

# Lives and livelihoods: Estimates of the global mortality and poverty effects of the Covid-19 pandemic.

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## **Abstract**

We evaluate the global welfare consequences of increases in mortality and poverty generated by the Covid-19 pandemic. Increases in mortality are measured in terms of the number of years of life lost (LY) to the pandemic. Additional years spent in poverty (PY) are conservatively estimated using growth estimates for 2020 and two different scenarios for its distributional characteristics. Using years of life as a welfare metric yields a single parameter that captures the underlying trade-off between lives and livelihoods: how many PYs have the same welfare cost as one LY. Taking an agnostic view of this parameter, we compare estimates of LYs and PYs across countries for different scenarios. Three main findings arise. First, we estimate that, as of early June 2020, the pandemic (and the observed private and policy responses) had generated at least 68 million additional poverty years and 4.3 million years of life lost across 150 countries. The ratio of PYs to LYs is very large in most countries, suggesting that the poverty consequences of the crisis are of paramount importance. Second, this ratio declines systematically with GDP per capita: poverty accounts for a much greater share of the welfare costs in poorer countries. Finally, a comparison of these baseline results with mortality estimates in a counterfactual “herd immunity” scenario suggests that welfare losses would be greater in the latter in most countries.

**JEL:** D63, I15, I32, O15.

**Keywords:** Covid, welfare, poverty, mortality

## Highlights

- Years of life provide a theoretically-grounded and intuitive welfare metric for the evaluation of policies generating a “lives vs livelihoods” trade-off.
- As of early June 2020, the pandemic had generated 68 million additional poverty years and 4.3 million years of life lost across 150 countries.
- The welfare costs of Covid-19 arising from increases in poverty, relative to mortality, are highest among poor countries and fall with GDP per capita.
- Counterfactual estimates suggest that a “no-intervention” scenario would have generated larger welfare costs for almost all countries.

# 1 Introduction

In 2020-21, the world is experiencing possibly its most severe global crisis since the Second World War. The Covid-19 pandemic is first and foremost a health crisis: in the six months since the first cases were reported in Wuhan Province, China, in December 2019, 7.1 million cases and 406,000 deaths were confirmed worldwide by 9 June,<sup>1</sup> and this is widely held to be an underestimate. Yet, there are other welfare costs beyond those associated with mortality induced by the disease. The disease itself and the policy and individual behavioral responses to it have induced massive economic supply and demand shocks to essentially every country in the world, triggering the deepest and most widespread economic crisis since (at least) the Great Depression of the 1930s.

The fact that the bulk of the non-pharmaceutical interventions in response to the epidemic, such as lockdowns, mandatory social distancing, travel restrictions and the like, contribute to the economic costs - by preventing many or most workers from reaching production sites and consumers from demanding certain goods and services that cannot be consumed from home - has led to important debates on the optimal policy choice in the face of an apparent trade-off between lives and livelihoods (i.e. incomes and jobs). This trade-off is for instance discussed by [Gourinchas \(2020\)](#). Yet, as noted by [Acemoglu et al. \(2020\)](#), some policies can be dominated in terms of both their mortality and economic consequences.

While we feel that the analysis of policy trade-offs is best conducted at the level of the individual policy instrument, it may nonetheless be informative to assess the relative magnitudes of the mortality and economic costs of the pandemic. In particular, we are interested in the economic costs as manifested through increases in income poverty – clearly a strict subset of all economic costs. Specifically, this paper seeks to address two sets of questions: First, what were the social welfare costs of the pandemic (as of early June 2020) arising from increased mortality and higher poverty? What were their relative magnitudes, and did these magnitudes vary systematically across countries? Second, how did these welfare costs at baseline compare with plausible counterfactual estimates of the mortality costs under a hypothetical “no intervention” scenario in which infection rates were constrained only by herd immunity? Did these comparisons vary across countries?

Naturally, a comparison of mortality and poverty costs is complicated by the fact that it inherently involves evaluating human lives. Economists typically compare economic costs to human lives using one of three approaches: attaching a monetary value to human life ([Viscusi, 1993](#); [Rowthorn and Maciejowski, 2020](#)), estimating the indirect mortality that economic losses could imply ([Ray and Subramanian, 2020](#)), or resorting to social welfare defined as expected lifetime utility ([Becker et al., 2005](#); [Jones and Klenow, 2016](#);

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<sup>1</sup>This figure was reported on the Covid-19 Dashboard by the CSSE at Johns Hopkins University & Medicine ([www.coronavirus.jhu.edu](http://www.coronavirus.jhu.edu)).

Alon et al., 2020).

While all of these approaches have merits, each of them also has limitations. Although many economists find it meaningful to place a price on human life, most people find the idea repugnant.<sup>2</sup> This limits the ability of the first approach to productively inform the public and political debate.<sup>3</sup> The second approach, which involves computing the indirect mortality caused by the economic losses, requires making strong assumptions about governments and individuals' reactions to these losses.<sup>4</sup> This arguably makes this approach too uncertain and hypothetical in order to serve as basis for a public debate. The third approach, based on social welfare analysis, has solid theoretical and ethical foundations (Adler et al., 2020). Yet, in its standard form, this approach generally requires selecting values for many parameters entering the definition of individuals' expected utility, such as a discount factor and the concavity of instantaneous utility. Importantly, none of their parameters directly and transparently captures the trade-off between human lives and economic losses. If this implicit trade-off can only be understood and discussed by specialists, this third approach cannot provide a decent basis for public debates on this trade-off.

Our approach is rooted in social welfare analysis but differs from the earlier literature in at least two important respects. First, drawing on Baland et al. (2020), we express the key trade-off in terms of years of human life, rather than in monetary units. We measure the impact of the pandemic on human lives by the number of years of life lost to Covid-induced premature mortality (lost-years, LYs), and its economic impact by the additional number of years spent in poverty (poverty-years, PYs).<sup>5</sup> The second difference is that this change in metric allows us to focus on a single, central normative parameter, namely the shadow price  $\alpha$  attached to one lost-year, expressed in terms of poverty-years. Essentially this parameter captures how many poverty-years are as costly (in social welfare terms) as one lost-year.

This approach is clearly similar to the standard social welfare approach and we make no claim that it is theoretically superior to it. Indeed, it may even be argued to have some limitations relative to standard models, such as ignoring economic losses that do not imply a crossing of the poverty line. But we argue that our approach has three important advantages in terms of informing the public debate: First, the change in metric from monetary units to years of human life may make the relative assessment of the value

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<sup>2</sup>For instance, on May the 5<sup>th</sup>, New York governor Andrew Cuomo declared during his daily briefing: "How much is human life worth? [...] To me, [...] a human life is priceless. Period."

<sup>3</sup>Pindyck (2020) discusses additional limitations associated with evaluations that attach a monetary value to human life.

<sup>4</sup>When investigating the indirect mortality associated with the Great Recession, studies typically find that mortality was actually reduced, rather than increased, during the recession (Modrek et al., 2013; Tapia Granados and Iolides, 2017).

<sup>5</sup>For instance, if an additional 4 percentage points of a 10 million people population spends two years in poverty, this implies 0.8 million poverty-years.

of a human life less shocking or “repugnant” to many members of the public. It may therefore overcome the emotional reaction of those who simply refuse to consider placing a monetary value on a life, and thus allow for a better-informed debate about real and important trade-offs, which are otherwise simply negated.

Second, we believe the use of a single, non-monetary, theoretically sound but easily interpretable parameter to express the trade-off can also be useful to inform the public debate. Finally, even the exclusive focus on poverty may make a consideration of the trade-off more acceptable to those who tend to think of economic costs as morally irrelevant when they embody losses to the rich. By focusing exclusively on increases in destitution we introduce (an admittedly coarse) distributional sensitivity which may, once again, make a public debate of the real trade-off between lives and livelihoods more acceptable, and therefore more likely. From this perspective, ignoring economic losses to the non-poor can be seen as a strength, rather than as a limitation. In short: while we do not claim that our approach is superior to those already used in the literature, we argue that it is a valuable alternative; an addition to the professional toolkit that may have some important advantages in informing the public debate.

Importantly, we do not take a view on the exact value for the normative parameter  $\alpha$ . Rather, we present estimates of the number of lost-years and the number of poverty-years induced by the pandemic for each country, under a few different scenarios. The estimates of PY/LY ratios are interpreted as empirical analogues to  $\alpha$ . They tell us how many additional years are spent in poverty for each year of life lost to Covid-induced mortality in that country and scenario. It is left to the reader to form an assessment of which source of welfare loss is dominant.

We err on the side of caution by providing conservative estimates. The number of lost-years caused by a given death is taken to be the country-specific residual life expectancy at the age at which this death takes place.<sup>6</sup> The number of poverty-years generated in a given country is taken to be the variation in the country’s population living under the poverty threshold, caused by the Covid-induced drop in GDP forecast by Central Banks and the World Bank’s Global Economics Prospect. This variation corresponds to a number of poverty-years because we assume that these individuals only remain poor for a single year. This is also a conservative assumption because we ignore any long-term effects of additional poverty, such as insults to child development from worse nutrition in early childhood; learning costs from school closures; possible hysteresis effects of unemployment, and so on. In our baseline scenario, we also assume that the economic contraction is distribution neutral, i.e. that there is no change in inequality. This is conservative since most available evidence so far suggests that the economic costs of the pandemic disproportionately burden poorer people ([Bonavida Foschiatti and Gasparini](#),

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<sup>6</sup>This is conservative to the extent that individuals already having health issues such as diabetes or heart problems are more susceptible to die than healthy individuals.

2020).<sup>7</sup>

To the best of our knowledge, we provide the first global welfare analysis of the current consequences of the pandemic. Several papers provide a welfare analysis at national levels using the three approaches described earlier. [Rowthorn and Maciejowski \(2020\)](#) conduct a cost-benefit analysis of the economic, social, and health consequences of the pandemic in the UK in which the value placed on a human life governs the optimal policy response. In their baseline scenario they find the economic costs to be about four times larger than the health costs.<sup>8</sup> This is not inconsistent with our baseline results for the UK in which we estimate that about nine years are spent in poverty for every year of life lost. [Hall et al. \(2020\)](#) likewise conduct a social welfare analysis which resorts to a price for a human life, computing the fraction of GDP that the United States would be willing to give up in order to avoid all potential Covid-induced deaths.

[Ray and Subramanian \(2020\)](#) discuss the welfare implications of the pandemic in India and the indirect loss of lives that an economic lockdown entails. Though they refrain from quantifying these losses, they conclude that a lockdown without a social safety net is a less attractive option in India than in wealthier countries where the indirect mortality of such lockdowns is likely to be smaller relative to the direct health costs. These findings are also consistent with the empirical evidence we lay out. [Alon et al. \(2020\)](#) investigate the differential mortality risks between developed and developing countries using a model in which social welfare is defined as expected lifetime utility. In line with our findings, they find that Covid-induced mortality plays a larger role on the welfare consequences of lockdowns in developed countries than in developing countries. Also using an approach with social welfare defined as expected lifetime utility, [Bethune and Korinek \(2020\)](#) show that social welfare in the United States is not maximized under a no-intervention scenario, similar to what we find for high income countries.

Our analysis is also related to other recent papers. First, we borrow the time-units metric for a normative evaluation of the relative welfare costs of mortality and poverty from [Baland et al. \(2020\)](#). These authors employ that metric for an assessment of deprivation, whereas we use it for assessing welfare. Also, they apply their indicators to global deprivation before the outbreak of the pandemic. Second, [Sumner et al. \(2020\)](#), [Laborde et al. \(2020\)](#) and [Lakner et al. \(2020\)](#) estimate the Covid-induced increase in global poverty. We base our poverty estimates on the methodology developed by [Lakner et al. \(2020\)](#).

The remainder of the paper is organized as follows. Section 2 provides a simple conceptual framework that explicitly anchors the comparison between lost-years and poverty-

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<sup>7</sup>For instance, [Montenovo et al. \(2020\)](#) show that already disadvantaged groups are disproportionately affected by Covid-induced job losses in the United States. [Kikuchi et al. \(2020\)](#) find similar results for job and income losses in Japan. We therefore also discuss an alternative scenario where inequality is allowed to change during the pandemic.

<sup>8</sup>Our calculations are based on Table 1 in [Rowthorn and Maciejowski \(2020\)](#).

years on standard social welfare analysis. Section 3 presents mortality and poverty estimates as of early June 2020, first for a set of six countries (three developed and three developing) for which Covid-19 mortality data disaggregated by age are available (Section 3.1) and then for the rest of the world, using the age-distribution of deaths from population pyramids and infection-to-fatality ratios documented by [Salje et al. \(2020\)](#) and [Verity et al. \(2020\)](#) (Section 3.2). In both samples, the number of poverty-years is almost always at least ten times larger than the number of lost-years. In many cases, the PY/LY ratio is above one hundred or even one thousand. This suggests that, for most countries in the world, the welfare losses from the Covid-19 pandemic arise disproportionately from increases in poverty. This section also documents that the relative magnitude of human lives lost and poverty costs varies substantially with countries' GDP per capita, with developed countries facing both much larger mortality costs and much smaller poverty costs than developing countries - suggesting that the best policy responses may differ by country.

Section 4 then compares the estimated welfare consequences as of early June to a counterfactual “no-intervention” scenario in which contagion only stops when herd immunity is reached.<sup>9</sup> This permits a cleaner comparison of potential mortality burdens across different countries, since looking only at current mortality is hampered by the fact that countries are in different stages of the epidemic. In most countries, we find that the number of lost-years under “no-intervention” are considerably larger than the sum of the lost-years and poverty-years generated as of early June. This implies that, even if we conservatively assume that the “no-intervention” scenario has no poverty consequences, its negative welfare consequences are larger than the current welfare consequences as of early June.<sup>10</sup> This strongly suggests that no-intervention was - or would have been - a suboptimal policy, particularly in richer countries. Section 5 concludes.

