among African and Latin American countries. In particular, a one standard deviation-increase in regional poverty (moving from low to high poverty regions) resulted to an 11%-increase in COVID-19 incidence in early May, on average, through enhanced work mobility.

Our poverty variable was derived from the 2015 Small Area Poverty Estimates of the PSA by averaging the poverty incidence from cities and municipalities located within a province. The mean provincial poverty incidence in 2015 was about 28%, with Lanao del Sur, a province in the southern part of the country, having the highest incidence (65%) and the second district of Metro Manila having the lowest incidence (2.6%) (Table 3).

Population (density) and urbanity appear to also be associated with the spread of an infectious disease. For example, on the Diamond Princess cruise ship both the basic reproduction number (R_0) of COVID-19 virus SARS-COV-2 and population density were about four times higher than that in the epicenter in Wuhan, China (Rocklöv, et al. 2020). In higher population

⁵ The DOH only started reporting the statistics on COVID-19 testing on April 3 resulting to a reduced number of daily observations (N=6,290) at the provincial level.

⁶ Daily provincial data on PPE are derived by averaging the weekly data by facilities from DOH and assigning these to their respective province/district.

densities, maintaining a 1-meter distance, as recommended by WHO (2020d) becomes difficult and therefore, the spread of COVID-19 becomes more probable (Rocklöv and Sjödin, 2020). In the same token, highly-urbanized areas and megacities with high density of people can provide a perfect environment conducive to spreading infectious diseases (Neiderud, 2015). Hamidi et al. (2020), using structural equation modeling, found a positive correlation between metropolitan population and COVID-19 mortality rate.

On the other hand, Carozzi et al. (2020), using two instrumental variable strategies (historical populations and geological feature) found that although density and the timing of outbreak are correlated, they found no evidence that population density is correlated with COVID-19 cases and mortality.

To control for these factors, we use the population of the province and urbanity, both taken from the 2015 population census. The average provincial/district population is about 1.2 million while the average for urbanity variable, computed as the proportion of barangays classified as urban to the total number of barangays in a province, is 18% (Table 3). While Metro Manila all had urban barangays, the landlocked province of Apayao in the Cordillera Administrative Region (north of the Philippines) does not have any barangay classified as urban.

5. Results

We divide the discussion of our FE results into three. The first section presents the results of estimating equations 1 and 3 to determine the impact of ECQ on COVID-19 health outcomes (Table 4). The second section focuses on the impact of a lockdown (Table 5), defined as any of the five types of CQ, on COVID-19 incidence and mortality. The last section discusses the results, displayed in Tables 6 and 7, of examining whether heterogeneity in the effectiveness exists across the different types of CQ (equation 8).

In all three sections and for all tables discussed, we considered 15 possible health outcomes (daily and cumulative daily health outcomes), four treatments of time (no lag, a 7-day, 14-day and 21-day lag), and four different combinations of independent and control variables. In total, we ran 720 regressions and 1,080 postestimation linear combination tests. For brevity, we focus on robust and consistent results and present mostly a summary of results.

5.1 The effect of ECQ on COVID-19 cases

In this section, we first analyze the impact of the strictest CQ imposed in the different parts of the country starting March 17 on COVID-19 health outcomes. We hypothesize, and test equation (6), that being under ECQ relatively improves the welfare of the community after controlling for health capacity, sociodemographic characteristics, and time and fixed effects. We consider both real-time and lagged effects of ECQ on COVID-19 deaths and incidence using natural experiment (DID-FE) on panel dataset we constructed and discussed above. We also test for equation 7 to examine the relevance of other factors that could affect COVID-19 health outcomes in the treatment group.

5.1.1 The real-time effects ECQ on COVID-19 cases

Table 4 below shows the results of estimating equations 1 and 3 to determine the real-time or immediate/contemporaneous effects of ECQ as a policy intervention on COVID-19 health outcomes. Using DID-FE methodology, our findings suggest the following.

