



## How Two Tests Can Help Contain COVID-19 and Revive the Economy

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*Faced with COVID-19, countries are taking drastic action based on little information. Two tests can help governments shorten and soften economically costly suppression measures while still containing the novel coronavirus (COVID-19) pandemic. The first—a PCR assay—identifies people currently infected by testing for the presence of live virus in the subject. The second—an antibody test—identifies those rendered immune after being infected by searching for COVID-19-specific antibodies. The first test can help contain the disease because it facilitates the identification of infected persons, the tracing of their contacts, and isolation in the very early stages of an epidemic—or after a period of suppression, in case of a resurgent epidemic. The second can help us assess the extent of immunity in the general population or subgroups, to finetune social isolation and to manage health care resources. Wide application of the two tests could transform the battle against COVID-19, but implementing either on a large scale in developing countries presents challenges. The first test is generally available, but needs to be processed in adequately equipped laboratories with trained staff. The second test is easy to perform and can be processed quickly on the spot, but at this stage it is produced and available only on a limited basis in a few countries. This policy brief reviews the use of both tests, suggests strategies to target their use, and discusses the benefits and costs of such strategies. If PCR assay testing, together with tracing and isolation, helps reduce the duration of suppression measures by two weeks, and antibody testing allows one-fifth of the immune return to work early, the gain could be about 2 percent of national income, or about \$8 billion for a country like the Philippines. Because the estimated economic benefits of the tests are likely to far outweigh the cost, the international community must help countries develop the capacity to process the first test and procure the second.*

*“The social returns to gathering...information and acting upon it is high: it reduces both the death toll and the size of the economic contraction.”*

—Eichenbaum, Rebelo, and Trabandt (2020)

On March 16, 2020, the Philippines imposed a lockdown on the 53 million people in Luzon, the country’s economic and political center and home to half of its population. This “enhanced community quarantine” followed similar restrictions on the movement of people in many other countries struggling to flatten the COVID-19 infection curve. These countries have no choice: the spread of the disease threatens to overwhelm their capacity to treat.

But an impasse is imminent. Stringent controls, if in place for long, will lead to unacceptable economic distress. However, lifting the controls risks unleashing the pandemic. Governments across the world will have to choose between the risk to life from economic deprivation and the risk to life from increased disease transmission—unless there is a way of controlling the disease without stifling economic activity.

Fortunately, there may be. In the aftermath of the 2003 SARS and 2015 MERS epidemics, the Republic of Korea and Singapore invested in the capacity to test, track, and selectively socially isolate, and were therefore able to contain the pandemic without undue economic pain. If countries like the Philippines—which we use as an example in this note—could build at least some similar capacity to test soon, they may begin to consider an eventual phase-out of restrictions without fear of the disease escalating or recurring (World Bank 2020a). But can they build sufficient testing capacity in time and at an acceptable cost?

### What Tests Are Available for COVID-19?

There are two types of test (World Bank 2020b). Each has different functions.

1. *Polymerase chain reaction (PCR) assay.* The first type of test helps identify whether an individual is currently infected (and thus likely currently infectious) by detecting the presence in the body of the new coronavirus, which causes the disease COVID-19. The PCR assay is well established. It is performed by collecting a swab well inside the nose or back of the throat. The test needs to be processed in a laboratory with a PCR machine, but mobile units can reportedly perform the

function. It currently takes a few hours to get results once the sample has reached the laboratory, but faster kits are under development. The PCR assay is accurate when conducted carefully by trained technicians in a well-equipped laboratory. Other options—such as an antigen quick test or a mobile PCR platform—can be done at point of care, but they have only recently been developed and are not as sensitive or as precise as a PCR assay. These alternatives may improve rapidly, however, in which case mass decentralized antigen testing or PCR assays would be possible.

2. *Antibody test.* This type of test helps identify immunity to the disease by spotting signs of an immune response, indicating that someone has been infected by the coronavirus in the past. It is not yet clear how long the immunity detected by the antibody tests will last and how quickly new mutations of the virus are likely to emerge. Various types of antibody tests are now in use and under development. The test is performed by collecting a blood sample through a finger prick. Processing the test does not require a laboratory and relies only on a rapid test kit, with results available on the spot in a few minutes. Various antibody tests are reportedly being used in Singapore and the United Kingdom, and have just been approved by the US Food and Drug Administration.