## 2 A simple conceptual framework

This section briefly explains how our empirical comparison between years of life lost (LY) and additional years lived in poverty (PY) can be interpreted in terms of a standard utilitarian social welfare function, modified by the simplifying assumption that period utility depends only on being alive and non-poor, alive but poor, or dead. The approach is closely inspired by [Baland et al. \(2020\)](#), who apply it to a (different) problem in poverty measurement, namely developing poverty measures that account for premature mortality.

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<sup>9</sup>We follow [Banerjee et al. \(2020\)](#), whose “no-intervention” scenario assumes that herd immunity for Covid-19 comes about when 80% of the population is immunized.

<sup>10</sup>Coming up with a convincing counterfactual under alternative policies than the one actually implemented is, of course, challenging. Nonetheless, several papers are now trying to model how behaviors and macroeconomic outcomes change during pandemics, using such counterfactuals (see [Eichenbaum et al. \(2020\)](#) or [Garibaldi et al. \(2020\)](#)).

It is modified to suit our present purpose.

Consider a fixed calendar year  $T$ . For a given country, denote the set of individuals who are alive at time  $T$  by  $I$ , indexed by  $i$ . The expected residual longevity of individual  $i$  at time  $T$  is given by  $d_i - T$ , where  $d_i$  is the expected year of her death. In each calendar year  $t$  with  $T \leq t \leq d_i$ , individual  $i$  has expected status  $s_{it}$ , which is either being poor ( $P$ ) or being non-poor ( $NP$ ).<sup>11</sup> The expected future lifetime utility of individual  $i$  is

$$U_i = \sum_{t=T}^{d_i} u(s_{it}),$$

where  $u$  is the instantaneous utility function, with  $u(NP) > u(P) > 0$ .<sup>12</sup> Let the instantaneous utility of being dead equal zero. Abstracting from future births, a simple utilitarian expected social welfare function in this country is:

$$W = \sum_{i \in I} U_i.$$

Now assume that a pandemic starts in year  $T$  and can affect individual  $i$ 's lifetime utility in two ways. First, its economic costs may change her status from  $s_{it} = NP$  to  $s'_{it} = P$ , for one or more years  $t$  following the outbreak. Let  $\Delta u_p = u(NP) - u(P)$  denote the instantaneous utility loss from becoming poor for one period. Second, the mortality associated with the pandemic can advance the year of the individual's death to an earlier calendar year  $d'_i \leq d_i$ . Let  $\Delta u_d$  denote the instantaneous utility loss of losing one period due to premature mortality.<sup>13</sup>

Our definition of  $U_i$  implies that  $\Delta u_d$  should in principle depend on the counterfactual status  $s_{it}$  that individual  $i$  would have had in  $t \geq d'_i$  in the absence of pandemic. To avoid the normatively unappealing consequence of valuing the cost of premature mortality differently for the poor and the non-poor, we impose that the counterfactual status  $s_{it}$  equals  $NP$  for all  $d'_i \leq t \leq d_i$  and for all  $i$ . In other words, the utility loss from each year of life lost to the pandemic is  $\Delta u_d = u(NP)$ , identically for everyone.

Continuing to use the operator  $\Delta$  to denote the expected consequences of the pandemic relative to a non-pandemic counterfactual, we can write the change in individual expected

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<sup>11</sup>Since only two income categories are considered, our framework ignores changes in incomes that do not imply a change in income category.

<sup>12</sup>For simplicity, we assume that individuals do not discount the future. Note also that this formulation is inherently conservative, in the sense that income losses that take place above or below the poverty line, without causing a crossing of that line, do not contribute to welfare losses by assumption.

<sup>13</sup>Both  $\Delta u_p$  and  $\Delta u_d$  are assumed to be constant over time and across individuals, and thus have no  $i$  or  $t$  subscripts. Because we focus in this paper on the mortality and poverty costs of the pandemic, we abstract from various other possible effects of a pandemic, such as the long-term effects of additional malnutrition for children, or of school stoppages. Similarly, for simplicity, we do not allow for people to be made richer or to gain additional life years from the pandemic.



utility as:

$$\Delta U_i = U'_i - U_i = \sum_{t=T}^{d'_i} \mathbb{1}(s_{it}, s'_{it}) \Delta u_p + \sum_{t=d'_i}^{d_i} \Delta u_d,$$

where  $\mathbb{1}(s_{it}, s'_{it})$  takes value 1 if  $s_{it} = NP$  and  $s'_{it} = P$ , and takes value 0 otherwise.

Since  $u(P) > 0$ , then  $\Delta u_d > \Delta u_p$ , and we can write  $\Delta u_d = \alpha \Delta u_p$  for some  $\alpha > 1$ . Aggregating across individuals, the change in social welfare is given by:

$$\Delta W = \sum_{i \in I} \Delta U_i = \sum_{i \in I} \left( \sum_{t=T}^{d'_i} \mathbb{1}(s_{it}, s'_{it}) \Delta u_p + \sum_{t=d'_i}^{d_i} \alpha \Delta u_p \right).$$

Now define  $LY$  and  $PY$  as the sums of years lost to premature mortality and poverty, respectively, across the population, calculated as follows:

$$LY = \sum_{i \in I} (d_i - d'_i),$$

$$PY = \sum_{i \in I} \sum_{t=T}^{d'_i} \mathbb{1}(s_{it}, s'_{it}).$$

Then the total impact on welfare of the pandemic  $\Delta W$  is proportional to the weighed sum of the numbers of lost-years and poverty-years, i.e.:

$$\frac{\Delta W}{\Delta u_p} = \alpha LY + PY, \tag{1}$$

where the parameter  $\alpha = \frac{\Delta u_d}{\Delta u_p} > 1$  captures how many poverty-years have the same impact on welfare as one lost-year. In our framework, this parameter captures the normative trade-off between mortality and poverty costs. An individual might arise at their own valuation of the parameter by answering the following question: how many years of your remaining life would you be willing to spend in poverty in order to increase your lifespan by one year?<sup>14</sup> A societal value for the parameter would then be some aggregation of its citizens' individual values. Although it is expressed in time-units instead of monetary-units, this parameter plays the same role as the dollar value of a human life in other analyses. In this paper, we leave to the reader the choice of her preferred value for parameter  $\alpha$ , imposing only the lower bound at one derived above.

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<sup>14</sup>To be more precise, this question should specify that the number of years that the individual already expects to spend in poverty should not be counted in her answer.

### 3 Welfare costs as of early June

In this section, we study the welfare consequences of the pandemic as of early June 2020. In particular, we are interested in the relative contribution of poverty and mortality costs to the overall welfare losses in each country. To answer this question, we estimate a country's number of lost-years and compare it to an estimate of its number of poverty-years.

Equation (1) tells us that to arrive at the relative contribution of the two components, one would need a value for  $\alpha$ , which we wish to remain agnostic about. Our approach is to compute for each country (in each scenario) the value of  $\alpha$  an observer would have to hold so as to judge that Covid-related mortality and additional poverty make identical contributions to the welfare costs of the pandemic, given the observed outcomes. Using a superscript  $A$  to denote actual, or estimated, outcomes, this "break-even"  $\alpha$ , which we call  $\hat{\alpha}$ , is given by:

$$\hat{\alpha} = \frac{PY^A}{LY^A}.$$

For any  $\alpha < \hat{\alpha}$ , additional poverty is the dominant source of the current welfare costs of the pandemic. To be sure, we do not interpret the empirical  $\hat{\alpha}$  of a given country as an estimate of this country's preference parameter. Besides policy choices, the empirical  $\hat{\alpha}$  reflects a host of different factors, e.g. the date at which Covid-19 arrived in the country, the strength of its social safety net, its population pyramid, etc. Instead, we present these  $\hat{\alpha}$  so that the reader can form her own judgement about which form of welfare cost is dominant in the country, by comparing the empirical ratio  $\hat{\alpha}$  to her own  $\alpha$  value.

#### 3.1 Six countries with high-quality data

We first look at a restricted sample of six countries for which we have data on age-specific mortality from Covid-19.<sup>15</sup> Three of them are high-income countries: Belgium, the United Kingdom (UK) and Sweden. We selected these three countries because they had some of the highest numbers of Covid-deaths per capita as of early June.<sup>16</sup> The three remaining countries are developing countries for which age-specific mortality data are available as of early June: Pakistan, Peru and the Philippines. For each of these countries, we estimate  $LY^A$  and  $PY^A$  as follows.

To estimate a country's number of lost-years, we start from the age-specific mortality information: the number of Covid-related deaths distributed by age categories. Where available for individual countries, this information is obtained from Offices of National Statistics, Ministries of Health or other government offices. A specific list is included

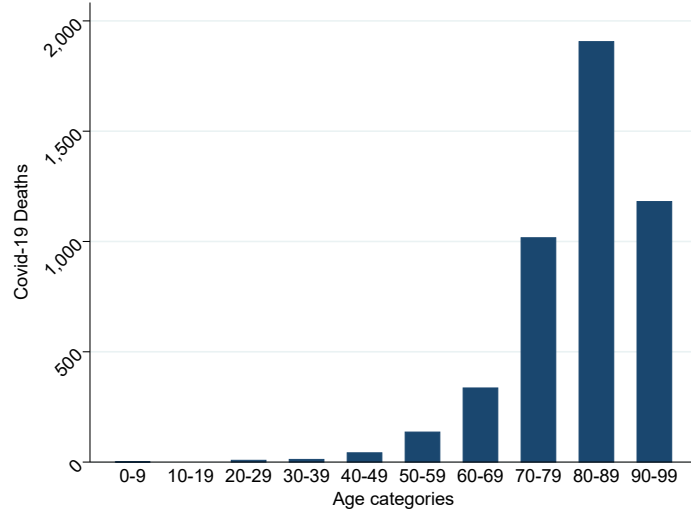
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<sup>15</sup>It is not possible to find age-specific mortality information for all countries.

<sup>16</sup>Belgium has the highest number, the United Kingdom has the second highest and Sweden has the fifth highest, beyond Italy and Spain, but Sweden has particularly detailed age-specific mortality information.

in Table A1 in the Appendix.<sup>17</sup> Then, for each death we assume that the number of lost-years is equal to the residual life expectancy at the age of death, as computed from the country’s pre-pandemic age-specific mortality rates, obtained from the *Global Burden of Disease* Database (Dicker et al., 2018). As noted earlier, we consider this assumption conservative, since individuals who die from Covid-19 are given the same residual life expectancy as that of other individuals with the same age.

One particularity of Covid-19 is that its mortality is concentrated among the old. This concentration is illustrated in Figure 1, which shows a histogram by age categories of the Covid-19 deaths observed in Sweden. This concentration implies that evaluations of mortality costs based on lost-lives, which disregard the age distribution of deaths, would tend to overestimate the welfare consequences of mortality, compared to our evaluation based on lost-years. In the case of Sweden, ignoring the age distribution of deaths would inflate the importance of mortality by a factor of 4.5.<sup>18</sup>



**Figure 1:** Distribution of Covid-19 deaths per age in Sweden as of early June.

To estimate each country’s number of poverty-years, we first take the income distribution for each country from PovcalNet for 2018, which is the latest year for which data are available. Next, we scale these distributions to 2020 by assuming that all household incomes grow in accordance with growth rates in real GDP per capita, meaning that the growth is distribution-neutral. We do so under two different growth scenarios: (1) using GDP growth estimates for 2019 and 2020 from around June 2020, which incorporate the expected impacts of the pandemic and associated policy responses, and (2) using GDP growth estimates for 2019 and 2020 from around January 2020, before Covid-19

<sup>17</sup>All of our data sources are described in greater detail in the Appendix.

<sup>18</sup>If the same number of deaths were to be distributed at random in the population, they would generate 4.5 as many lost-years as the current distribution. This factor is equal to the average residual life expectancy in Sweden (43 years) divided by the average residual life expectancy of those dying (9.5 years).

took off. Central Bank growth estimates are used for Sweden, Belgium and the United Kingdom while growth estimates from the January and June 2020 edition of the World Bank’s *Global Economic Prospects* (GEP) are used for Pakistan, Peru and Philippines (The World Bank, 2020).

Finally, following Lakner et al. (2020) but using each country’s most recent national poverty line, the impact of Covid-19 on poverty is computed by comparing the number of poor under the two growth scenarios.<sup>19</sup> Denoting the number of poor people in year  $y$  estimated on the basis of the growth estimate from month  $m$  in 2020 by  $H_y^m$ ,  $PY^A$  is estimated by the difference in differences:

$$PY^A = (H_{2020}^{June} - H_{2019}^{June}) - (H_{2020}^{Jan} - H_{2019}^{Jan})$$

While we cannot rule out that GDP estimates might have changed for reasons unrelated to Covid over this time interval (January - June 2020), it is safe to say that most of the changes are due to Covid-19. The difference in differences calculation assures that changes in the 2019 growth rates, which cannot have been due to Covid-19, are eliminated. We assume that this additional poverty lasts only for one year, so that the number of poverty-years is simply equal to this additional number of poor people. Our analysis therefore focuses on the short-term effects of the pandemic on poverty.