First, ECQ is positively associated with the following daily COVID-19 health outcomes: (a) total cases, (b) male cases, and (c) vulnerable cases using simple linear regression analysis (SLR). However, after adding provincial sociodemographic characteristics and health capacity variables (MLR2), the effects of ECQ on COVID-19 new daily cases become negative and statistically significant.⁷ Or another way to put it is that ECQ as an intervention policy becomes effective in bringing down the COVID-19 daily new cases when coupled with sufficient health capacity and when preferences to comply are accounted for. In particular, the results of our postestimation analysis of ECQ coefficients (equation 6) reveal that provinces under ECQ had 9% lower daily new cases (Column 2).

Second, if we add another set of COVID-19 variables such as the nine PPE, ECQ is more effective in reducing daily incidence (MLR3 specification). Provinces under ECQ had about 12% lower COVID-19 daily cases relative to their counterparts (Column 3). Third, using the same

⁷ MLR1.1 refers to the econometric specification with only time-invariant variables, interacted with the policy variable, as controls while MLR2 contains an additional vector for COVID-19 tests and MLR3 contains an additional COVID-19 PPE vector.

econometric specification (MLR3), areas under ECQ also have lower daily male cases (10%) and vulnerable cases (6%) (Columns 5 and 7).

Table 4. The real-time effects of ECQ on COVID-19 cases

	Daily Cases			Male Cases		Vulnerable Cases	
	SLR (1)	MLR2 (2)	MLR3 (3)	SLR (4)	MLR3 (5)	SLR (6)	MLR3 (7)
ECQ	0.23*** (0.07)	0.54 (0.9)	0.55 (0.91)	0.17*** (0.06)	0.51 (0.85)	0.12*** (0.04)	0.46 (0.67)
Population x ECQ		0.01 (0.04)	-0.01 (0.04)		-0.01 (0.03)		0 (0.03)
Poverty x ECQ		-0.08* (0.05)	-0.04 (0.05)		-0.03 (0.05)		-0.07* (0.04)
Urbanity x ECQ		-0.51 (0.32)	-0.53** (0.26)		-0.63** (0.25)		-0.37 (0.27)
Doctors x ECQ		0.13 (0.1)	0.09 (0.1)		0.08 (0.09)		0.07 (0.07)
Other health staff x ECQ		-0.18 (0.14)	-0.13 (0.15)		-0.12 (0.14)		-0.09 (0.11)
Hospitals x ECQ		0.03 (0.04)	0.03 (0.05)		0.01 (0.04)		-0.02 (0.03)
COVID-19 tests		✓	✓		✓		✓
COVID-19 PPE			✓		✓		✓
<i>Lincom test</i> ECQ		-0.09** (0.04)	-0.12** (0.05)		-0.1** (0.04)		-0.06** (0.03)
Observations	11,730	6,290	5,440	11,730	5,440	11,730	5,440

Notes: Robust standard errors in parentheses. Number of provinces/districts = 85. Date dummies included in all specifications. *Lincom* refers to postestimation linear combination tests of ECQ coefficients. All continuous variables are in log form. The complete FE and postestimation test results are shown in Appendix 3.

*** p<0.01, ** p<0.05, * p<0.1

5.1.2 The lagged effects of ECQ on COVID-19 cases

There are four interesting results when we did our lagged analysis. First, the efficacy of ECQ in reducing total, male and vulnerable cases persist even a week later. However, we find that the negative impact on health outcomes is less after a week (about 2 to 3 percentage point difference).

Second, consistent with our real-time analysis, ECQ as a policy variable becomes effective when combined with health capacity (before and during the COVID-19 outbreak) and

sociodemographic characteristics. Third, we find that ECQ has a delayed effect on proportion of male cases and COVID-19 incidence rate, which only decreased a week and three weeks later, respectively. All the results of our lagged analysis are presented in Appendix 4 for brevity.

5.2 The real-time and lagged effects of lockdown on COVID-19 cases and deaths

We proceed to testing whether provinces under any form of a lockdown are better off, in terms of COVID-19 health outcomes, compared to their counterparts. Table 5 shows that, without controlling for other variables (SLR), lockdown is effective in reducing COVID-19 mortality, vulnerable cases and incidence rate. In particular, using a real-time analysis, we find that provinces under a lockdown have lower cumulative crude mortality (21%) and cumulative vulnerable cases (23%) compared to areas not under quarantine. On the other hand, only when we use a 21-day lag analysis do we find provinces under lockdown to have lower incidence rate (1%) relative to their counterparts.