### How and When Can the Two Tests Help?

The two tests can serve as complements to each other. Figure 1 shows the proportions of the population infected and recovered over time and indicates at what points in the disease progression the various testing strategies are most useful.

The PCR assay can be deployed, in combination with tracing and selective isolation of positive cases, as an alternative to stringent suppression when the level of infection is sufficiently low, early at the beginning of the pandemic (to the left of the first vertical red line in figure 1) (as was done in Korea) and later when a suppression strategy has sufficiently lowered the level of infection (to the right of the second red vertical line) (as might be done in China). The thresholds depend on the national capacity to test, track, and isolate (TTI).

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While the virus is spreading (shown in the space between the two red vertical lines), a containment strategy with strict suppression measures can be deployed. The thresholds depend on the national capacity to test, track and isolate (TTI), not just in the main cities but also across the country. For example, Korea can carry out as many as 18,000 PCR assays per day, whereas the Philippines has only just succeeding in ramping up capacity to 1,000 PCR assays per day.

The PCR assay has been central to the testing, contact tracing, and targeted isolation efforts in China; Hong Kong SAR, China; Korea; Singapore; and Taiwan, China. It may still be important for some developing countries like Lao People’s Democratic Republic, Myanmar, Papua New Guinea, and the Pacific Island countries in quickly identifying the infected and tracking those with whom they have directly or indirectly interacted. Therefore, their capacity to process PCR assays and to track and isolate should be ramped up as soon as possible. These steps can also play an important role in containing an epidemic after a period of stringent suppression—a situation in which a country like China may currently be.

The antibody test could be useful in at least three respects. First, if the test were carried out on a representative sample of the population in any country that has experienced significant community transmission, it would reveal the country’s level of acquired immunity at that time. Combined with information on mortality and morbidity, it could help us understand the epidemiological profile and devise appropriate testing strategies. For example, it is conceivable that the virus has already infected a large proportion of the population and we are closer to achieving the critical level of resistance known colloquially as herd immunity. This knowledge would be a global public good and could mitigate a potential misallocation of the health investments that all countries are in the process of making.

Second, stratified random sampling could reveal the patterns of immunity across population groups differing by region, age, gender, and other salient characteristics. That would facilitate more targeted and phased social distancing policies based on risk profile. For example, in an island country like the Philippines, stronger suppression measures could be implemented in some islands rather than others.

Finally, more granular implementation of the test could help identify individuals who had developed immunity and could therefore

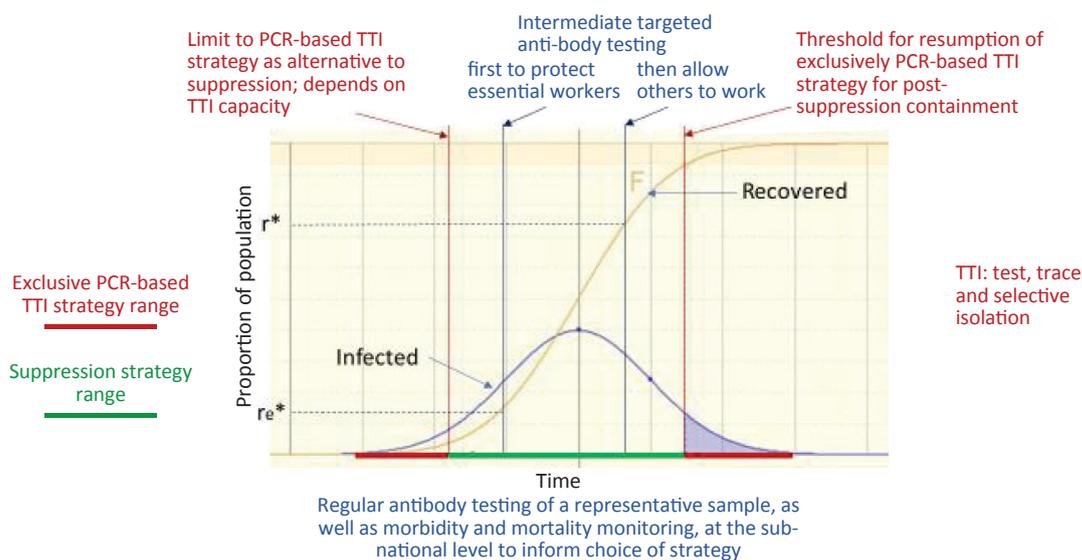
safely return to tasks requiring close human interaction. The antibody test would in practice serve as an “immunity certificate or passport,” allowing people to return to work and move around. Such testing could be one of the key tools to implement smart containment and mitigation strategies (Loayza 2020).

