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COVID-19 and health system vulnerabilities in the poorest developing countries[1]

by Lars Jensen and George Gray Molina

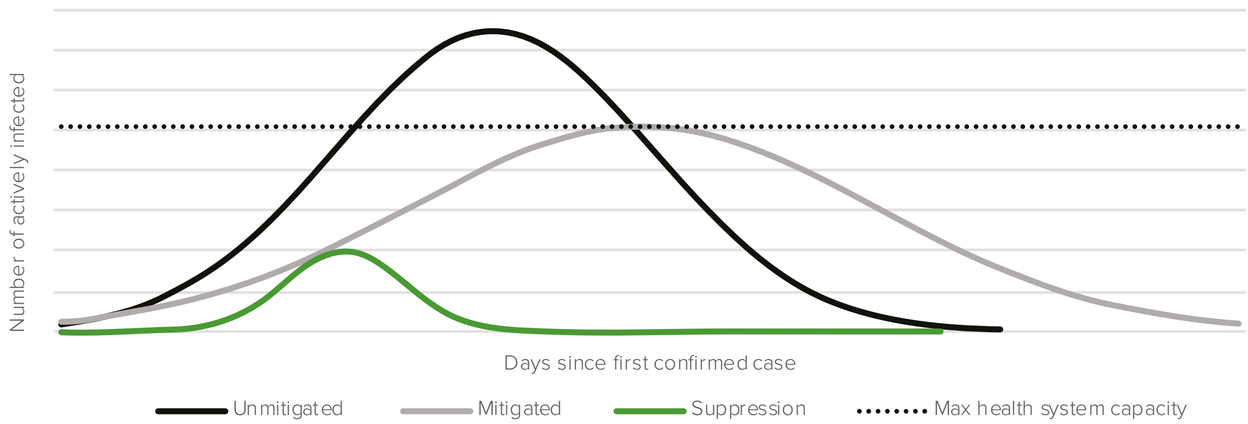
Low health system capacity makes developing countries highly vulnerable to the novel coronavirus. We show that the 20 most vulnerable countries in the world will run out of ICU beds if, on average, just 0.04% of their population is actively infected. This translates to 2,371 cases in Mali and 5,370 cases in Haiti. The Imperial College estimates that, even under their strictest policy scenario to contain the spread of the virus, 2.5% of the population will be actively infected at the peak of the pandemic. In this paper, we sketch the possible dimensions of that crisis which represent severe challenges to both the health and socio-economic response.

Everyone is by now familiar with the bell-shaped epidemic curve depicted in Figure 1 and the term "flatten the curve." In an unmitigated scenario (depicted by the black line), the peak of infections will overburden existing health systems in terms of critical care provision including mechanical ventilation, supplementary oxygen, and the ability to adequately protect doctors, nurses, and other health care workers. This will lead to a higher number of deaths.

Pressure can be mitigated by social distancing which will slow the spread leaving health systems better able to cope (depicted by the grey line). Still we have witnessed how easily health systems in even advanced economies can be overrun under mitigation strategies, and why many countries have reverted to suppression strategies which can roughly be translated into "extreme social distancing" brought about by policies that force workplace and school closures, ban large events and gatherings and restrict travel. Suppression strategies aim to reverse the spread ("turn the curve lower and earlier") by forcing the reproductive rate (Ro) below 1 (depicted by the green line), thus avoiding a breach of health system capacity, or alternatively buying time to increase capacity.

Suppression comes at great economic and social costs and the longer it is instilled, and disproportionately so in lower income countries