When we add time-invariant variables (sociodemographic characteristics of a province and health capacity prior to the outbreak), we find that provinces under a lockdown have 2% lower incidence rate. It is worth noting that by April 3, almost all provinces (99.7%) were already under lockdown and therefore, our analysis is limited to MLR1.1 specification, which only controls for time-invariant provincial characteristics that were available even prior to April 3.

Table 5. The real-time and lagged effects of lockdown on COVID-19 cases and deaths

	Real time (0-lag)		21-day lag	
	Cumulative Daily Deaths	Cumulative Vulnerable Cases	Incidence Rate	
	SLR (1)	SLR (2)	SLR (3)	MLR 1.1 (4)
Lockdown	-0.21** (0.1)	-0.23** (0.11)	-0.01* (0.01)	-0.08* (0.04)
Province chars				✓
<i>Lincom test</i> Lockdown				-0.02** (0.01)
Observations	11,730	11,730	9,945	9,945

Notes: Robust standard errors in parentheses. Number of provinces = 85. Date dummies included in all specifications. All continuous variables are in log form. Complete regression results are presented in Appendix 5. *** p<0.01, ** p<0.05, * p<0.1

5.3 The impact of the different CQs on COVID-19 cases and deaths

In this section, we discuss the FE results of estimating equation 8 to determine whether heterogeneity exists among the different quarantine measures imposed in the country in terms of their impact on the different health outcomes we consider in this paper. Tables 6 and 7 below show the concatenated results of our real-time analysis while Appendixes 6–9 contain the full SLR and MLR results of our DID-FE panel regressions using real-time and lagged analyses.

5.3.1 The real-time effects of the different CQs on COVID-19 deaths

It can be gleaned from Table 6 below that our policy variables are effective (negative and statistically significant) when we expand our base model and incorporate health capacity and sociodemographic characteristics into the analysis. In particular, if we use MLR2 specification, we find that those under MECQ have about 7% lower mortality rate compared to those under GCQ (Column 1). This finding is robust if we extend the analysis and use MLR3 (with additional set of health capacity variables such as COVID-19 PPE) (Column 2).

In terms of cumulative daily deaths, the results for provinces under MECQ are robust across the three different specifications MLR1.1, MLR2, and MLR3 (Columns 3, 4, 5). Those under MECQ have about 90%, 67% and 55% less cumulative crude mortality compared to those not under any lockdown, those under GCQ, and those under GCQ or CQ, respectively. In addition, Column 3 shows that those not under any lockdown have higher daily mortality by about 38% than those under CQ and by about 57% than those under MGCQ. This suggests that CQ, MGCQ and MECQ are effective in reducing mortality relative to no lockdown at all.

For the health outcome cumulative mortality rate, Column 6 shows that while those under CQ have higher cumulative mortality rate by about 6%, those under MECQ have about 7% lower mortality rate compared to those under GCQ (MLR2). This suggests that heterogeneity across the different types of quarantine measures exists – stricter quarantine type is more effective. This is further confirmed using more control variables (MLR3 Column 7), which shows that those under MECQ have about 7% less cumulative mortality rate than those under less strict types of quarantine (CQ or GCQ).

Table 6. The real-time effects of the different CQs on COVID-19 deaths

	Mortality Rate		Cumulative Deaths			Cumulative Mortality Rate	
	MLR2 (1)	MLR3 (2)	MLR1.1 (3)	MLR2 (4)	MLR3 (5)	MLR2 (6)	MLR3 (7)
Quarantine types	✓	✓	✓	✓	✓	✓	✓
Province chars.	✓	✓	✓	✓	✓	✓	✓
COVID-19 tests	✓	✓		✓	✓	✓	✓
COVID-19 PPE		✓			✓		✓
<i>Lincom tests</i> GCQ			-0.2 (0.18)				
CQ	0 (0.01)		-0.38* (0.2)	0.12 (0.14)		0.06* (0.03)	
ECQ	0.01 (0)	0.01+ (0)	0.03 (0.13)	0.06 (0.06)	0.03 (0.04)	0.01 (0.03)	0.01 (0.02)
MECQ	-0.07*** (0.02)	-0.07*** (0.02)	-0.9*** (0.21)	-0.67*** (0.15)	-0.55*** (0.11)	-0.07** (0.03)	-0.07*** (0.02)
MGCQ	0.01 (0.01)	0 (0.01)	-0.57** (0.26)	-0.02 (0.06)	-0.01 (0.06)	0.02+ (0.01)	0.01 (0.01)
<i>Observations</i>	6,231	5,405	11,730	6,290	5,440	6,290	5,440