There are, however, two concerns about the use of the antibody test. First, it could have unintended consequences. People could choose to or be coerced into being infected so that they could get the “immunity certificate” sooner; or people, hopeful to return to work but not yet infected, could seek counterfeit immunity certificates. Moreover, social tensions could arise between those who have and those who do not have immunity certificates. The second concern is about the accuracy of the test. The sensitivity (avoiding false negatives) and the specificity (avoiding false positives) are important parameters of the test. A high specificity is crucial to avoid false positives, especially when the aim is to use the antibody test to identify individuals who have developed immunity. The sensitivity and specificity of tests tend to improve over time, but it will be important to monitor test performance in developing country contexts. It is also important to recognize that the accuracy standards required to glean broad epidemiological information by testing a representative sample may be lower than those in a test for individual diagnostic use.

The numerical example that follows illustrates how we could calculate the critical proportion of population that has recovered,  $r^*$ , at which point the benefits of a population-wide antibody test would cover the costs. It also shows that the threshold may come earlier ( $r_e^*$ ) for subgroups, such as health workers, who in general provide a high social benefit. Immune health workers could be assigned exclusively to the care of suspected and confirmed COVID-19 cases. This would have the double benefit of ensuring greater continuity of care for both COVID-19 cases as well as patients with other conditions, as health workers without immunity would have less contact with the virus. In the figure, the break-even line for essential workers is far to the left of the break-even line for the general population, indicating the high relative benefit of immunity testing for them.

Table 1 extends this discussion by presenting an assessment of the net benefits of implementing the PCR assay and the antibody test at three different levels of the population.

Figure 1. When the PCR Assay and the Antibody Test are Most Useful



Note: The shape of the curve and the placement of the lines are stylized. Further, the figure does not show either the susceptible proportion of the population or the levels of infection that would have prevailed in the absence of any containment strategy.  $F$  depicts the proportion of the recovered population.  $r^*$  = the recovered population proportion for which the benefits of a population-wide antibody test would just equal the costs of a population-wide antibody test;  $r_e^*$  = lower threshold for proportion of subgroups, such as health workers; PCR = polymerase chain reaction; TTI = test, trace, and isolate.

### 1. *Testing of a representative sample of the population, obtained by stratified random sampling*

In countries in which community transmission has been established, the greatest net benefit currently is from an antibody test on a population representative sample. Such a test would provide information about the percentage of population already immune, which in turn would inform the optimal allocation of health care resources and containment decisions based on geographical and demographic characteristics.

The net benefit from a PCR assay on a representative sample is low because reasonable estimates of incidence can be based on morbidity and mortality data, as well as information from the antibody test on a representative sample of the population. The sample size needed for the antibody test would be 2,000–10,000 households per country or region, depending on need for geographical precision and the presumed (ex ante) rate of seropositivity (having blood serum that tests positive for COVID-19 antibodies). This test would be most valuable if repeated at regular intervals.

### 2. *Testing of targeted segments of the population*

- The PCR assay should be used to test for possible infections, in order to facilitate contact tracing and targeted isolation efforts for countries in early stages of epidemic (see the strategies followed by Hong Kong SAR, China; Korea; Singapore; and Taiwan, China) and in the case of resurgent epidemics after suppression (as China is currently doing).
- Both tests should be used for health care and other essential staff to determine whether they are currently infectious (PCR assay) or already immune (antibody test).
- The antibody test should be used to decide who can be allowed to return to work, giving priority to professions and services that provide essential services (such as health care workers) and require greater human contact (such as first responders). That is, workers who rank high on both the “essential” and “need for proximity” dimensions should be tested first.

### 3. *Comprehensive and massive testing, approaching universal levels*

Given the constraints on the availability and implementation of the tests, comprehensive tests are unlikely to be feasible and are best seen as a longer-term goal of targeted antibody tests. We suggest starting with the targeted testing as in point 2 and gradually expanding testing as capacity increases, along the “essential” and “need for proximity” dimensions, moving toward comprehensive testing.