Figure 1. The epidemic curve – scenarios

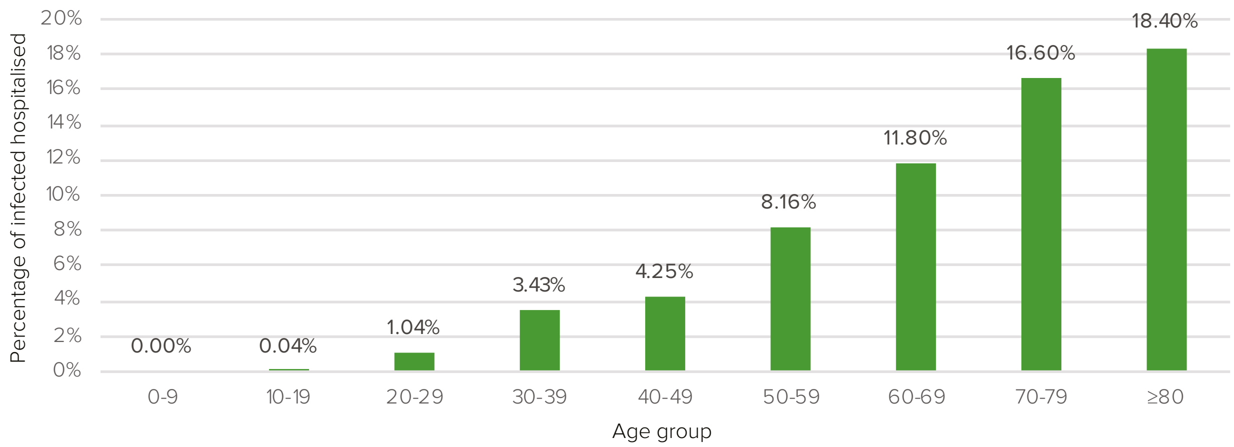


Source: Authors' illustration

where many live in or close to poverty and where there is little or no social protection. Suppression strategies help to keep the health system from being overwhelmed - until a vaccine or cure is found. When suppression strategies are eased, as they have been in many countries, we have seen an uptick in new cases. Massive roll-out of testing and contact-tracing can be a less costly alternative to social distancing, but most countries are not yet set up for such as it will require many health workers and the use of digital tools. Without it, and without near-term prospects for a vaccine or better treatment, societies are left trying to manage the virus without breaching health-system capacity and protect against the socio-economic costs of social distancing.

Infection fatality and hospitalization ratios

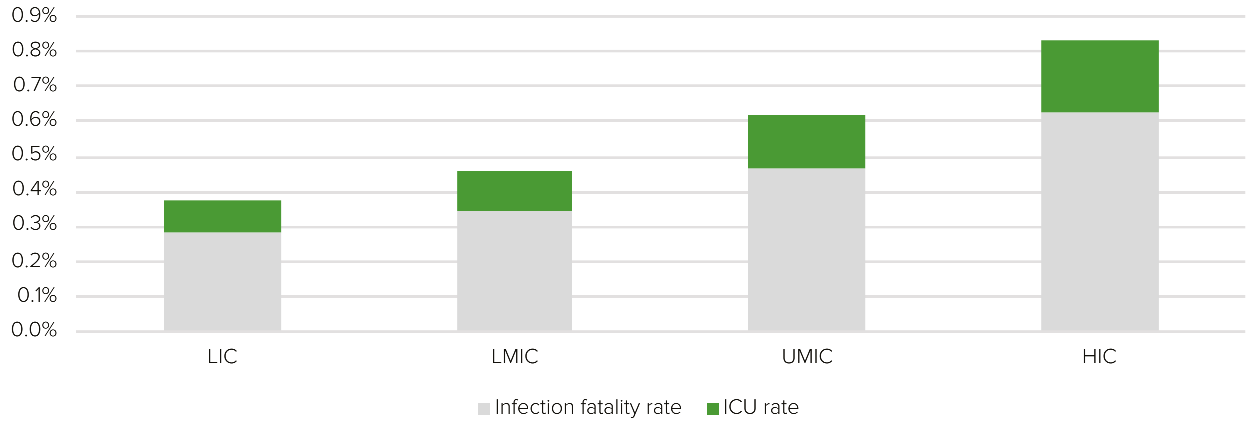
Figure 2: Estimates of the proportion of C19 infections that would lead to hospitalization



Source: Verity et. al (2020), Table 3, p.7 (cf. footnote 2)

On March 30, Verity et al. (2020) published a set of age-group-specific COVID-19 hospitalization and infection fatality ratios (IFRs) which, according to the authors, are suitable for application across populations.[2] Figure 2 shows the estimated hospitalization ratios — i.e., the percentage of infected individuals that will need hospitalization. As evident, there is steep age-gradient of risk with less than 1% of cases aged 20-29 in need of hospitalization and more than 16% of cases aged 70-79. The hospitalization and infection fatality ratios formed the basis for Imperial College's 201 country pandemic simulations across several scenarios.[3]

Figure 3: Infection fatality and ICU rates across income groups – average values across IC's four scenarios



Source: Imperial College (R0=3 simulation)

Note: Low income countries (LIC), Lower-middle income countries (LMIC), Upper-middle income countries (UMIC) and High income countries (HIC).