These are rather conservative assumptions, in the sense of yielding a small number of poverty-years, for at least two reasons. First, we assume that the additional poverty generated by the pandemic lasts only for one year. This assumption also allows us to avoid using GDP forecasts beyond 2020, the uncertainty around which is extremely large. Second, our baseline scenario assumes that all incomes grow - or shrink - in the same proportion, although there are reasons to believe that the poor could be affected more than proportionally by the recession (Bonavida Foschiatti and Gasparini, 2020). Yet, we acknowledge that, for the countries that enacted substantial social assistance policies aimed at protecting the incomes of their citizens during the crisis, our distribution-neutral assumption cannot be deemed conservative (Lustig et al., 2020). As this is mostly the case of developed countries, this assumption tends to downplay the difference, across developed and developing countries, that we document in the relative sizes of the Covid-induced mortality and poverty welfare costs.

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<sup>19</sup>In all projections, it is assumed that only 85 percent of growth in GDP per capita is passed through to growth in welfare observed in household surveys in line with historical evidence (Lakner et al., 2020). In contrast to the data from PovcalNet which are expressed in 2011 PPPs and in per capita terms, the national poverty lines for Pakistan, Peru and the Philippines are expressed in local currency units and per adult equivalents. To convert the national poverty lines into 2011 PPPs and per capita terms we follow the approach of Jolliffe and Prydz (2016), which is to find the poverty line in per capita 2011 PPPs that gives the same poverty rate as the national poverty line in local currency units and per adult equivalents. The national poverty line used for Sweden, Belgium and the United Kingdom is 60% of median income in 2019. We keep this line fixed at the 2019 level also for 2020 to avoid a shift in poverty lines.

The results for our six countries are summarized in Table 1. We explain how to read Table 1 using the case of Sweden. The first six rows present basic economic and demographic indicators, such as Sweden’s GDP per capita, population, life expectancy at birth, etc. The second panel presents mortality statistics. Given the age-distribution of the 4639 Covid-related deaths recorded in Sweden (shown in row 7), each death leads on average to 9.5 lost-years. The total number of years of life lost in Sweden (up to early June 2020) is obtained by multiplying these two numbers: 43,973. The third panel turns to the economic shock. The Central Bank of Sweden forecasts a GDP reduction of 11.5 percentage points as a result of the Covid-19 pandemic. Under our distribution-neutral growth assumption, this GDP reduction leads to an additional 410,000 poor people, with respect to the national poverty line of 28.9 dollars per person per day (in 2011 PPP exchange rates). As we conservatively assume they are poor for one year only, this figure is directly equal to the number of poverty-years. The last row in Table 1 provides the “break-even”  $\hat{\alpha}$  ratios. In the case of Sweden, there are 9.4 times as many poverty-years as lost-years. This means that the two sources of welfare costs would have the same magnitude if 9.4 poverty-years were judged to be as bad as one lost-year. Finally, we provide the *per-capita* numbers of lost-years and poverty-years, which simplifies comparisons. In Sweden, the additional poverty corresponds to 0.0409 years per person while the number of lost-years corresponds to 0.0044 years per person.

**Table 1:** Estimation of the pandemic’s welfare costs in six countries as of early June 2020 (baseline, distribution-neutral contraction)

	(1)	(2)	(3)	(4)	(5)	(6)
	Belgium	Sweden	UK	Pakistan	Peru	Philippines
<b>Economic and demographic characteristics</b>						
GDP p.c. in 2017 (2011 PPP\$)	43,133	47,261	40,229	4,764	12,517	7,581
National poverty line (2011 PPP\$)	27	28.9	25.8	2.8	5.3	2.6
Population (in millions)	11.59	10.10	67.88	221.0	32.98	109.5
Life expectancy at birth	81.18	82.31	80.78	65.98	80.24	69.51
Age (mean)	41.42	41.14	40.62	25.86	32.53	28.53
Residual life expectancy (mean)	42.01	43.06	42.40	46.25	50.55	44.92
<b>Covid-19 mortality, current scenario</b>						
Number of deaths	9,605	4,639	48,848	2,056	5,465	1,002
LYs per death	9.467	9.479	10.14	18.46	21.97	16.90
LYs per person	0.00785	0.00435	0.00730	0.000172	0.00364	0.000155
<b>Covid-19 economic shock</b>						
On GDP per capita (in %)	-8.5	-11.5	-14.5	-6.7	-13.1	-8.4
On poverty HC (in million)	0.32	0.41	4.37	7.39	1.58	2.96
On poverty HCR	0.0279	0.0409	0.0644	0.0335	0.0480	0.0270
<b>Break-even <math>\hat{\alpha}</math></b>	3.553	9.383	8.816	194.8	13.20	174.8

The main finding of this section, from an inspection of Table 1, is that the poverty costs are substantial relative to the mortality costs. This is obvious in the case of Pakistan and

the Philippines, for which the break-even  $\hat{\alpha}$  are 195 and 175, respectively. It is relatively clear as well in the case of Peru, for which break-even  $\hat{\alpha}$  is 13. If one were to take the view that  $\alpha = 10$ , then Sweden and the United Kingdom would be very near the break-even point at which the welfare costs of the pandemic arise in equal parts from greater poverty and mortality. Under that assumption ( $\alpha = 10$ ), Belgium (with  $\hat{\alpha} = 3.6$ ) would be the only country in our sample for which Covid-induced mortality is clearly the dominant source of welfare losses from the current crisis. All things considered, it seems safe to say that, given individual and public policy responses, the poverty costs of the pandemic in these six countries are not dwarfed by its mortality costs. Indeed, for most plausible parameter estimates, the reverse is true (at least) in Pakistan and the Philippines.

### 3.2 The whole world

The findings above suggest that the poverty effects of the pandemic are substantial, even in relation to its mortality effects. They also hint at a possible pattern where that cost ratio is much larger for developing countries relative to developed countries. To investigate those conjectures further we go beyond our six-country sample, and extend the analysis to as many countries as possible.

Unfortunately, publicly available data on Covid-related deaths are not distributed by age-categories for most countries in the world, which prevents us from directly computing the number of lost-years, as we did in the previous subsection. In order to overcome this problem, we assume that country-specific infection probabilities are independent of age. Then, using estimates of Covid's age-specific infection-to-fatality ratios (IFR), we can infer the infection rate necessary to yield the number of deaths observed in the country, given its population pyramid. For developed countries, we use the age-specific IFRs estimated for France by [Salje et al. \(2020\)](#). For developing countries, we use analogous ratios estimated for China by [Verity et al. \(2020\)](#).<sup>20</sup>

Formally, let  $N_{aj}$  denote the size of the population of age  $a$  in country  $j$ ,  $d_{aj}$  the number of Covid-related deaths at age  $a$  in country  $j$ ,  $d_j$  the total number of Covid-19 deaths in country  $j$ , and  $\mu_{aj}$  the *IFR* at age  $a$  in country  $j$ . The proportion of people

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<sup>20</sup>The life expectancy at birth in China is larger than in many other developing countries. This may signal that, at a given age, Chinese citizens are affected by fewer health issues that increase the probability of dying from Covid-19 than their counterparts in the developing world. This may imply that the IFRs are smaller in China than in other developing countries. When distributing observed deaths across age-groups, the impact that larger IFRs in developing countries would have is a priori ambiguous, as this impact would depend on the relative increases of IFRs in different age-groups. However, given that the IFRs from France and China are not drastically different from one another and because we do not observe many Covid-induced deaths in these countries, we expect such impact on lost-years to be minor.

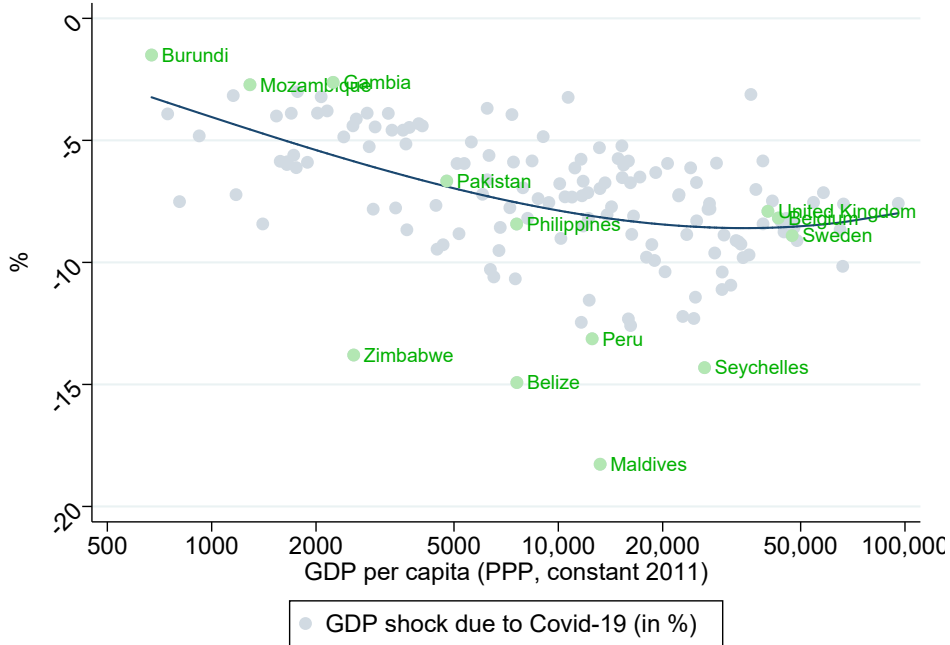
who are or have already been infected by Covid-19 in country  $j$  is estimated as:

$$\varphi_j = \frac{d_j}{\sum_{a=0}^{99} N_{aj} \mu_{aj}}. \quad (2)$$

The number of Covid-related deaths at age  $a$  in country  $j$  is given by:

$$d_{aj} = \varphi_j N_{aj} \mu_{aj}. \quad (3)$$

Our global estimates of the poverty impacts of Covid-19 come from [Lakner et al. \(2020\)](#). There are two methodological differences between these estimates and those reported in Section 3.1. First, rather than using growth data from Central Banks, GDP estimates now come from the January and June 2020 editions of the World Bank's *Global Economic Prospects* (GEP) ([The World Bank, 2020](#)), supplemented with the April 2020 and October 2019 edition of IMF's *World Economic Outlook* (WEO) when countries are not in the GEP (which mostly applies to high-income countries). As before, the extrapolation assumes distribution-neutral (negative) growth. Figure 2 below plots this difference in forecasts – the GDP shock due to Covid – against GDP per capita for the 150 countries in our sample. We continue to assume that this additional poverty lasts only for a single year, so that the number of poverty-years is equal to this additional number of poor people.

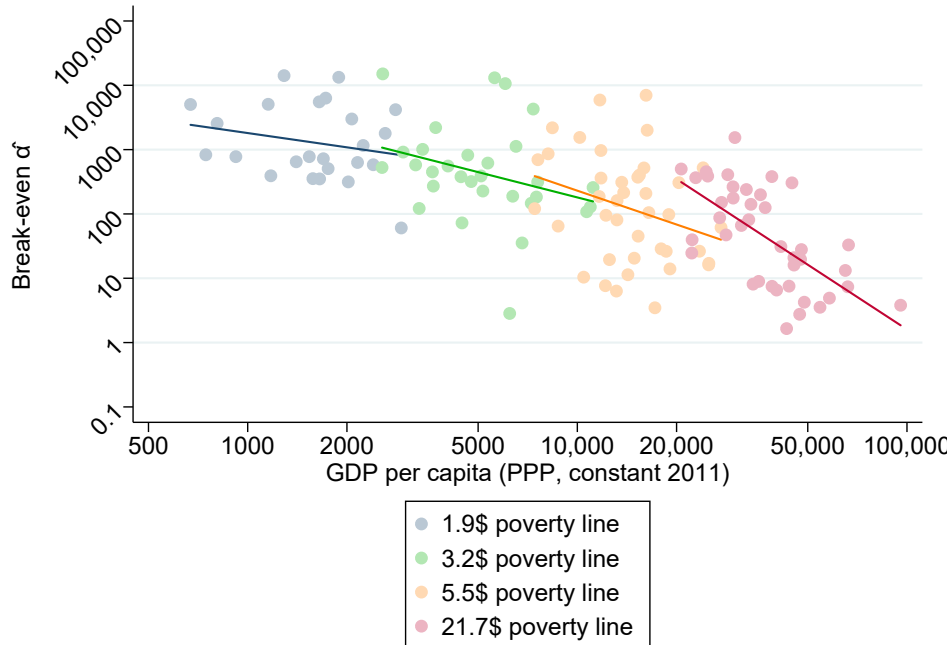


**Figure 2:** Shock to GDP due to Covid-19 (baseline estimates)

Second, instead of using national poverty thresholds, we use the World Bank's income class poverty thresholds, as derived by [Jolliffe and Prydz \(2016\)](#), namely \$1.90 per person

per day in low-income countries (LICs); \$3.20 a day in lower-middle-income countries (LMICs); \$5.50 a day in upper-middle-income countries (UMICs); and \$21.70 a day in high-income countries (HICs). These lines were obtained as the median national poverty lines for each income category in a dataset constructed by those authors.

