Covid-19 through an economist’s lens: How to design an optimal containment policy for poor countries

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Introduction

• Covid-19 is the biggest public health crisis since Spanish flu 100 years ago
• As of this morning, 4,190,817 confirmed cases around the world
• 286,514 deaths
• Entered low income countries in mid-March
• Low death numbers: Bangladesh 239, Sudan 74, South Africa 206
• Strong policy response modelled on high-income countries: extended lockdowns in, for example, India, Bangladesh, Uganda.
Outline

• Health impact of Covid-19 in low-income country
• Economic impact of Covid-19
  • Projections
  • Real time statistics
• Modelling epidemics
• Modelling epidemics and the economy
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Severity of Covid-19 in low income countries

• To design optimal containment policy, we need to know how severe Covid-19 will be in low income countries.

• Some argue that Covid-19 is less of an issue in developing countries because of their younger age distribution
  • “The much lower estimated benefits of social distancing and social suppression in low-income countries are driven by three critical factors: (a) Developing countries have smaller proportions of elderly people to save via social distancing compared to low-fertility rich nations.” (Barnett-Howell and Mobarak, April 2, 2020).

• Others disagree:
  • “A deceptive claim about the virus is that it is much less worrying for the developing world as it is so much younger in %. But only one third of those 65+ live in high-income countries. It is people that die not %s, and there are a lot more old people in the developing world.” (Martin Ravallion on Twitter, May 5, 2020)
Severity of Covid-19 in low income countries

- Can we extrapolate from experience in high-income countries to low income countries?
- Four challenges:
  (i) Low income countries differ in demography
  (ii) Differ in prevalence of co-morbidities
  (iii) Differ in quality of health system
  (iv) Estimates from high-income countries are adjusting throughout the epidemic
Severity of Covid-19 in low income countries

• Estimates from high income countries
  “At first, based on early numbers in late February, epidemiologists and experts estimated about 1% of infected people would die from COVID-19, but it turns out it is hard to come up with one number that accurately captures how deadly this virus is. It is killing people in different states and different countries at different rates. According to Johns Hopkins, the mortality rate here in the U.S. is 5.7%. In Italy, it's over 13%. In China, it's 5.5% - which made us wonder. Why is the true death rate so all over the place and so hard to pin down?” (National Public Radio Broadcast)

• Early estimates of mortality risk (Infection Fatality Ratio) based on Case Fatality Ratios, which will overestimate mortality given limited and non-random testing of population.
Severity of Covid-19 in low income countries

• As time progresses, mortality estimates are falling and converging across settings
Severity of Covid-19 in low income countries

• Estimates from high income countries suggest there is some portability of mortality across contexts

• Core assumption needed to extrapolate: Infection Fatality Rate conditional on age and co-morbidity status is a ‘universal’ disease parameter.

• In that case can apply Bayes rule to triangulate from existing estimates
Severity of Covid-19 in low income countries

- With $P(d \mid c, I, age)$, calculate the infection fatality ratio depending on comorbidity status and age
- Calculate average infection fatality ratio in each country by aggregating over joint distribution of age and co-morbidity.
- Also adjust for weaker health system capacity in developing countries.
Predicted number of Covid-19 fatalities in Uganda

By age

Total

Deaths, 40% infected
Deaths, 60% infected
Deaths, 80% infected
Deaths+ICU, 80% infected (best case)
Deaths+ICU, 80% infected (worse case)
Predicted number of Covid-19 fatalities in Ethiopia

By age

Total

- Deaths, 40% infected
- Deaths, 60% infected
- Deaths, 80% infected
- Deaths+ICU, 80% infected (best case)
- Deaths+ICU, 80% infected (worse case)

age_mid

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• Modelling epidemics and the economy
Growth in sub-Saharan Africa in 2020 is projected at −1.6 percent, the lowest level on record.
Sources of contraction (IMF Regional Economic Outlook)

• Strong containment and mitigation measures will disrupt production and reduce demand sharply;
• Plummeting global economic growth together with tighter global financial conditions will spill over to the region;
• Sharp decline in commodity prices, especially oil, is set to compound these effects, exacerbates challenges in some of the region’s largest resource-intensive economies.
Real time impacts Senegal, restrictions but no lockdown (Center for Global Development study)

- More than 85% of households report loss in income
Real time impacts Senegal

- Over a third are eating less food
Real time impacts Senegal

- The large majority would support a lockdown, 90% stopped going to mosque
Real time impacts Senegal

- School closure is reducing learning and exacerbating inequality
Real time impacts Senegal

- Thousands have moved to rural areas
Real time poverty impacts Bangladesh (lockdown for six weeks) from BRAC survey April 16.