Figure 3 above shows for country income groups the average ICU and infection fatality ratios from Imperial College's end-of-pandemic simulations across their four scenarios of social distancing.[4] Lower (higher) income countries have lower (higher) hospitalization and fatality rates mainly driven by their younger (older) populations. Not shown in Figure 3 is that these estimations also assume that the benefits (fall in ICU and fatality rates) from social distancing are higher in higher-income countries because the elderly have lower social-contact rates compared to those in lower-income countries.

Imperial College's age-group specific hospitalization and fatality rates are likely too low for poor countries and too high for rich countries. This is because of underlying assumptions that all populations (a) have access to similar quality and quantity of health care services as in China, and (b) have comorbidity profiles similar to that of the Chinese population.

For the poorest developing countries, two unknown factors could significantly push up both ratios despite young populations. First, little is known about how COVID-19 will affect populations with a higher prevalence of infectious diseases and malnutrition. Second, low quantity and quality of — and access to — formal health care services will significantly push up the fatality ratio.

Another Imperial College study suggests that the poorest quintile of the population in low income countries (LICs) and lower-middle income countries (LMICs) has a 32% higher probability of dying from COVID-19 compared to the richest quintile partly because of lack of access to available treatment, but also lack of protective measures and higher exposure to the virus.[5] Ultimately, these factors will contribute to higher fatality ratios for low- and lower middle-income countries than the ones portrayed in Figure 3, but how much?

It is still difficult to compare COVID-19 infection fatality ratios between countries to investigate such matters because of the high uncertainty involved, especially of the denominator (number of infected people). However, a big study published in 2018 looked at excess mortalities in LICs and LMICs (compared to HICs) due to poor quality (safety and effectiveness) of health care services and concluded that poor quality accounts for on average 25% of total deaths across 13 conditions studied ranging from HIV/AIDS to maternal mortality.[6] In other words, poor-quality health care pushes up the average mortality ratio by a factor of 1.33 in LICs and LMICs compared to HICs. Bear in mind that these excess mortality estimates were only for people who actually did access health care but died from substandard or poor-quality care. Another study finds that as a percentage of total excess mortality in LMICs, 42% were due to non-access or non-utilization of services and 58% due to poor quality.[7]

In other words, in LMICs, for every one person dying from lack of access to health care, 1.38 people are dying due to poor-quality health care. Now factor in the risk of an overburdened health system — a scenario likely to hit lower-income countries earlier and worst—and the magnitude of the coming crisis appears more clearly.

Health systems and COVID-19 – which countries are most vulnerable?

We use Imperial College's critical care estimates and compare these against estimates of ICU bed capacity to identify which countries are most vulnerable. Doing so we produce four crude estimates:

1. The number of pre-COVID-19 unoccupied ICU beds, designated here as ICUBEDS;
2. The maximum number of actively infected individuals a country can have at any time before it runs out of ICUBEDS, designated here as C19MAX; and also stated as a percentage of total population C19MAXPOP;
3. The ICU bed deficit (excess demand) for different percentages of actively infected population, or ICUDEFx, where x denotes the percentage of 2%, 5%, and 10%.

C19MAX is simply our ICUBEDS estimate divided by the percentage of total infected in need of critical care at the end of the pandemic under the unmitigated scenario (with Ro=3), C19ICU, as in (1)

$$(1)\ \text{C19MAX} = \frac{\text{ICUBEDS}}{\text{C19ICU}}$$

ICUDEFx is as in (2) where x denotes the percentage of actively infected population.

$$(2)\ \text{ICUDEFx} = \text{ICUBEDS-x} \times \text{Population} \times \text{C19ICU}$$

Critical care capacity

One major caveat in the suggested comparison is that there is very little up-to-date cross-country data on the number of hospital beds, and particularly ICU beds. Also, beds are not necessarily a precise indicator of health-system capacity, including the speed of which capacity can be expanded to accommodate increasing demand. Nevertheless, it is fair to assume that lower-income countries and countries with less effective institutions will find it disproportionately harder to expand existing capacity.

With these caveats in mind we take our measure of total hospital beds per capita from the 2019 Global Health Security index (GHS[8]), which takes most of its hospital bed data from the World Bank, where the most recent datapoint is 2015, and for many countries as old as 2010. To check whether these outdated measures are still reliable, we were able

Table 1: Recent ICU bed estimates in low- and lower middle-income countries – recent studies