Figure 3 shows the break-even  $\hat{\alpha}$  for all 150 countries in our global sample, plotted against GDP per capita. In order to average-out some of the measurement errors, we fit a line through these ratios for each income-based group of countries: LICs, LMICs, UMICs, and HICs. Noting that both axes in Figure 3 are in logarithmic scale, we observe a very pronounced negative slope in the relationship, despite the fact that poverty lines increase between country categories. Naturally, the downward slope is even more pronounced when a constant poverty line is used, as shown in Figure A.9 in the Appendix, for the international poverty line of \$1.90 per day. In fact, the fitted break-even  $\hat{\alpha}$  ratios for low-income countries exceed 1,000, and, for middle-income countries, they are generally greater than 100. If we take seriously the interpretation of  $\alpha$  suggested earlier - a value close to the average answer that individuals would give as to how many years of their remaining life they would be willing to spend in poverty in order to increase their lifespan by one year - then these empirical estimates of the break-even  $\hat{\alpha}$  are extremely large, suggesting that the welfare costs from poverty typically dominate the mortality costs in poor countries. They are also quite large in many high-income countries, though not uniformly so: about a third of the HICs have  $\hat{\alpha}$  in the  $[1, 10]$  range.



**Figure 3:** Break-even  $\hat{\alpha}$  in all countries as of early June 2020 (baseline, distribution-neutral contraction)

This finding is further emphasized when considering less conservative estimates of the



number of poverty-years generated by the pandemic. Our baseline estimates rely on the assumption that all incomes would shrink in the same proportion. Yet, the poor could be affected more than proportionally by the recession, in which case inequality would increase. The results of [Bonavida Foschiatti and Gasparini \(2020\)](#) for Argentina suggest that the recession generated by the response to the Covid-19 pandemic could increase the Gini coefficient by 3.6%. In order to account for possible increases in inequality, we compute a second estimate of poverty-years that is based on a 3.6% increase in Gini coefficients of all countries in 2020.<sup>21</sup>

We also consider the poverty impact in case the pandemic requires more stringent and sustained lockdown measures. To this end, we utilize the fact that the GEP also provides a downside growth scenario, which precisely assumes a worse and longer recovery phase (see Figure A.8).<sup>22</sup> Analogues of Figure 3 for each of these alternative poverty scenarios are shown in Figure A.10 in the Appendix.

Overall, Figures 3 and A.10 confirm that, if the epidemic suddenly ended at the beginning of June 2020, its poverty costs would in most countries be very large relative to its mortality costs, and especially so in developing countries. Importantly, however, this finding does not mean that lockdowns were misguided, excessively long, or too strongly enforced. Our findings so far do not allow any conclusions on the optimality of actual policy responses. They merely allow us to quantify different sources of the welfare impact of the crisis (the epidemic taken together with individual and policy responses), as it unfolded up to early June.

There are two reasons why these results cannot be used to assess the policy response. First, different countries are still in different phases of the epidemic, and cross-country comparisons of break-even  $\hat{\alpha}$  must take that into account. Second, the observed outcomes (which incorporate the actual responses) must be compared to plausible counterfactuals corresponding to alternative policy responses, to assess their relative merits. This is what we turn to next, using a counterfactual “no-intervention” policy scenario as a comparator.

## 4 Welfare costs under no-intervention

In this section, we compare the baseline estimates of welfare costs as of early June 2020, discussed above, with the potential mortality costs in a counterfactual “no-intervention” policy scenario. This allows us to shed some light on the question of whether no-intervention could have been a superior policy response to what was observed until early

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<sup>21</sup>One challenge with modeling the impact of changes in Gini coefficients is that there are infinitely many possible distributional changes resulting in the same change in the Gini. Using the framework of [Lakner et al. \(2020\)](#), we assume that inequality increases in a manner consistent with a linear growth incidence curve, approximating what was found in Argentina.

<sup>22</sup>For most high-income countries, for which we are using WEO forecasts rather than GEP, there is only one GDP scenario, so the baseline and downside scenarios coincide.

June 2020.

A no-intervention scenario implies that the epidemic only stops in a country once herd-immunity is achieved. We follow [Banerjee et al. \(2020\)](#) who consider that herd-immunity is achieved when 80% of the population has been infected by the virus.<sup>23</sup> Under this scenario, all countries have the same infection rate, which allows comparing their potential mortality costs. We err on the side of caution by assuming that the poverty costs in the no-intervention scenario are zero. This is a conservative assumption since, even in the absence of lockdowns or other policy-driven measures, aversion behavior by individual workers and consumers is nonetheless likely to have led to non-trivial economic contractions ([Sheridan et al., 2020](#)).<sup>24</sup> From Equation (1), we have that the actual welfare consequences  $\Delta W^A$  would be equal to the no-intervention welfare consequences  $\Delta W^{NI}$  when

$$\alpha LY^A + PY^A = \alpha LY^{NI} + PY^{NI}.$$

As we assume zero economic consequences under our no-intervention scenario ( $PY^{NI} = 0$ ), this yields a second, different threshold value for the  $\alpha$  parameter, namely  $\tilde{\alpha}$ :

$$\tilde{\alpha} = \frac{PY^A}{LY^{NI} - LY^A}$$

This is the value of  $\alpha$  at which, given the estimated magnitudes of  $LY^A$ ,  $PY^A$ , and  $LY^{NI}$ , the counterfactual welfare costs of mortality under the no-intervention scenario would equal the actual costs,  $\alpha LY^A + PY^A$ . For any  $\alpha > \tilde{\alpha}$ , the welfare consequences under the no-intervention scenario would have been worse than those estimated for the actual outcome.<sup>25</sup> Again, we do not interpret the empirical  $\tilde{\alpha}$  of a given country as an estimate of this country's preference parameter. Instead, we present these  $\tilde{\alpha}$  such that the reader can form an opinion as to whether no-intervention would have led, in her own view, to worse welfare consequences.

## 4.1 Heterogenous mortality under no-intervention

In this section, we perform a cross-country comparison of potential mortality burdens  $LY^{NI}$  under the no-intervention scenario. This exercise reveals large quantitative differences in the potential number of lost-years between developing and developed countries.

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<sup>23</sup>We also investigate the robustness of our results under lower infection rates.

<sup>24</sup>Under this – clearly extreme – assumption of a zero poverty effect, this “no-intervention” scenario can effectively be interpreted as a “no-response” scenario: neither governments nor individual firms or consumers adjust their behavior to the pandemic. It is an evidently unrealistic scenario, useful only to generate the counterfactual mortality costs as a clear underestimate of the total welfare costs of a pure herd-immunity strategy.

<sup>25</sup>It should be evident that  $\tilde{\alpha}$  is completely different from  $\hat{\alpha}$ , for any given country. In particular,  $\tilde{\alpha}$  depends on counterfactual estimates of mortality under no-intervention in that country.

We compute a country’s potential number of lost-years under herd-immunity as follows. We assume an 80 % infection rate for all age categories of the population.<sup>26</sup> The number of infected individuals in each age-category is computed from the country’s population pyramid. The probability that an infected individual of a given age dies is deduced from age-specific infection-to-fatality ratios (IFR), once again using the IFR estimates for China from [Verity et al. \(2020\)](#) for developing countries, and those for France from [Salje et al. \(2020\)](#) for developed countries.<sup>27</sup> Then, the number of lost-years for a given death is the country’s residual life expectancy at the age of death. Summing the lost-years over all deaths provides the potential number of lost-years.

We consider two no-intervention scenarios. Under the “saturation” scenario, we assume that contagion is fast and hospitals are overwhelmed by the flow of infected individuals in need of care. In order to reflect this, the IFRs used assumes that all patients who would need intensive care cannot access ICU and die. This is our reference no-intervention scenario. Under the “no-saturation” scenario, we assume that contagion is slow and hospitals are not overwhelmed by the flow of infected individuals in need of care. Then, the IFRs used assume that all patients who would need intensive care have access to ICU. See Appendix A2 for more details.

Our estimates of the potential number of lost-years can differ across countries for three reasons: (i) age distributions; (ii) residual life expectancies; and (iii) IFRs used. We find that the potential mortality burden is several times larger in high-income countries than in low-income countries. This is despite the use of IFRs from China in the latter countries, which implies more lost-years than the IFRs from France would. To a large extent, this difference is the consequence of the concentration of Covid-deaths in old-age categories, as already illustrated in Section 3.1. Hence, younger populations in less developed countries reduce their potential mortality burden. An additional, but related, reason for this difference is that residual life expectancies at given ages are smaller in less developed countries.

Table 2 illustrates the heterogeneous mortality burdens for two countries: Japan and Zimbabwe. The population of Japan is considerably older than that of Zimbabwe. For instance, a third of Japan’s population is older than 60 years, whereas less than 5% of Zimbabwe’s population falls into that category. Residual life expectancy in Japan is larger than that of Zimbabwe in each age-category presented. For instance, individuals

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<sup>26</sup>Assuming a constant infection rate for everyone is a strong assumption because infection rates are expected to vary by age and by socio-economic status ([Lustig et al., 2020](#)). In the conclusion, we discuss this assumption, its impact on our results and argue that further research on the topic should try to relax this assumption, once the necessary evidence is available.

<sup>27</sup>As noted earlier, it is possible that the IFRs are smaller in China than in other developing countries. If this is the case, then we underestimate the number of lost-years under no-intervention in developing countries, and, as a consequence, underestimate the number of developing countries in which no-intervention was a dominated option. However, given that the IFRs from France and China are not drastically different from one another, we expect such impact on lost-years under no intervention to be limited.

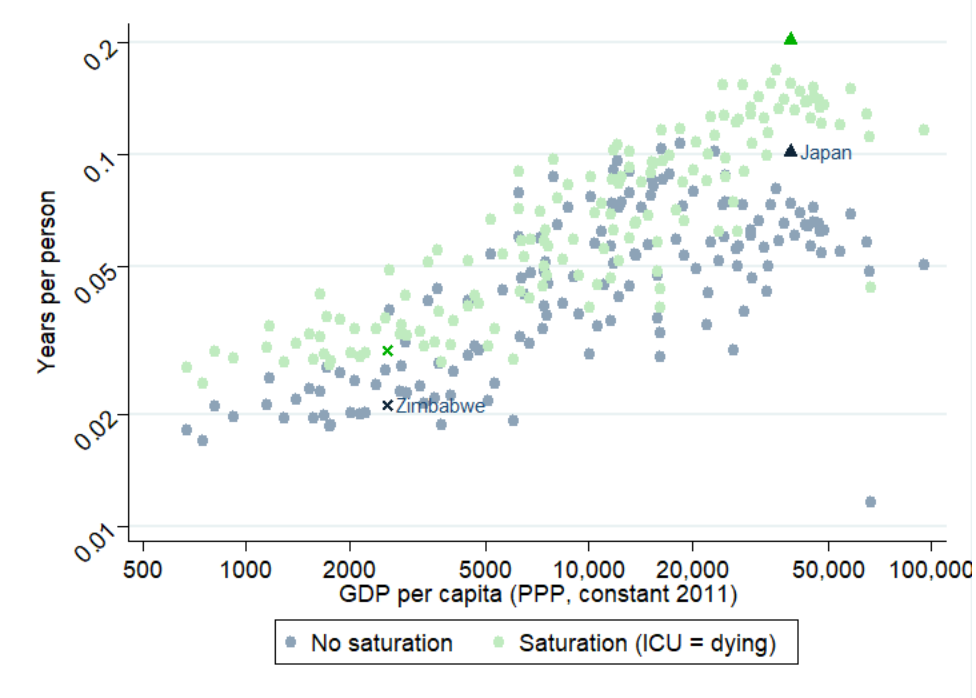
in the 60+ age category can expect *on average* to live for 16 years in Japan, and only for 11 years in Zimbabwe.

**Table 2:** Mortality risks in Japan and Zimbabwe

	(1) Japan	(2) Zimbabwe
<b>Population per age group (%)</b>		
0-29	26.6	69.5
30-59	39.0	25.8
60+	34.4	4.69
<b>Residual life-expectancy per age group</b>		
0-29	69.1	52.7
30-59	40.1	28.8
60+	15.6	11.2
<b>Covid-19 LYs per person</b>		
No intervention and no saturation	0.102	0.0212
No intervention and saturation	0.204	0.0298

Moving beyond that illustrative two-country example, Figure 4 plots years of life lost to Covid-19 under the no-intervention scenarios ( $LY^{NI}$  per person) - both with and without saturation - against GDP per capita for all countries in our sample. Notice that once again both axes are in logarithmic scale. The figure shows that potential mortality burdens are several times larger in high-income countries than in low-income countries. Under the “saturation” scenario, a large fraction of high-income countries has a per capita number of lost-years above 0.1 years per person. This is in sharp contrast with low-income countries, whose per capita number of lost-years is always below 0.05 years per person under the same scenario. In particular, the number is 0.2 years per person in Japan and 0.03 years per person in Zimbabwe, implying that the potential mortality burden in Japan is more than six times larger. Strikingly, high-income countries still have considerably larger potential mortality burdens under the “no-saturation” scenario than low-income countries under the “saturation” scenario. In particular, the number of lost-years per person is more than three times larger in Japan under the “no-saturation” scenario than in Zimbabwe under the “saturation” scenario.

Another striking aspect of Figure 4 is the heterogeneity of mortality burdens even among countries with similar levels of GDP per capita. Above \$5,000 per capita, one country can have more than twice the mortality burden of another country with similar GDP per capita. This illustrates the roles that population pyramids and residual life expectancies play in shaping Covid-19 mortality, quite separately from pure income considerations.



**Figure 4:** Per capita number of lost-years under two no-intervention scenarios

We also observe that the size of potential mortality burdens seems limited. These limited burdens follow from the small fraction of infected people who eventually die (typically smaller than 1% (Salje et al., 2020)) and the high concentration of deaths among the very old. In the case of Japan, whose population is particularly old, the potential number of lost-years under “saturation” corresponds to less than 0.4% of the total number of years at stake (the population multiplied by its average residual life expectancy). This explains why economic losses may be a significant source of welfare costs in this pandemic.