Findings highlights:
3 indicators of vulnerability

- **Income drop:** above 70% drop in income for all extreme poor, moderate poor and vulnerable non-poor alike

- **Economic inactivity:** 71% in urban, 55% in rural; 50% for poor, 40% for vulnerable non-poor

- **Reduced consumption:** 40% poor, 35% vulnerable non-poor
Real time poverty impacts Bangladesh

5 Policy Messages

- Covid-19 impact is on both poor and ‘new poor’
- ‘New poor’ are those who used to be 40% above poverty line but now has gone below poverty line
- Food insecurity has started with nutritional decline but crisis to intensify by end-April
- Because impact is broad-based, immediate safety net has to go beyond targeting and prioritize self-targeting vehicles such as Open Market Sale (OMS)
- 5600 crore taka immediate 1-month food security support package for the poor to be supplemented by an additional package for new poor
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Modelling epidemics: SIR/SIRD models

• The simplest SIR model models the evolution of an epidemic by a system of difference equations that model how the number (or share) of susceptible (S), infected (I) and recovered (R) individuals evolves from one period to the next.

• For Covid-19, there is a non-negligible mortality risk, so add a fourth category, dead (D), to the model

\[
\begin{align*}
S_{t+1} &= S_t - \lambda S_t \\
I_{t+1} &= I_t + \lambda S_t - \gamma I_t \\
R_{t+1} &= R_t + \gamma(1 - \eta)I_t \\
D_{t+1} &= D_t + \gamma \eta I_t
\end{align*}
\]
The mechanics of an epidemic

The risk of infection $\lambda_t$

- Simplest assumption: random mixing, so the risk of infection is proportional to the number of infectious individuals at time $t$

$$\lambda_t = \beta I_t$$

- $\beta$ is the per-capita rate at which two individuals come into effective contact per unit time

- If we know the basic reproduction number $R_0$ (a disease parameter), then we can estimate $\beta = R_0/(ND)$, where $N$ is population size and $D$ is the duration of infectiousness.

- To make free of population size define $c_e = \beta N = R_0/D$, effective contacts made by each person per unit time.

- Alternatively, if we know (or determine) the per-capita contact rate, we can calculate the effective disease reproduction rate $R_t = \beta ND$. 
The mechanics of an epidemic

• Important question in an epidemic is whether $R_0$ (or $R_t$) are greater or less than 1. If we can get the reproduction number to below 1, the disease will die out.

• The basic reproduction number for Covid-19 is estimated to be between 2-3, giving an estimate for the effective contact rate of $c_e = 0.1893$.

• This is in line with estimates from Toda (2020) for contact rates around Europe (even post-epidemic).

• For the basic reproduction number, we can calculate herd immunity as $H = 1 - 1/R_0 = 60\%$.

• Alternatively, we could ask how low we would have to keep the contact rate (through lockdowns, etc) to get the basic reproduction number to below 1: $c_e = 0.07$. At beginning of April, only China had a contact rate this low (Toda, 2020).
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Modelling the epidemic and the economy together

• Economists main insight has been that contact rates are endogenous and linked to economic activity.
• Explicit modelling of interaction between epidemic and economic activity

Example: Eichenbaum, Rebelo, Trabandt (2020)

• People may behave differently during an epidemic
  • $\text{NewInf}_t = \pi_1 (S_t C^s_t)(I_t C^i_t) + \pi_2 (S_t L^s_t)(I_t L^i_t) + \pi_3 (S_t I_t)$
  • Consume and work less to reduce the risk of getting infected

• Lockdown policies may affect the economy
  • Often modelled as a discouragement of consumption
  • $(1 + \mu_t)c_t = w_t l_t + \delta_t$
Optimal government policy

- Optimal containment follows the share of infected
- In a calibration to the US, it averts 20% of deaths

Source: Eichenbaum et al. (2020)
Eichenbaum et al. in a developing country context

• Poor households may not be able to adjust consumption flexibly
  ➢ Introduce a subsistence constraint

• Populations are young and mortality risk most likely lower for them
  ➢ Allow for interactions between different age groups

• People in different areas can adjust differently
  ➢ Introduce a ‘rich, urban’ and a ‘poor, rural’ sector

• Calibrate model to demographics and economy of Uganda
Eichenbaum et al. in a developing country context

- Even without government policy, households adjust consumption (if they can)
- Children are the largest group and contribute most to the spread of the epidemic
- Including different age groups reduces the overall death rate by about 90% (assuming herd immunity)
• Reducing contacts, e.g. through school closures, slows the epidemic and reduces deaths

• Consumption restrictions are more powerful if people have more room to adjust

• Early lockdowns without behavioral change do nothing to slow the epidemic, they just delay
Thank you!
### References

- **Real time data collection**

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Pakistan
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