## What Are the Benefits and Costs of the Two Tests?

The expansion of both types of testing, and incorporation in transmission control strategies, may yield significant returns. For example, it is estimated that 25 percent to 50 percent of COVID-19 infections are asymptomatic. These individuals, once recovered, are likely immune and do not need to socially distance (once there is no live virus in their systems anymore), but will not know their status without an antibody test. The fear of infection is a persuasive deterrent to economic activity, and even in the absence of official closures and restrictions there will likely be a high and possibly excessive degree of social distancing by individuals acting privately. This fear would be alleviated in the recovered population if recovered individuals knew their status. In fact, the return to any individual tests depends on the extent to which recovered colleagues or customers also know their status and return to the market. Widely available low-cost testing can help solve this information-related market failure.

With “smart containment” (whereby social planners can identify who is susceptible/infected/recovered—which massive antibody testing could make possible), the decline in national income would be 5.6 percentage points lower than otherwise, Eichenbaum, Rebelo, and Trabandt (2020) estimate. That suggests the gains could be substantial even with the levels of testing that may be feasible. For example, even if only one-fifth of the immune could return to work, the gain could be about 1 percent of national income, or close to US\$4bn for a country like the Philippines.

The most significant benefit of the PCR assay is that it could shorten the duration of stringent suppression measures by reducing the risk of resurgence. Since the Eichenbaum, Rebelo, and Trabandt (2020) estimates suggest that the average decline in national income over the first year is more than 22 percent with suppression measures, the reduction in the duration of such measures by just two weeks could translate roughly into an increase in national income by 1 percent. In the case of the Philippines, that would be nearly US\$4 billion.

These gains dwarf the costs of tests. Cost estimates are difficult to produce given the rapid technological change, diagnostic accuracy improvement, and the uncertainty about how soon and at what price new products will be available in low- and middle-income countries. The PCR assay can be done either manually or through an automated process. The manual process is cheaper but complex, prone to human error, and time consuming. Therefore, the more expensive automated process, using a “plug-in” cartridge and relatively fool proof in settings where laboratory capacity is limited, is used more widely in PCR testing for different diseases in developing countries. One of the “plug-in” cartridge options that is widely available for the COVID-19-specific assay, costs \$198 for a cartridge and every cartridge can perform 10 tests. Including amortization of a new PCR machine, laboratory equipment, consumables, transport, labor, and personal protective equipment, the overall unit cost will be around \$23.

The antibody test is a rapid test which resembles existing rapid HIV test kits that can be administered by a health care worker collecting a finger-prick. It does not require transport and analysis of the specimen to a qualified lab. Preliminary unit cost estimates for this test are between \$US2.50 and \$US5.30 per test for the antibody test, including the test kit itself, consumables, protective equipment, and labor in a developing country setting.

With the increase in demand if massive testing is implemented—leading to increased economies of scale—we would anticipate that the costs will decline. Increased demand may also lead to innovation in test technology that would ease complementary human capital and laboratory capacity constraints for large-scale testing. For example, options for self-administered (“at home”) tests kits, as well as door-to-door testing by minimally trained health community workers, are currently being evaluated for safety, accuracy, and acceptability; and regulatory approval for their use is being secured.

The benefit-cost calculus also depends on the extent to which investments in testing today will be specific to COVID-19 and thus have only limited benefits after the COVID-19 pandemic recedes or the extent to which they could more generally strengthen health capacity and therefore have durable value. It is likely that a significant proportion of public sector investments in testing (laboratory capacity, human capital, and so on) in low- and middle-income countries are investments in general health systems that will pay returns in other aspects of diagnostic and perhaps curative health care, apart from contributing to preparedness for future pandemics. For example, PCR machines are a “general-purpose” technology that can be used for the detection of many other bacteria or viruses and any well-equipped laboratory should have one, but they are still not very common in developing countries.

*Estimating Break-Even Recovery Thresholds for the Implementation of the Antibody Test*

The discussion that follows estimates the “break-even” point of how large the number of recovered would have to be (which would determine the likely number of workers liberated from isolation) in order to justify testing of an entire population, which in turn would enable “immunity certificates” to be issued for individuals to return to economic activity outside the home.