Notes: Robust standard errors in parentheses. Number of provinces/districts = 85. Date dummies are included in all specifications. All continuous variables are in log form. Complete regression results are presented in Appendix 6. *** p<0.01, ** p<0.05, * p<0.1, + p<0.15

5.3.2 The real-time effects of the different CQs on COVID-19 cases

Table 7 below shows the following robust results (across MRL2 and MLR3) of estimating the impact of different types of CQ on COVID-19 incidence using real-time analysis.

First, provinces under ECQ, the strictest form of CQ, have lower COVID-19 cases (total, male and vulnerable cases) relative to areas under GCQ. Second, ECQ, as a policy variable, becomes more effective in reducing COVID-19 incidence as we add more variables for health capacity.

Third, we also find that those under MECQ have lower vulnerable cases and proportion of cumulative vulnerable cases relative to those under less strict quarantine.

Table 7. The real-time effects of the different CQs on COVID-19 cases

	Daily Cases		Male Cases		Vulnerable Cases		Prop of Cumulative Vulnerable Cases	
	MLR2 (1)	MLR3 (2)	MLR2 (3)	MLR3 (4)	MLR2 (5)	MLR3 (6)	MLR2 (7)	MLR3 (8)
Quarantine types	✓	✓	✓	✓	✓	✓	✓	✓
Province chars.	✓	✓	✓	✓	✓	✓	✓	✓
COVID-19 tests	✓	✓	✓	✓	✓	✓	✓	✓
COVID-19 PPE		✓		✓		✓		✓
<i>Lincom tests</i> CQ	0.11 (0.11)		-0.08 (0.15)		0.07 (0.05)		-0.04 (0.1)	
ECQ	-0.1** (0.04)	-0.12*** (0.04)	-0.07* (0.04)	-0.1** (0.04)	-0.05* (0.02)	-0.06** (0.03)	-0.02 (0.03)	-0.02 (0.03)
MECQ	0.02 (0.21)	0.03 (0.18)	-0.11 (0.14)	-0.17 (0.13)	-0.51*** (0.16)	-0.49*** (0.11)	-0.1*** (0.04)	-0.07** (0.03)
MGCQ	0.05 (0.09)	0.07 (0.08)	0.02 (0.08)	0.03 (0.07)	-0.01 (0.05)	0 (0.04)	0.03 (0.03)	0.02 (0.03)
Observations	6,290	5,440	6,290	5,440	6,290	5,440	6,290	5,440

Notes: Robust standard errors in parentheses. Number of provinces = 85. Date dummies included in all specifications. All continuous variables are in log form. Complete regression results are presented in Appendix 7. *** p<0.01, ** p<0.05, * p<0.1

5.3.3 The lagged effects of the different CQs on COVID-19 mortality and incidence

We test whether our real-time results persist over time and the delayed/lagged effects are displayed in Appendixes 8–9, for brevity, and discussed as follows.

First, we find that the results of our lagged analysis are consistent with those of our real-time analysis. Specifically, those under MECQ have lower cumulative deaths and cumulative mortality rate than those under less strict lockdown (CQ or GCQ) even if we analyze our health outcomes a week or two weeks later and this is true for both MLR2 and MLR3 specifications. However, those under CQ have higher cumulative mortality rate (about 4%) than those under GCQ.

Second, in analyzing the lagged effects of the different quarantines on COVID-19 incidence, we observe that ECQ is ineffective when we do not have other control variables. However, once we include health capacity (both prior and during the COVID-19 outbreak) as well as sociodemographic characteristics that could potentially capture the preferences and likelihood

to comply to quarantine guidelines, ECQ becomes effective as a health intervention policy. In particular, those under ECQ have less total and male cases, which are consistent with our real-time analysis, suggesting persistence in the efficacy of this policy. In addition, those under ECQ also have less proportion of male cases a week later, which is robust across two the econometric specifications (MLR2 and MLR3).