Finally, recall that these mortality comparisons are based on a policy scenario implying similar infection rates in all countries. At this stage, many alternative scenarios are still possible, and we do not speculate on which are more likely. Yet, *realized* mortality tolls could still be larger in some low- and middle-income countries than in some high-income countries. This would for instance be the case if the latter are able to stop the epidemic at current infection rates while the former are unable to do so.

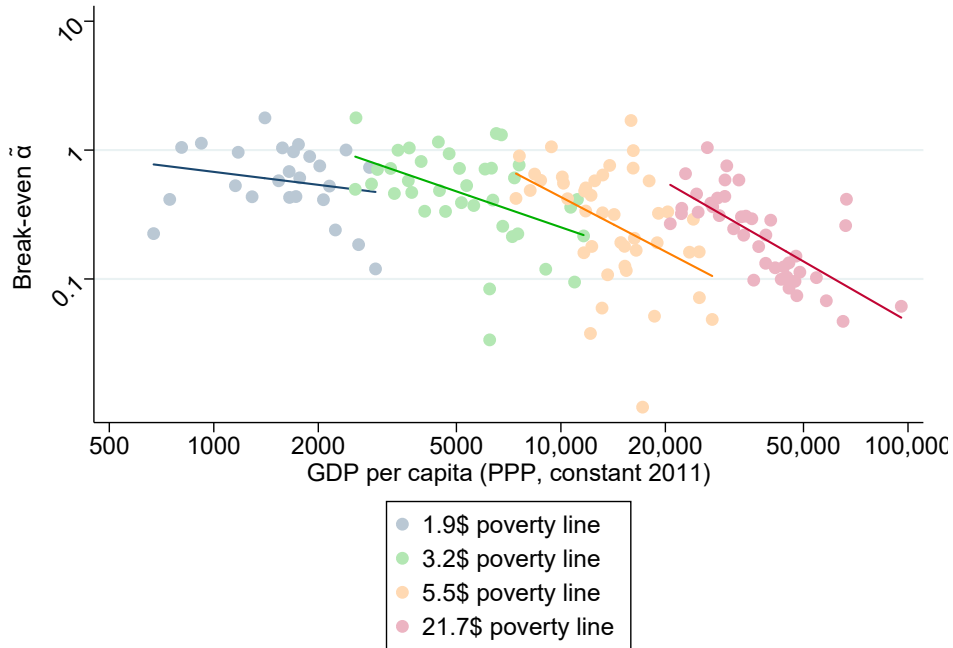
## 4.2 Actual versus “no-intervention” welfare consequences

Finally, we turn to the comparison between the actual and no-intervention welfare consequences. As explained above, the latter are larger than the former if  $\alpha > \tilde{\alpha}$ .

The first finding of this section is that, except for a few very poor countries, the welfare consequences under our no-intervention scenario are greater (i.e. *worse*) than the actual

welfare losses as of early June, for any plausible  $\alpha$ .<sup>28</sup> This implies that doing nothing was a dominated policy response in many countries, at least if the epidemic progressively disappears after early June and if Covid-induced poverty lasts for one year only.

This finding ensues from Figure 5, which shows break-even  $\tilde{\alpha}$  under “saturation” mortality and with poverty computed for income class-specific poverty thresholds, as before. The figure uses the baseline growth estimates and the distribution-neutral growth assumption. The graph shows that break-even  $\tilde{\alpha}$  are less than one in almost all developed and in most developing countries. But, as we saw in Section 2,  $\alpha$  is theoretically bounded below at 1, so the estimated welfare outcomes are worse under no-intervention for all admissible normative criteria.



**Figure 5:** Break-even  $\tilde{\alpha}$  in all countries as of early June 2020 (baseline, distribution-neutral contraction, no-intervention scenario with saturation, group-specific poverty thresholds)

We argue that the sub-optimality of no-intervention *in developed countries* is robust to taking less conservative poverty estimates. First and foremost, we assume conservatively that the no-intervention scenario has zero poverty costs, which is implausible. Second, if we relax our assumption that additional poverty only lasts for one year, and assume that the current poverty costs are in fact two or three times larger than our estimates, the result still holds for developed countries. Indeed, as shown in Table 3, the median break-even  $\tilde{\alpha}$  for this group of countries is never larger than one-third under the various scenarios considered. In the case of upper-middle income countries, the median break-even  $\tilde{\alpha}$  is never greater than one under the various scenarios considered, which also suggests sub-

<sup>28</sup>Recall that  $\alpha > 1$ .

optimality of no-intervention for these countries. Lastly, this sub-optimality is also largely robust to assuming smaller infection rates under no-intervention than 80% (as suggested by Banerjee et al. (2020)). Under smaller infection rates, the mortality consequences of no-intervention are smaller and therefore break-even  $\tilde{\alpha}$  values are larger. Even if the infection rate leading to herd immunity varies across populations and periods (Randolph and Barreiro, 2020), this threshold infection rate is not expected to be lower than 50% (Fontanet and Cauchemez, 2020).<sup>29</sup> Figure A.11 in Appendix shows the break-even  $\tilde{\alpha}$  values under an infection rate of 50%. This smaller infection rate does make a difference: about half of the low-income countries have their break-even  $\tilde{\alpha}$  values above one and it is also the case for a non-negligible minority of middle-income countries, as well as three developed countries. However, this does not necessarily imply that no-intervention would have been better for these countries. First, their break-even  $\tilde{\alpha}$  values are almost always below two or three, which could very well be below the reader’s  $\alpha$  value. Second, these break-even  $\tilde{\alpha}$  values assume zero poverty consequences in the no-intervention scenario, which artificially increases break-even  $\tilde{\alpha}$  values. Finally, the vast majority of developed countries still have their break-even  $\tilde{\alpha}$  values below one-half, implying for these countries that no-intervention would have been dominated.

**Table 3:** Lives and livelihoods - break-even  $\tilde{\alpha}$  as of early June 2020, under “no intervention” scenario and saturation, medians by World Bank (WB) income groups

	(1) LIC	(2) LMIC	(3) UMIC	(4) HIC	(5) World
<b>Median of economic and demographic characteristics</b>					
GDP p.c. in 2017 (2011 PPP\$)	1,697	5,481	13,822	35,938	11,676
Residual life expectancy	47.82	46.47	45.11	41.86	45.12
<b>Median of Covid-19 mortality, no intervention and saturation</b>					
Deaths per capita	0.00169	0.00289	0.00503	0.0113	0.00434
LYs per death	17.77	16.10	14.97	11.89	14.95
LYs per person	0.0302	0.0445	0.0762	0.128	0.0655
<b>Median shock on poverty HCR</b>					
Poverty line (median)	1.9	3.2	5.5	21.7	5.5
Baseline scenario, distribution-neutral	0.019	0.021	0.021	0.028	0.023
Baseline scenario, +3.6% in Gini	0.036	0.0355	0.043	0.040	0.037
<b>Median break-even <math>\tilde{\alpha}</math>, no intervention and saturation</b>					
Baseline scenario, distribution-neutral	0.609	0.491	0.323	0.259	0.387
Baseline scenario, +3.6% in Gini	1.089	0.869	0.642	0.354	0.646

<sup>29</sup>The infection rate leading to herd immunity depends on preventive behaviors, e.g., use of masks or social distancing practices. Our no-intervention scenario should account for typical behavior at the outbreak of the pandemic, when pre-pandemic behavior was still largely the norm. With less preventive behaviors, the threshold infection rate is expected to be larger.

Yet, we cannot rule out no-intervention as a plausible policy in some low-income countries. Their median break-even  $\tilde{\alpha}$  is slightly larger than one under one of the two scenarios shown in Table 3 (under our baseline 80% infection rate). This is the scenario in which we allow inequality to increase, which leads to higher poverty costs of the pandemic and therefore larger break-even  $\tilde{\alpha}$  values. At least some low-income countries have break-even  $\tilde{\alpha}$  larger than two (see Figure 5). For values of  $\tilde{\alpha}$  in that range, the welfare comparison in the poorest countries remains theoretically ambiguous, although only for observers placing a low normative value on an additional year of life relative to a year in poverty.

Given an observer’s fixed normative choice of  $\alpha$ , the lower  $\tilde{\alpha}$  the greater the welfare losses associated with the no-intervention scenario, relative to the actual early June estimates. The downward-sloping relationship in Figure 5 thus indicates that the welfare losses from policy inaction relative to the responses observed until early June 2020 increase sharply with GDP per capita. This effect is emphasized when using a common poverty line for all countries, such as the international extreme poverty line (IPL) of \$1.90 a day (Ferreira et al., 2016). Figure 6 provides a scatter plot of  $\tilde{\alpha}$  for all countries using the IPL. The slope of the fitted line is very steep. When using extreme poverty in all countries, we obtain  $\tilde{\alpha}$  values well below 0.1 in high-income countries.<sup>30</sup> This is because even in the case of a deep recession, high-income countries would have very little extreme poverty, because incomes are far above the extreme threshold.<sup>31</sup>

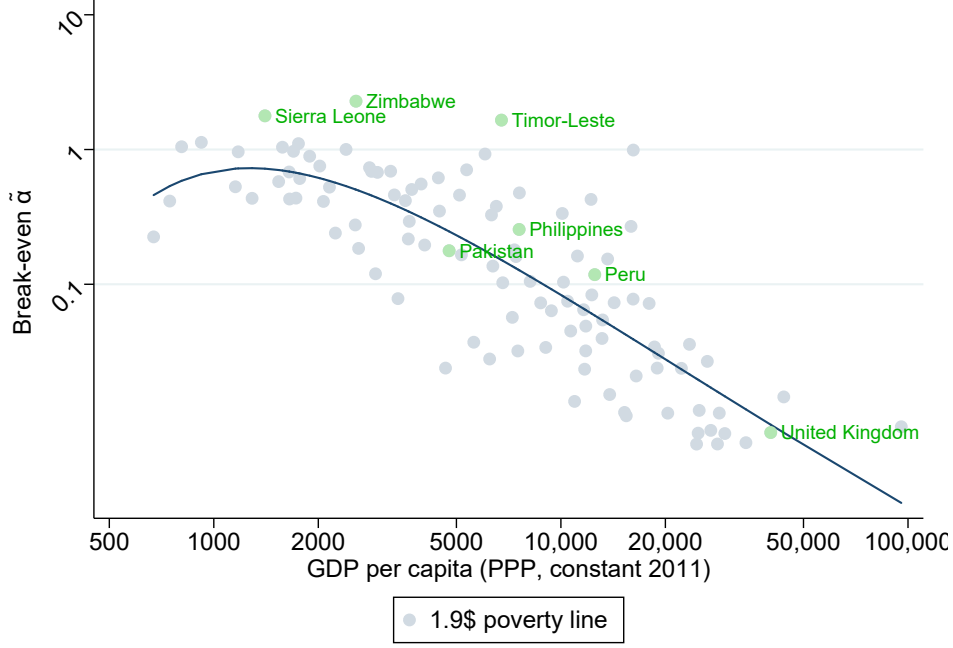
This finding suggests that a country’s optimal intervention is likely to differ as a function of its development level. For a given rate of infection and negative GDP shock, the relative sizes of the two sources of welfare consequences vary greatly with GDP per capita. On average, the more developed the country, the larger are the mortality costs and the smaller are the poverty costs. We have shown that these differences are quantitatively large. This implies that best policy responses might be more targeted towards containing infections in developed countries and towards containing poverty in developing countries - even though we treat the value of a year of human life as identical across countries throughout.

Table 4 summarizes our main estimates for the four income categories of countries and for the world, under our different scenarios. These estimates are the building blocks behind our break-even  $\hat{\alpha}$  and  $\tilde{\alpha}$ . The table reiterates the point that for LICs, PYs are on average of the same magnitude as LYs in all no-intervention scenarios, while for HICs LYs dominate in the no-intervention scenarios or if considering the frugal \$1.90 poverty line. For the world as a whole, PYs dominate greatly in the current scenario but are surpassed by LYs in both no intervention scenarios. Table 4 also provides a sense of

<sup>30</sup>Even when using the \$3.2 a day or \$5.5 a day lines instead of the extreme line, break-even  $\tilde{\alpha}$  values remain below 0.1 in high-income countries. See Figure A.13 in the Appendix.

<sup>31</sup>Even assuming a 50% infection rate under no-intervention, break-even  $\tilde{\alpha}$  values remain below 0.1 in high-income countries. See Figure A.12 in the Appendix.





**Figure 6:** Break-even  $\tilde{\alpha}$  in all countries as of early June 2020 (baseline, distribution-neutral contraction, no-intervention scenario with saturation, extreme poverty threshold)

the additional increases in poverty likely to arise if the pandemic-reduced recession is inequality-increasing, instead of distribution neutral. Applying a stylized "Argentina" growth incidence curve across all countries, as described above, adds 62 million PYs when the IPL is used for all countries, and 133 million PYs when the income-class specific "WB classification" poverty lines are used.<sup>32</sup>

## 5 Concluding remarks

The Covid-19 pandemic has generated huge losses in well-being around the world, by increasing mortality, causing ill-health and suffering, closing schools, etc. In combination with individual and policy responses, the pandemic has also generated a large global negative economic shock, with GDP declines currently expected to range from 4.8% on average in low-income countries to 8.9% on average in high-income countries. These marked economic contractions are causing substantial increases in poverty, reversing – at least temporarily – a hitherto sustained trend of global poverty decline which had been in place since 2000.