This discussion aims to help understand how extensive antibody testing can be used to limit the economic impact of a shutdown by reducing the share of population asked to withdraw from activity. Well-enforced lockdowns are now widespread in OECD countries, and lockdowns have also been ordered in a number of low- and middle-income countries. If a lock-down is not well enforced and a large share of workers disregard such an order, then clearly the value of widespread testing is diminished. Formally modeling these considerations is beyond the scope of this Research Policy Brief.

**Table 1. Test, Test, Test: What, How, and Why**

Scale of the Test	PCR Assay	Antibody Test
<b>Representative sample of the population (stratified randomized sampling)</b>		
<p>Numbers: Depends on country size and need for geographical precision at subnational level.</p> <p>Sample sizes of recent demographic health survey (DHS):                      India: 600,000 households (to get representative results at the state level)                      Bangladesh: 17,300 households                      Nigeria: 40,427 households                      Philippines: 27,496 households                      Mali: 9,510 households.</p> <p>Frequency: Depends on initial level of immunity measured</p>	<p>To estimate the extent of current infection and hence determine the need for nonpharmaceutical interventions (NPIs) and pharmaceutical interventions (PIs).</p> <p><i>Low net benefit because reasonable estimates of incidence can be based on morbidity and mortality data, as well as information from the antibody test on a representative sample of the population.</i></p>	<p>To assess the extent of immunity in the population or subgroups (by area, age, gender, etc.) in order to determine the need for NPIs and PIs, and finetune social isolation or health care investment.</p> <p><i>High net benefit because could significantly reduce economic costs of suppression strategies and creating treatment capacity</i></p>
<b>Targeted testing</b>		
<p>Numbers: Depends on estimated size of the population of targeted workers ranked according to the dimensions of essential services and need for proximity with gradual expansion to other occupations.</p> <p>Philippines example:                      Population: 110 million                      Health care workers (2018):                      Total: 187,250, including                      90,308 nurses, 40,775 doctors,                      43,044 midwives, and 13,413                      medical technologists                      Education workers (2018):                      880,000 public school teachers.</p> <p>Frequency: Depends on initial level of immunity measured in representative sample.                      Individuals testing positive once on the antibody test can be excluded from subsequent testing.</p>	<p>Central to the test, trace, and isolate strategy and hence possible substitute for stringent suppression in the early stages of a pandemic or when suppression has reduced infection levels. Must be complemented by tracking and isolation capacity.</p> <p>Also complements the antibody test of essential workers but would need to be repeated regularly for noninfected workers.</p> <p><i>Potentially high net benefits if it can lead to early phase-out of economically costly suppression measures for all or for subgroups.</i></p>	<p>To assess and certify the immunity of categories of workers who can return to work, starting with essential workers (health care, education) and progressively to include others; hence, complements stringent suppression.</p> <p><i>Potentially high net benefits if it can allow dilution of restrictions and revive critical segments of the economy.</i></p>
<b>Comprehensive testing</b>		
<p>Numbers: Basically, the country’s population, unless priority is placed on some age groups or other demographics.</p> <p>Frequency: Depends on initial level of immunity measured in a representative sample.                      Individuals testing positive once for antibody test can be excluded from subsequent testing.</p>	<p>Objectives are not clear.</p> <p><i>Low net benefits.</i></p>	<p>Objectives are not clear, except that it could be the limiting case of targeted testing. In any case, it would have to be repeated for subgroups that have not been infected.</p> <p><i>Unclear net benefits.</i></p>
<p>Note: NPIs = nonpharmaceutical interventions; PIs = pharmaceutical interventions.</p>		

However, we should note that during pandemic outbreaks, much individual activity is curtailed even in the absence of a lockdown due to fear of infection. Wide-spread testing would help alleviate such fear among those who test positive and enable the resumption of some share of economic activity.

Define the working age population as,  $P = S + I + R$ , where  $S$  stands for susceptible,  $I$  for infected, and  $R$  for recovered (Kermack and McKendrick 1927). This exercise does not consider mortality.

The ratio of those recovered is  $r = R/P$ . The unit cost of an antibody test is  $c$ . The average benefit of bringing one person back to work early is  $b$ .