Country	A. Recent ICU beds per 100,000 capita	B. Old* ICU beds per 100,000 capita	C. Income	D. Publication year of recent study
Mongolia	8.27	16.1	LMIC	2020
Indonesia	2.59	2.79	LMIC	2020
India	2.17	1.63	LMIC	2020
Philippines	2.11	2.32	LMIC	2020
Laos	2.09	3.46	LMIC	2020
Nepal	1.98	0.47	LIC	2020
Pakistan	1.42	1.37	LMIC	2020
Haiti	1.09	1.11	LIC	2019
Myanmar	0.61	2.11	LMIC	2020
Zambia	0.55	4.49	LMIC	2016
Liberia	0.49	1.24	LIC	2020
Gambia	0.40	1.69	LIC	2018
Kenya	0.30	3.18	LMIC	2017
Uganda	0.12	0.76	LIC	2020
Nigeria	0.07	1.13	LMIC	2017

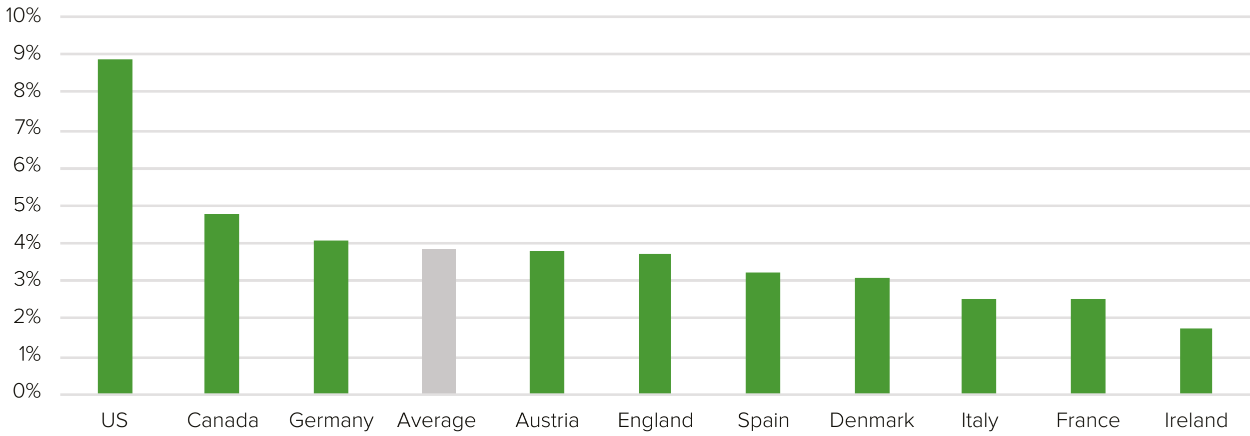
Source: Studies linked in column D and GHS/WB data.

*Note: *The often-outdated data from GHS/WB is only for total Hospital beds (not types of beds) and we estimate ICU beds using the percentages stated in the main text below.*

to find more recent ICU bed data for 15 LICs/LMICs from secondary sources, cf. Table 1 column A. As GHS (and WB) only reports total hospital beds per capita we apply the estimated percentage of total beds that are ICU from Imperial College's critical care bed supply model, based on income groups for the cross-country analysis.[9] In HICs, 3.6% of total beds are assigned as ICU, UMICs 3.3%, LMICs 2.4% and LICs 1.6%. Comparing these estimates listed in column B to the more recent estimates from secondary sources listed in column A, we see that for only three of the 15 countries (India, Nepal and Pakistan) the more recent data estimates are better. As evident, SSA countries are at the bottom. Nigeria has the fewest ICU beds per capita of only 0.07 beds per 100,000 capita.

For all countries we assume a "normal times" ICU bed-occupancy rate of 80%. Available data for ten OECD countries shows that, on average, ICU beds are 3.85% of total hospital beds, albeit with large variation, cf. Figure 5. The OECD reports occupancy rates only for acute care beds (which include ICU beds), and data for nine of the ten countries in Figure 4 show that the year-round acute bed occupancy rate averages 79.8%. Across the larger OECD sample of countries, the average is 75.2%.

Figure 4: ICU beds as a percentage of total hospital beds



Source: OECD for ICU beds and GHS for total hospital beds. OECD March 25, 2020 - Beyond Containment: Health systems responses to COVID-19 in the OECD

This is not to suggest that some countries cannot rapidly increase the number of ICU beds, although some surely cannot. Many countries have already increased capacity in preparation for COVID-19 and our estimates do not reflect that. Rather our estimates are indicators of the level pressure/stress on pre-COVID-19 existing health care systems.