In this paper we focus on the mortality and poverty costs of the pandemic. We propose a simple framework to conduct a welfare evaluation of those costs, relying on a comparison of the number of years lost to Covid-19 deaths (lost-years) with the number

<sup>32</sup>These conclusions are qualitatively unchanged when using the downside growth scenario (results available upon request).

**Table 4:** Lives and livelihoods - pandemic's aggregate effects on mortality and poverty (Current = early June 2020)

	(1) LIC	(2) LMIC	(3) UMIC	(4) HIC	(5) World
<b>Total number of Covid-19 deaths, in million</b>					
Current scenario	0.000773	0.0171	0.0892	0.288	0.396
No intervention, no saturation	1.015	9.396	14.82	7.387	32.66
No intervention, saturation	1.159	10.23	15.61	13.28	40.32
<b>Total increase in lost-years, in million</b>					
Current scenario	0.0113	0.221	1.217	2.875	4.325
No intervention, no saturation	14.73	121.4	195.9	73.75	406.4
No intervention, saturation	20.59	153.7	227.8	157.9	560.7
<b>Total increase in poverty-years, in million</b>					
<i>Distribution-neutral scenario</i>					
1.9 PPP-\$ poverty line	13.74	47.12	6.780	0.235	68.22
WB classification poverty line	13.74	138.7	53.90	28.46	234.8
<i>+3.6% in Gini scenario</i>					
1.9 PPP-\$ poverty line	21.00	91.58	16.43	0.569	130.5
WB classification poverty line	21.00	196.4	106.5	44.44	368.3

of additional person-years spent in poverty in 2020. Drawing on a rich combination of data sources on Covid-19 mortality; demographic structures and age distributions; and on income distributions for 150 countries in the world, we estimate that the pandemic had generated 4.3 million lost years and as many as 68.2 million additional poverty years globally (using the extremely frugal international poverty line of 1.90 per day) by early June 2020. If median poverty lines are used for LICs, LMICs, UMICs and HICs, we estimate that 235 million poverty-years are being generated this year.

Across countries, the poverty-years to lost-years ratio ranges from just above 1 to more than 10,000. It is 3.6 in Belgium and 195 in Pakistan, for example. We document a strong association between this ratio and GDP per capita, with poverty costs being systematically larger in poorer than in richer countries, both in absolute terms and relative to mortality costs. These results are for our baseline scenario, which conservatively assumes a distribution-neutral allocation of the income losses associated with the declines in GDP. Poverty costs are even greater in an alternative scenario where we allow for some increase in inequality, based on the pattern estimated for Argentina by [Bonavida Foschiatti and Gasparini \(2020\)](#). For most developing countries, it is difficult then to avoid the conclusion that one would have to place a very low weight on the welfare cost of falling into poverty to conclude that the mortality costs of the pandemic exceed its poverty costs.

It is important to note that this does *not* mean that public interventions aimed at containing the spread of the virus have been “a cure worse than the disease”. Indeed we show that, for most countries, the absence of any non-pharmaceutical interventions would have led to mortality costs which exceed, on their own, the total welfare losses accrued as of early June, for any plausible value of  $\alpha$ . Thus, we must conclude that, for the vast majority of countries, no-intervention was a dominated response. Interventions were successful in slowing the spread of the disease and, even if they led to increases in poverty, welfare losses were substantially lower than under no-intervention. As with our estimates for early June, the mortality costs of the pandemic differ markedly between developed and developing countries in the counterfactual, no-intervention scenario. For given infection rates, developed countries face mortality costs several times higher than those of developing countries, because their populations are considerably older, and because they have longer residual life expectancies at given ages.

Taken together, the evidence we present makes it difficult to escape the conclusion that the optimal policy responses to the pandemic cannot be “one size fits all”. Responses should almost certainly differ across countries, with policymakers in poorer countries being justifiably more concerned with the poverty costs faced by their populations than those in richer countries. That said, we have not sought to identify the optimal position countries should take when facing policy trade-offs. We do not even believe that there necessarily *is* a trade-off between “lives and livelihoods” for every policy response to Covid-19. Developing a vaccine, for example, would clearly reduce both lost-years and poverty-years in the future. The same is likely true for early contact-tracing and large-scale testing. Imposing social-distancing early likely dominates doing it late ([Demirguc-Kunt et al., 2020](#)), and so on. Optimal policy choices require examining these trade-offs at the level of the individual policy, in a manner informed both by the demographic and socio-economic context, and by the set of other policy options available to the government.

What we hope to have contributed is a simple and transparent approach to estimating the relative welfare costs of Covid-induced increases in mortality and poverty. This approach may also be relevant for other economic problems that involve similar “lives-versus-livelihoods” trade-offs. For instance, assessments of the welfare costs of past pandemics mostly relies on methods attributing a monetary value to human life ([Martin and Pindyck, 2019](#)). Also, well-being comparisons across countries and time, which involve accounting for the quality and quantity of life, are typically based on expected lifetime utility ([Becker et al., 2005](#); [Jones and Klenow, 2016](#)). Cost-benefit analysis of environmental projects is regularly performed on the basis of a monetary value to human life ([Robinson et al., 2019](#); [Agency, 2014](#)). Another major field where this trade-off is pervasive is health economics, where cost-benefit analysis of drugs and policies are also based on a monetary value to human life ([Hausman, 2015](#)). In the latter case, the health impact of diseases is typically measured based on quality-adjusted life-years (QALYs), a

concept that takes into account not only the length of life but also health losses incurred by those surviving these diseases (Whitehead and Ali, 2010), physical losses or mental losses (Chisholm et al., 1997). Our methodology could readily be adapted in order to account for these costs by replacing lost-years by QALYs.

That said, there are also many ways in which our analysis can be improved in future research. Our estimates of lost-years and poverty-years are based on several strong assumptions that further research should try to relax, once the required evidence and data becomes available. For instance, our estimates of poverty-years should be refined for the countries that enacted substantial social assistance programs.<sup>33</sup> Also, our estimates of lost-years under “no-intervention” assume a constant infection rate across age categories. However, given the larger IFRs affecting the elderly, one might expect these individuals to adopt more cautious behavior and, therefore, observe lower infection rates in their age categories. In that case, herd-immunity could be reached with fewer deaths, implying that our estimates of lost-years are too high. Alternatively, infection rates might also be higher among the elderly if their immune system is less efficient at protecting them when they are in contact with an infected individual. Reviewing the early literature on the topic, Biswas et al. (2020) do not find significantly different risk of infection between individuals younger than 50 years and individuals older than 50 years. More generally, we ignore many important questions that may arise in the presence of a trade-off between lives and livelihoods. For instance, if the additional poverty-years are mostly concentrated among the young while the lost years of life are mostly concentrated among seniors, this may spark debates around inter-generational justice that are not tackled in this paper. These and other questions will certainly warrant refinements to some of our assumptions and modeling choices, as better data about this pandemic becomes available.

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<sup>33</sup>Lustig et al. (2020) find early evidence of considerable heterogeneity in the impacts of changes in social protection programs implemented in Argentina, Brazil, Colombia and Mexico during 2020 in response to the pandemic.

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## A Appendix

### A.1 Data sources

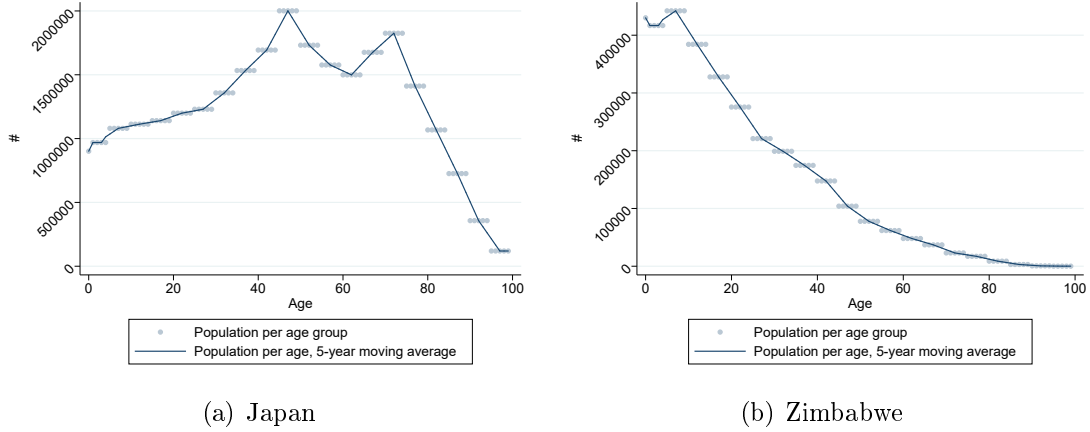
**Table A.1:** Data sources

Variables	Sources	Transformation
Population per age group	Global Burden of Disease ( <a href="#">Dicker et al., 2018</a> ) UN population division	Missing data imputed using IHME data Smoothing using 5-year moving average
Covid-19 mortality	Our World in Data (7/6/2020)	
Covid-19 mortality per age group		
Belgium	Sciensano (7/6/2020)	Smoothing using 9-year moving average
Sweden	Statista (5/6/2020)	Smoothing using 9-year moving average
England and Wales	Office for National Statistics (22/5/2020)	
Scotland	National Records of Scotland (31/5/2020)	Smoothing following data from England and Wales
Northern Ireland	Department of Health (6/6/2020)	Smoothing following data from England and Wales
Pakistan	http://covid.gov.pk (8/6/2020)	Smoothing using 9-year moving average
Peru	Ministry of Health (7/6/2020)	Smoothing using 9-year moving average
Philippines	Department of Health (7/6/2020)	Smoothing using 9-year moving average
United Kingdom	Authors' estimates	Aggregation of data from constituent countries
All countries	Authors' estimates	Smoothing using 5-year moving average See section <a href="#">A.2</a>
Infection to Fatality Ratio (IFR)		
IFR in LIC and MIC	<a href="#">Verity et al. (2020)</a>	Exponential fit (see Section <a href="#">A.2</a> )
IFR in HIC	<a href="#">Salje et al. (2020)</a>	Exponential fit (see Section <a href="#">A.2</a> )
IFR if health care saturation	Authors' estimates	Maximum of $P(ICU infected)$ and IFRs
Mortality from other causes in 2017	Global Burden of Disease ( <a href="#">Dicker et al., 2018</a> )	
GDP per capita in 2011 PPP\$	World Bank, World Development Indicators	
GDP growth forecast		
Belgium	National Bank of Belgium	
Sweden	Sveriges Riksbank (Central Bank of Sweden)	
United Kingdom	Bank of England	
LIC and MIC	World Bank, Global Economic Prospects	
HIC	IMF, World Economic Outlook	
Poverty forecast	PovcalNet and Lakner et al. (2020)	

## A.2 Variables

Data sources are described in table A.1. The following transformations were applied to the data.

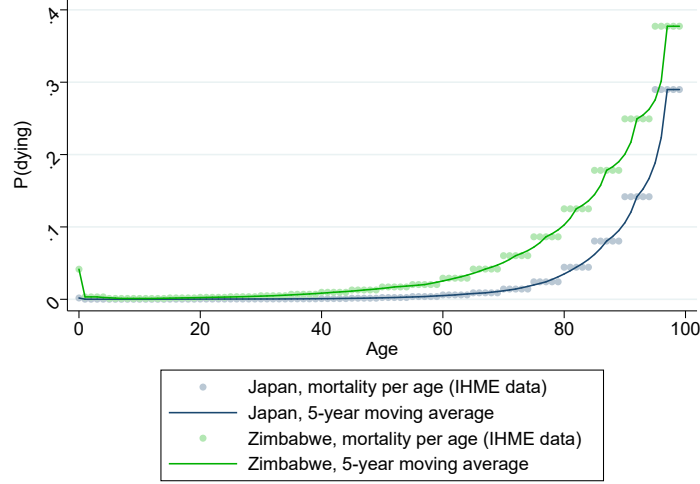
**Population by age** The population data from the UN population division are organized in 5-year categories. The population data from the IHME are also organized in 5-year categories, except the category 0-4 which is split in two (0-1 and 1-4). For each country, we first split the population of the age category 0-4 into two sub-categories following the same distribution as the 0-1 and 1-4 categories in the IHME data. We smooth the resulting data using 5-year moving averages. The results are shown in figure A.1 for Japan and Zimbabwe. Smoothing is expected to lead to more precise results. For Belgium, for example, the correlation between the 5-year moving average and population by age from STATBEL is slightly larger (0.997) than the correlation between the original data and STATBEL population by age (0.994).



**Figure A.1:** Age pyramids for Japan and Zimbabwe

**Mortality by age** We use data on population and number of deaths by age category from the Institute of Health Metrics and Evaluation. The most recent data are for the year 2017. We first smooth the two variables using 5-year moving averages. We then calculate the mortality by age as the ratio of the number of deaths by age (moving average) to the population by age (moving average). The results are shown in figure A.2 for Japan and Zimbabwe.