We begin by considering  $c$  and  $b$  to be the market costs and benefits, respectively. Depending on the context, we could consider other social costs and social benefits. The condition for the total benefits of bringing workers back to work to cover the costs of a population-wide test is given as:

$$bR = cP.$$

The break-even level of  $r$  is:

$$r^* = c/b.$$

Therefore, the critical recovery ratio at which the benefit of population testing outweighs the costs is simply the ratio of the unit cost of an antibody test to the average benefit of bringing one person back to work.

Based on our evidence, the cost,  $c$ , in a country like the Philippines is about US\$5. It seems likely that a vaccine will become available 12 to 18 months after a test can be carried out, but suppression measures could reduce the level of infections sufficiently to end the lockdown much earlier than that.

Let us assume the expected average benefit ( $b$ ) of bringing a person back to work early is about half their annual salary. For the Philippines, half the per capita income ( $b$ ) is \$1,742. Then  $r^*$  in the Philippines would be 0.0029. Since the working age population of the Philippines is about 70 million, that would mean the number of recovered would have to be about 200,000. For perspective, the Imperial College COVID-19 Response Team estimates for the Philippines imply that after 250 days, nearly 5 million people would have recovered under a suppression scenario triggered at 0.2 deaths per 100,000 (Walker et al. 2020).

The logic of this argument is simply the following: until randomized testing suggests we have reached the threshold  $r^*$ , it would be better to transfer the money that would have been spent on a working population-wide antibody test—US\$ 350 million (\$US5 per test times 70 million workers), in the case of the Philippines—to affected workers because the cost of carrying out such a test would lead to lower aggregate earnings for the people brought back to work. But for any  $r > r^*$ , the test would yield a positive rate of return. If, as noted, the social benefit of being at work was higher than the market income—for example, because working helped maintain skills—then the threshold for testing could well be lower.

While the thresholds are of course sensitive to the unit costs of tests and the benefit of bringing people back to work, in many countries the anticipated large scale of infection suggest that these thresholds will easily be surpassed in the near future. In other words, the rate of return to carrying out such a test is likely to be high.

### What Can the International Community Do?

A precedent in medicine could be adapted for the current situation. Traditionally, public-private partnerships have been established to create new drugs or improve access to drugs where prices are high because of intellectual property rights. For example, the Meningitis Vaccine Project helped develop a new vaccine that has virtually eliminated the recurring outbreaks of meningitis that devastated 25 African countries for decades. The Project was coordinated by the World Health Organization (WHO) and the global health organization PATH, with substantial funding from the Bill and Melinda Gates Foundation. Technology was transferred from the United States and the Netherlands to the Serum Institute of India, which agreed to manufacture the vaccine at the low target price of 50 cents per dose.

Similar initiatives or advance market commitments, i.e. promises to purchase at a preannounced price, could help remedy market and policy failures in the market for tests. First, while the recent pandemic has generated a burst of spontaneous innovation in tests, additional incentives may be needed to encourage innovation in tests tailored for developing countries. Such innovations could include a simpler PCR assay that relies less on complementary human and laboratory capacity. Second, while tests remain scarce, developing countries may find it difficult to outbid richer countries in the market for tests. Third, some test-producing countries have imposed export restrictions that could deprive developing countries of access to medical supplies, including tests (Mattoo and Ruta, 2020).

The international community could also catalyze collaboration to expand the supply of these tests as well as complementary products and skills. The priority would be to encourage the production of the simplest versions of the PCR assay and antibody tests which meet sensitivity and specificity standards, and to make them available to developing countries. In parallel, an effort could be made to procure in bulk the necessary PCR machines and personal protective equipment for the staff handling specimen collection, and enhance the capacity to process them, as well as to organize the testing in representative samples of the population. Private companies could be directly contracted to expand production of test kits and equipment to fulfill the needs of developing countries. Medical colleges across the world could be contracted to provide intensive courses in testing for health personnel and other suitably qualified people—including those who cannot pursue their regular professions in current circumstances.

We recognize that tests are not a silver bullet and must be implemented as part of a battery of public health interventions. Tests require a strengthening of the capacity to use them and compete for resources with the capacity to treat the victims of the disease. But if it is feasible to build the necessary capacity, then tests can help at relatively low cost to reduce the number of victims, not just of the disease but also of the economic immiseration associated with other stringent suppression strategies.

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