Conclusions

Our results show that the average country in our sample of 183 will be out of pre-COVID-19 existing available unoccupied ICU beds when 0.23% of its population is actively infected. For the 20 most vulnerable countries – all of which are either LICs or LMICs - this figure is only 0.04%, cf. Table 2. Our estimates should not be treated as accurate point-estimates, especially due to the outdated data on beds, but the broad picture and ranking they convey is reliable enough; the young population age-advantage of poor countries is outweighed by weak health systems even before accounting for possible differences in comorbidities, poor quality of care, and inequality of access. Fourteen of the 20 most vulnerable countries are from SSA, five from South Asia and one (Haiti) from LAC.

The implications are severe. In the long run, they involve strengthening health-system capabilities and investing in health-system preparedness. However, in the short run, they involve urgent socio-economic and health-policy responses: How to compensate for lost incomes and jobs, for vast numbers of informal-sector workers? How to succeed in sustaining at least partial and targeted containment systems that do not overwhelm existing health capabilities? What are the lessons emerging from other low-income and vulnerable economies around the world? Although this brief only sketches the size of the challenge, upcoming briefs will begin to address the depth of the response.

Table 2: Top 20 most vulnerable countries

Country	Region	Income	ICUBEDS	C19MAX	C19MAXPOP	ICUDEF_2	ICUDEF_5	ICUDEF_10
Mali	SSA	LIC	6	2,371	0.012%	-1,056	-2,650	-5,306
Nepal	SA	LIC	27	5,059	0.017%	-3,136	-7,882	-15,792
Madagascar	SSA	LIC	17	5,195	0.019%	-1,808	-4,546	-9,109
Ethiopia	SSA	LIC	107	30,135	0.026%	-8,043	-20,269	-40,645
Guinea	SSA	LIC	12	4,036	0.031%	-778	-1,963	-3,939
Niger	SSA	LIC	22	8,145	0.034%	-1,283	-3,240	-6,501
Sierra Leone	SSA	LIC	10	3,205	0.040%	-487	-1,232	-2,473
Senegal	SSA	LMIC	23	7,074	0.042%	-1,049	-2,657	-5,336
Benin	SSA	LIC	19	5,507	0.045%	-806	-2,042	-4,103
Chad	SSA	LIC	20	7,604	0.046%	-852	-2,160	-4,340
Burkina Faso	SSA	LIC	26	9,706	0.046%	-1,084	-2,748	-5,521
Haiti	LAC	LIC	25	5,370	0.047%	-1,053	-2,669	-5,364
India	SA	LMIC	4,507	732,497	0.053%	-165,311	-420,039	-844,584
Mauritania	SSA	LMIC	8	2,473	0.053%	-307	-780	-1,568
Eritrea	SSA	LIC	8	1,941	0.055%	-288	-731	-1,471
Afghanistan	SA	LIC	61	21,307	0.055%	-2,153	-5,474	-11,009
Cote d'Ivoire	SSA	LMIC	48	15,785	0.060%	-1,548	-3,940	-7,929
Pakistan	SA	LMIC	606	136,376	0.062%	-19,028	-48,479	-97,564
Uganda	SSA	LIC	70	30,647	0.067%	-2,009	-5,127	-10,324
Bangladesh	SA	LMIC	614	111,413	0.068%	-17,551	-44,799	-90,212

Endnotes

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[2] https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30243-7/fulltext. Estimates are based on Chinese data but corrected for biases stemming from demographics, ascertainment, and censoring.

[3] https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/COVID-19/report-12-global-impact-COVID-19/

[4] We have used the simulation with R0=3. In IC's mitigated scenario the whole population practices social distancing (SD). In the mitigated+ scenario whole of population still practices SD but increasingly so for the elderly. In the suppression scenario suppression is triggered when deaths reach 0.2 per 100,000 per week. In IC's unmitigated scenarios 80%+ of the population will be infected. More specifically, at the end of the pandemic in the unmitigated R0=3 scenario, 88.1% of the population infected, 2.97% of infected will have been in the hospital (0.72% in the ICU) and 0.54% of those infected will die. In the strictest mitigation and suppression scenario (still with R0=3), countries will on average have 7.38% of their population infected, 1.98% of infected will need hospitalization and 0.4% of infected will die. At the peak of the epidemic the number of active infections will on average reach close to 2% of the population.

[5] https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/COVID-19/report-22-equity/

[6] See chapter 4 in: https://www.nap.edu/catalog/25152/crossing-the-global-quality-chasm-improving-health-care-worldwide

[7] https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31668-4/fulltext

[8] An index that scores and compares countries' health system capacity based on ability to prevent, detect, respond and treat, plus norms and risks that affect health security https://www.ghsindex.org/about/

[9] Cf. footnote 3.