With regard to cumulative proportion of vulnerable cases, the results are again consistent with our real-time analysis. MECQ areas have better health outcomes than those under less strict quarantine like GCQ even a week or two weeks later. However, we find that CQ is less effective in reducing proportion of vulnerable cases relative to GCQ.

Our lagged results suggest that heterogeneity in the health outcomes across the different types of CQ persists a week or even two weeks later.

6. Discussion

The results of our above empirical exercise suggest the following. First, when we focus our real-time analysis on ECQ as a policy variable, we find that it is only effective in reducing daily COVID-19 cases (total, male, and vulnerable cases) when combined with the health capacity of a province/district both before and during COVID-19 and sociodemographic characteristics. The efficacy of ECQ in curtailing COVID-19 daily cases persist a week later but in a reduced magnitude.

Second, when we examine the efficacy of ECQ relative to other CQs, we find that heterogeneity in the health outcomes across the different types of quarantine exists. For example, ECQ is more effective in reducing daily COVID-19 cases (total, male, and vulnerable cases) than GCQ, which is a less strict CQ. This result is robust across the different econometric specifications that we used and persists over time. In addition, we also find MECQ to be more effective than GCQ in reducing COVID-19 deaths and cases. Similar to the ECQ results, the efficacy of MECQ persists over time and is robust across the different econometric models considered.

Third, the coefficients of our control variables (Appendixes 3–9) suggest that urbanity matter more in reducing daily COVID-19 incidence in areas under ECQ, which is robust across the time periods (real-time and a week later). A possible explanation would be that urbanity captures the income effect. For example, communities and households in urban areas belong to

higher socioeconomic status and therefore can afford PPE more and have better access to relevant COVID-19 mitigation information.

In addition, we find that population, urbanity and other health workers, such as nurses, are more important in reducing all three COVID-19 death outcomes in MECQ areas than those in GCQ. Health care workers, other than doctors, are also relevant in reducing COVID-19 cases in provinces/districts under MECQ than those in GCQ. The results on our control variables also persist over time, similar to the behavior of our policy variables.

7. Conclusion

The current COVID-19 pandemic has resulted to catastrophic morbidity and mortality around the globe since it first appeared in Wuhan China in December of 2019. The Philippines is not inured to the devastating impact of COVID-19 on health and the economy. One of the government responses to mitigate the adverse effects of the virus and curtail its spread is an antiviral-based containment policy (*cordon sanitaire* or lockdown).

The first quarantine measure, imposed by the government for NCR, was implemented on March 15 after the local (community) transmission was confirmed. Since then, different types of quarantine of varying degrees were implemented in several parts of the country, which at times led to public confusion due to lack of clear implementing rules and guidelines and insufficient information from the authorities. For example, the omnibus guidelines on the implementation of CQs in the country were only approved by the IATF on May 15, about two months after the first CQ was imposed. Suffice it to say, the different types of CQ and their varying intensities and definitions were not clearly communicated to the public.

This paper attempts to investigate whether the imposition of the different quarantine measures was efficacious in reducing the number of COVID-19 cases and deaths, which we measure in various ways. In addition, we also test whether heterogeneity among the different types of lockdown, in terms of their impact on the health outcomes, exists.

As the literature suggests and as experts have claimed, different NPIs should be combined in order to have the desired effects on health outcomes, thus, we combined our policy variables (CQs) with the use of PPE in the health sector. We also considered the health capacity of the

country to cover for the two-pronged approach (flattening the curve through quarantine and raising health capacity) in combatting the outbreak.

The task of compiling and generating our quarantine and health longitudinal data, which are sourced from the myriad of official government data, government pronouncements, EOs, resolutions and news outlet is a daunting one. To conduct our evidence-based analysis and arrive at our empirical estimates, we had to generate a balanced panel data consisting of 11,730 units of observations on a daily basis across the 81 provinces and 4 districts of Metro Manila from January 30 to June 15. The sheer task of generating the first data on CQ in the country as well as organizing the different health outcomes, health capacity and sociodemographic variables on a daily basis is the first contribution of this paper.