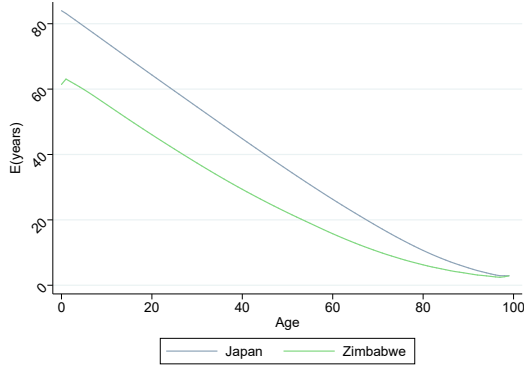
**Residual life expectancy by age** The maximal age in our data is 99. We denote  $m_{aj}$  the probability that an individual of age  $a$  in country  $j$  has of dying within a year and  $\lambda_{aj}$  its residual life expectancy. For each country, we calculate the residual life expectancy at 99 as  $1/m_{99,j}$ . We calculate the median value of the estimates obtained for each country



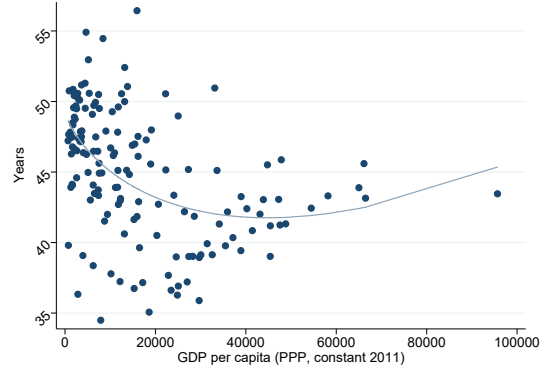
**Figure A.2:** Mortality by age for Japan and Zimbabwe

and assume that the result - 2.9 years - is the residual life expectancy at 99 for all countries. We then calculate  $\lambda_{aj}$  backwards for all ages, as  $\lambda_{aj} = 0.5m_{aj} + (1 + \lambda_{a+1,j})(1 - m_{aj})$ . The life expectancy at age  $a$  is given by  $l_{aj} = a + \lambda_{aj}$ . The residual life expectancy and life expectancy at age  $a$  are shown in figure 3(a) for Japan and Zimbabwe. The average residual life expectancy in country  $j$  is given by  $\bar{l}_j = \sum_{a=0}^{99} N_{aj}\lambda_{aj}/N_j$ , where  $N_{aj}$  is the size of the population of age  $a$  in country  $j$  and  $N_j$  is the total population of country  $j$ .

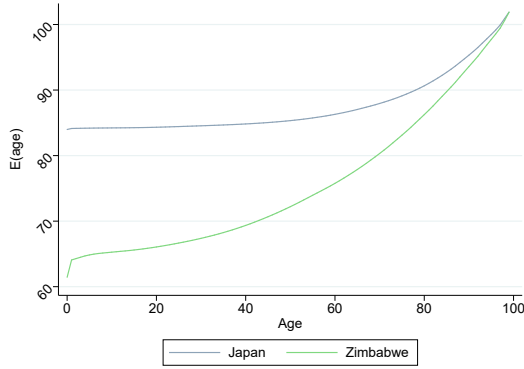
**Infection Fatality Rate (IFR)** For high-income countries, we use IFR estimates from Salje et al. (2020), who analyzed data on Covid-19 mortality from France. For low-income and middle-income countries, we use IFR estimates from Verity et al. (2020), who analyzed data on Covid-19 mortality from China. Both IFR estimates are provided for 10-year age categories below 80 years old and then one 80+ residual category. The literature on Covid-19 suggests that Covid-19 mortality is increasing exponentially with age (Promislow, 2020). We therefore smooth the IFR estimates of Verity et al. (2020) and Salje et al. (2020) using an exponential fit. Results are shown in figure A.4. For the “no-intervention” scenario leading to herd immunity, it is likely that the IFR would be higher than the estimates of Verity et al. (2020) and Salje et al. (2020) because health care systems would be saturated. For this no-intervention scenario with saturation of health care systems, we construct a higher-bound IFR by assuming that all infected individuals needing intensive care die. For this purpose, we use the data of Salje et al. (2020) and multiply the probability to be hospitalized if infected by the probability to go to intensive care if hospitalized. We smooth the series using an exponential fit. When this higher-bound IFR is lower than the IFR estimated by Verity et al. (2020) and Salje et al. (2020), we consider the maximum of the values.



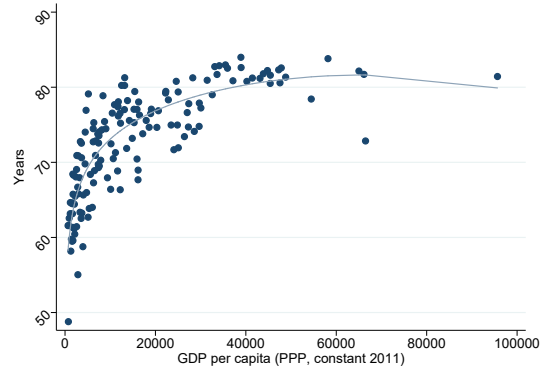
(a) Residual life expectancy by age



(b) Average residual life expectancy

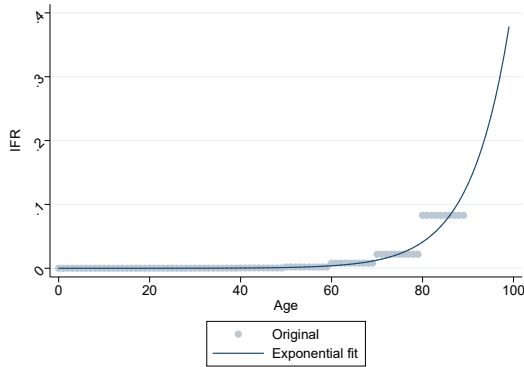


(c) Life expectancy by age

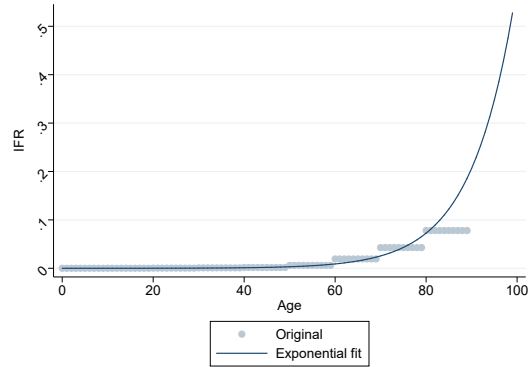


(d) Life expectancy at birth

**Figure A.3:** Residual life expectancy and life expectancy



(a) IFR from (Salje et al., 2020)



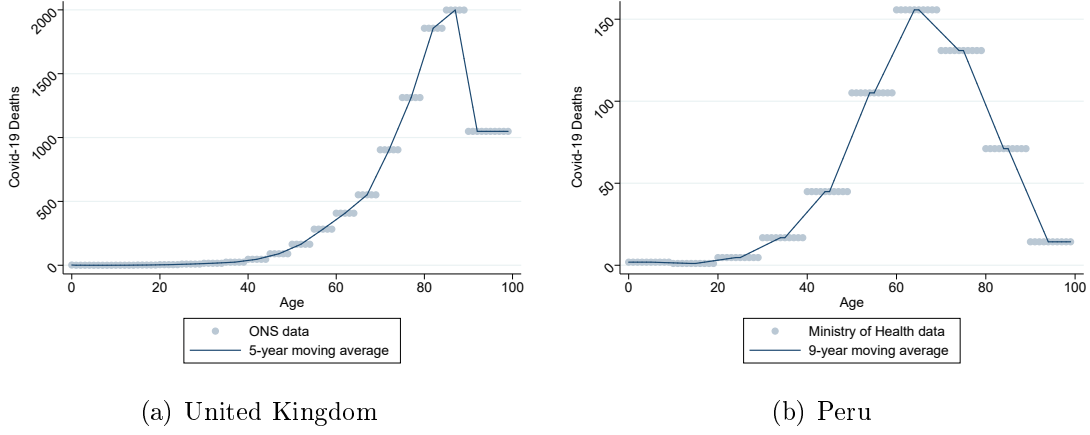
(b) IFR from (Verity et al., 2020)

**Figure A.4:** IFR estimates in China (Verity et al., 2020) and France (Verity et al., 2020)

**Covid-19 deaths by age** For Belgium, Sweden, the United Kingdom (UK), Pakistan, Peru, and the Philippines, we have data on Covid-19 deaths by age category from early June 2020. We use a 5-year moving average to smooth the UK data, which are organized in 5-year categories. For other countries, categories are of 10 years or larger. We use

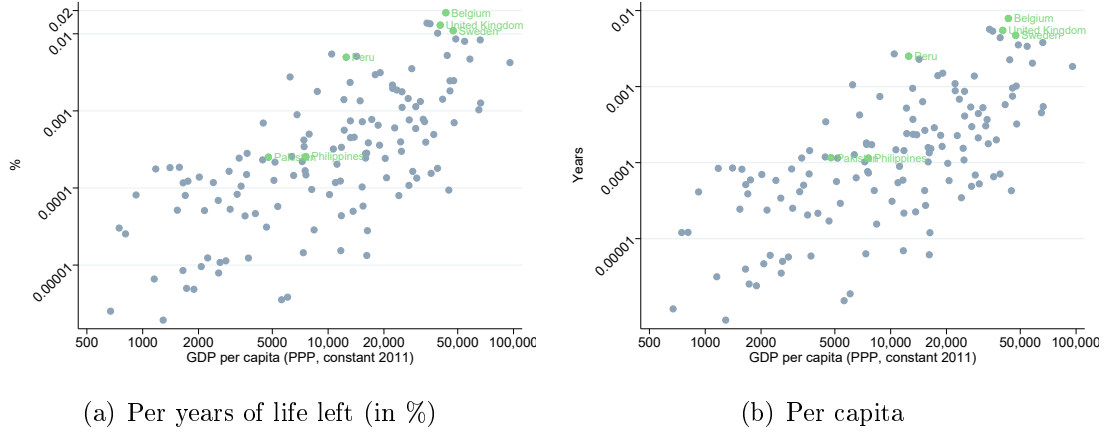
9-year moving averages to smooth the data. Results are shown in figure A.5.

For other countries, we estimate Covid-19 deaths by age by exploiting the IFR estimates and by assuming that the probability of Covid-19 infection is independent of age. We consider three scenarios. First, the current scenario. We denote  $d_{aj}$  the number Covid-19 deaths and  $\mu_{aj}$  the *IFR* at age  $a$  in country  $j$ . The total number of Covid-19 deaths in country  $j$  is denoted  $d_j$  (data were taken from Our World in Data). Our estimate of the proportion of people infected in country  $j$  is given by  $\varphi = d_j / \sum_{a=0}^{99} N_{aj} \mu_{aj}$ . The number Covid-19 deaths at age  $a$  in country  $j$  is given by  $d_{aj} = \varphi N_{aj} \mu_{aj}$ . The second and third scenarios assume that nothing is done to stop the spread of the epidemic, which infects 80% of the population until reaching herd immunity (Banerjee et al., 2020). In this case,  $d_{aj} = 0.8 N_{aj} \mu_{aj}$ . The two “herd immunity” scenarios differ in the IFR assumed (no saturation versus saturation of the health care systems).

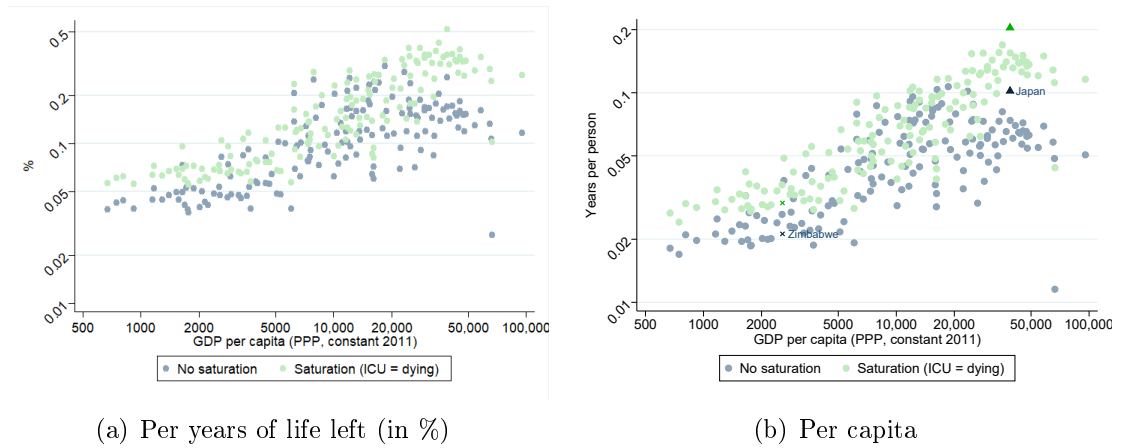


**Figure A.5:** Covid-19 deaths

**Years of life lost due to Covid-19** The total number of years of life lost due to Covid-19 in country  $j$  is given by  $\delta_j = \sum_{a=0}^{99} d_{aj} \lambda_{aj}$ . Results are shown in figure A.6 for the current scenario and in figure A.7 for the “herd immunity” scenarios.

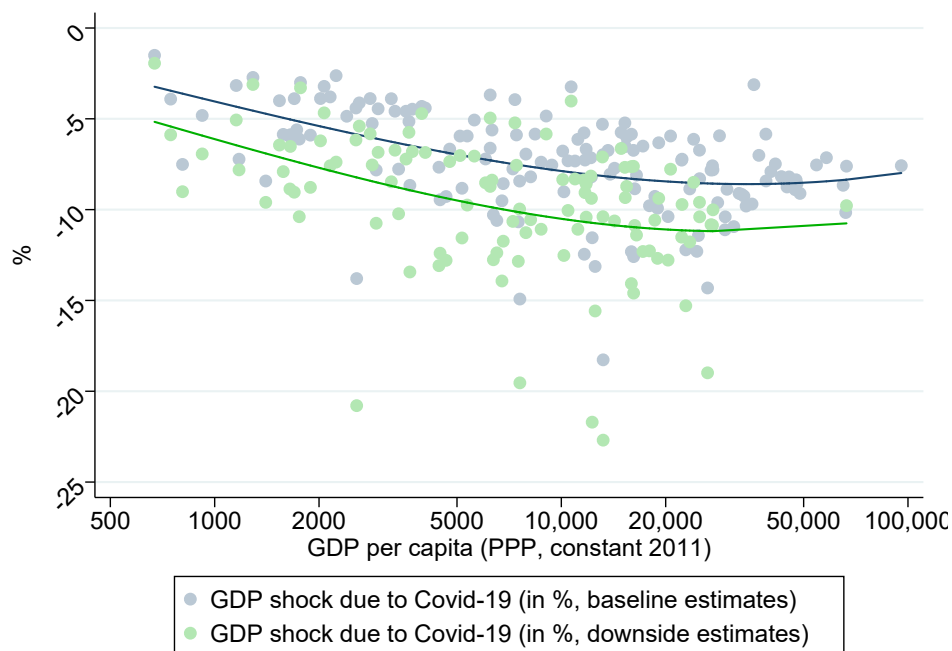


**Figure A.6:** Years of life lost due to Covid-19 - current scenario

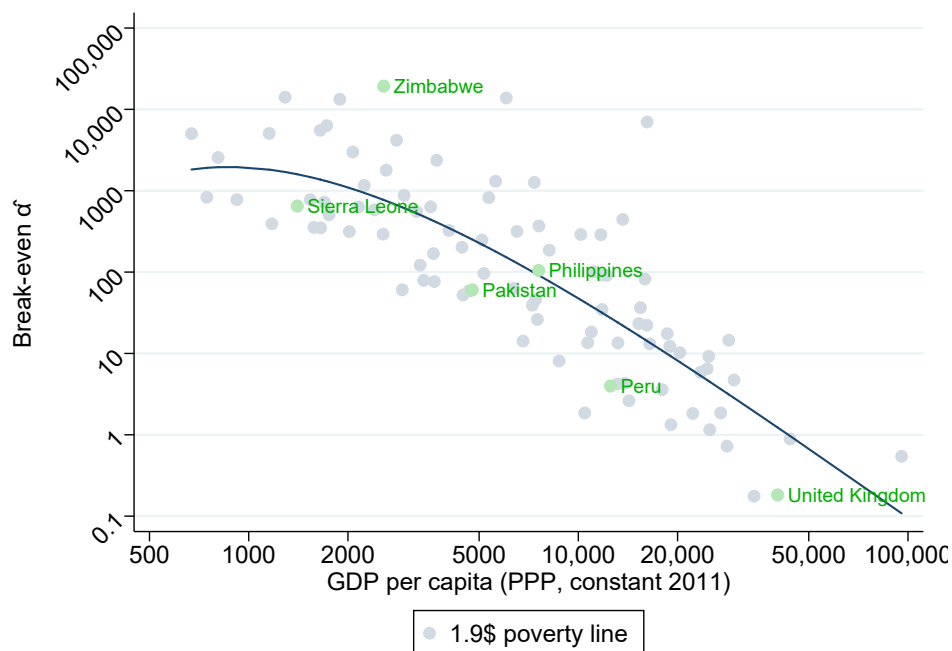


**Figure A.7:** Years of life lost due to Covid-19 - "herd immunity" scenarios

## B Supplementary figures and tables for publication on-line

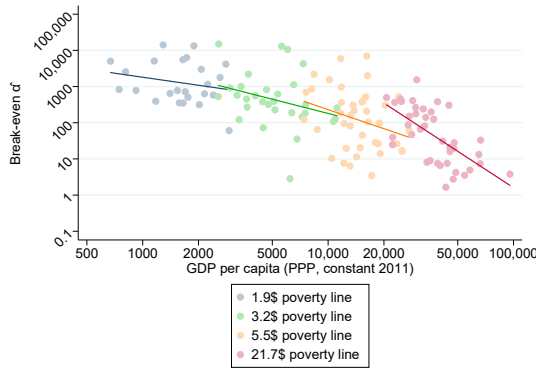


**Figure A.8:** Shock to GDP due to Covid-19 (baseline and downside estimates)

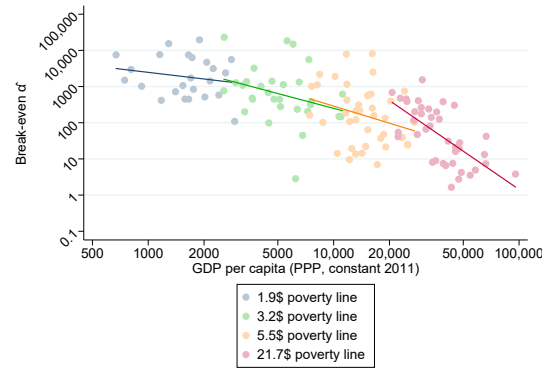


**Figure A.9:** Break-even  $\hat{\alpha}$  for the 1.9 PPP-\$ poverty line and the baseline growth scenario, Covid-19 mortality as of early June 2020

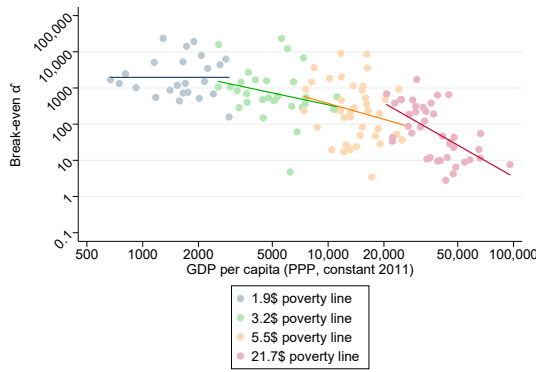




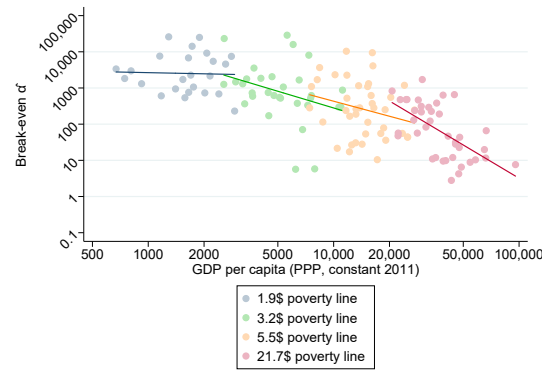
(a) Baseline, distribution-neutral



(b) Downside, distribution-neutral

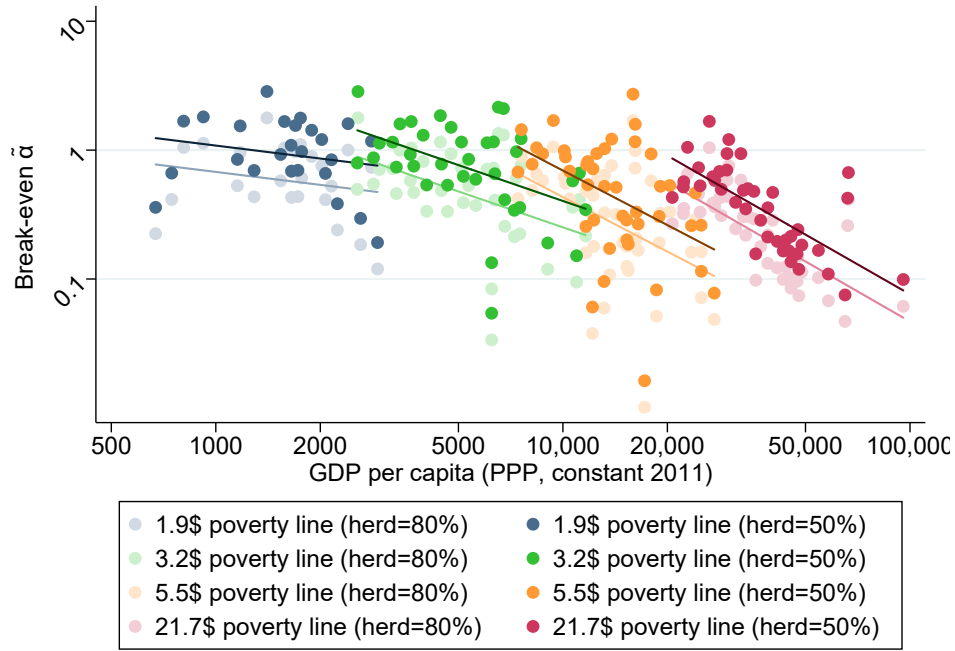


(c) Baseline, +3.6% in Gini

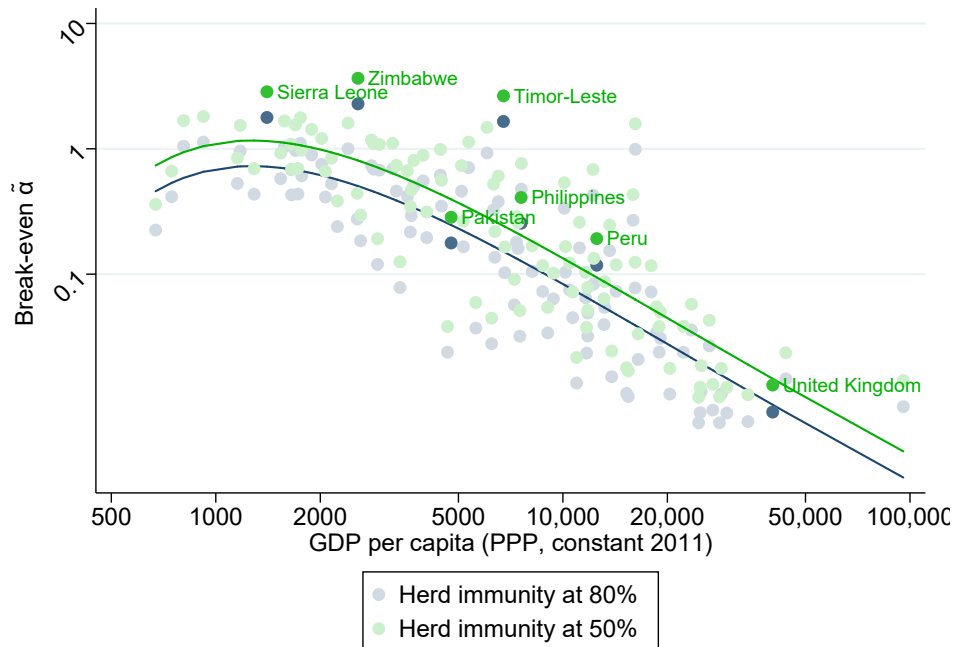


(d) Downside, +3.6% in Gini

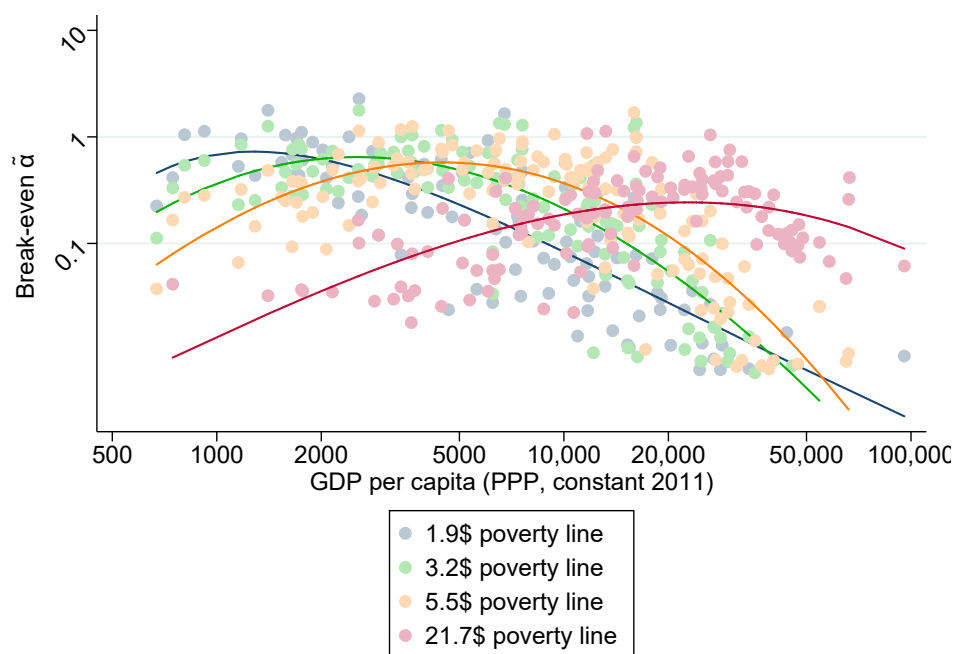
**Figure A.10:** Break-even  $\hat{\alpha}$  as of early June 2020 for the different scenarios of economic shock



**Figure A.11:** Break-even  $\tilde{\alpha}$  and herd immunity thresholds of 50% vs. 80% in all countries as of early June 2020 (baseline, distribution-neutral contraction, no-intervention scenario with saturation, group-specific poverty thresholds)



**Figure A.12:** Break-even  $\tilde{\alpha}$  and herd immunity thresholds of 50% vs. 80% in all countries as of early June 2020 (baseline, distribution-neutral contraction, no-intervention scenario with saturation, extreme poverty threshold)



**Figure A.13:** Break-even  $\tilde{\alpha}$  for different poverty lines (baseline scenario, distribution-neutral), Covid-19 mortality estimated in a no-intervention scenario with saturation of health care system