The second contribution is that, to the best of our knowledge, this is the first empirical study on the effectiveness of the different lockdown measures as a public health policy in addressing COVID-19 in the Philippines. Further expanding our empirical exercise and integrating the role of health capacity and the innate characteristics of the provinces in determining COVID-19 cases and mortality in the country is our third contribution.

To arrive at our empirical results, we employed a quasi-experimental analysis (DID) and run FE regressions to examine how health outcomes have evolved over time, that is, before and after the imposition of the health policy interventions (different CQs) across the different provinces that were treated differently at different periods. We use a generalized multi-group and multi-period DID approach and account for the unobserved heterogeneity across provinces. Inherent in the DID methodology is the consideration of the counterfactual question – what would have been the health outcomes of the provinces under a CQ (treatment group) had they not gone under treatment, which are imputed from the observed outcomes for the untreated group.

Our results can be summarized into four. First, consistent with the literature on social distancing discussed (Earn et al., 2012; Fung et al., 2015; Ahmed et al., 2018), a community quarantine as a health policy intervention is only effective when combined with health capacity, other NPIs and sociodemographic characteristics of a province/district. Second, we also discover that there exists heterogeneity in the effectiveness across the different CQs imposed in the Philippines. The results suggest that stricter CQs are more effective in curbing COVID-19 incidence and mortality. Third, the efficacy of the epidemiological interventions persists over time, after a week or two, albeit in a reduced magnitude (less impact) as consistent with the findings of

Bonacini, et al. (2021). Fourth, we find that other health staff (nurses and other health care workers), urbanity and population matter in reducing COVID-19 cases and deaths in areas that are under quarantine.

However, we should note that despite the varied types of CQ imposed at different periods across the different parts of the country, COVID-19 cases and deaths continue to rise at an alarming rate. In fact, the Philippines, to date, has been among the ASEAN countries with high incidence and mortality attributed to the pandemic.

Three possible reasons for the worsening COVID-19 health outcomes in the Philippines are presented here. First, individuals at different degrees of quarantine measures have their own microeconomic incentives to comply to the guidelines and protocols instituted during a lockdown. Given that individuals are heterogeneous, their decision-making and response to a targeted intervention vary. An economic agent sometimes only considers the impact of his behavior on his own utility or on his network of family and friends without regard of the larger impact to the entire community. This is observed, for example, when the country eventually eased out of a stricter CQ, it resulted to COVID-19 cases skyrocketing and various medical associations imploring the government to impose again a stricter lockdown measure from August 1–15 (Manila Bulletin, 2020).

This leads to the second reason, which is inadequate health capacity and overwhelmed health system that is unable to cope with the sudden surge in demand for health care as attested to by the health care workers' plea and warning in early August. In Asia, success stories in controlling COVID-19 in China, Hong Kong and Singapore, for example, can be attributed to aggressive contact tracing, early and rapid response to new COVID-19 cases and border closures.

The third reason for the continued rise in COVID-19 cases in the country despite the many lockdowns imposed can be attributed to their oft-confusing implementation – from insufficient information amidst the sudden changes in lockdown status to belated protocols and guidelines.

Given the above reasons for the continued rise in COVID-19 cases in the country, some simple solutions are offered. First, a proper and informative nomenclature of CQ types like Level 1, 2, etc. would have been more helpful and could signal the intensity or strictness of the quarantine clearly. Second, it would really benefit the country to have an aggressive and proper system for surveillance, monitoring and isolating affected individuals. While the testing of COVID-19 cases has improved over the months, contact tracing is still lacking. Third, there should be full support

from the government of health care workers risking their lives in dealing with the pandemic – from providing sufficient hazard pay to ensuring that they are equipped with proper PPE. These measures could go a mile in boosting their morale and motivation. Fourth, a strict implementation of wearing a mask and face shield at all times in several public establishments would incentivize individuals to comply.

These are trying times and although the findings of this paper show that some of the lockdown measures, particularly the strictest ones (ECQ and MECQ), were effective in reducing COVID-19 cases and mortality, the next crucial steps include repairing the economy and strengthening the health capacity as it is unsustainable to continue with the lockdowns.

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