# Cost of covid–19

## Recruiting epidemiological models to estimate first round economic, welfare and public finance effects of COVID 19 strategies

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# Summary

**The COVID-19 epidemic was identified in China in December 2019. By April 2020 it is a widespread epidemic and the initial public policy responses have already been enacted in most countries.** Very commonly this includes some sort of lockdown to prevent infections and some sort of social protection and in some cases business support to ameliorate the immediate economic impacts of the lockdown. Both the disease and the initial 'reflex' response can be treated as an external shock.

**As of May 2020, most of the public policy choices are about what to do next.**

- How quickly should the blanket lockdown be relaxed?
- What should replace the blanket lockdown once it ends, in terms of alternative public health measures and healthcare investments?
- What can be done to minimize the longer-term economic damage, public finances and debt sustainability?
- What can be done to recover more quickly once the pandemic has passed?

**A critical part of the information needed to answer the first two questions is, what is the impact of policy on the course of the epidemic, on infections and deaths?** This is why every country needs an excellent, locally calibrated epidemiological model that can be re-run under different COVID-19 strategy scenarios such as investment in healthcare, timing of lockdowns, efficacy of follow on public health measures. Despite the similarity of the reflex response, local parameters characterizing the epidemic can be very different across countries, for example across East and South Asia, Europe and Africa (Henstridge 2020).

**It turns out that minimizing economic and public finance impact has a lot to do with the high-level policy decisions about public health.** This is why, in this note, an epidemiological model is recruited and adapted to assess the epidemiological, economic, welfare and public finance impacts of various COVID-19 strategies *simultaneously*. Certain economic support and poverty mitigation measures, notably social protection, may be designed to reinforce public health measures. Choices about public health measures have profound impacts on the economy and public finances.

The main conclusions about the immediate economic and public finance impact of COVID-19 strategies are:

- **Morbidity and mortality caused by the epidemic are highly sensitive to local conditions**, so the same policy response will not be optimal in every country.
- **The main epidemiological impact of blanket lockdowns is to 'buy time' before the infection starts again, and this time is bought at a very high economic cost.**

- **There is a high prize for finding targeted or ‘soft’ public health measures which will limit infections without blanket lockdowns.**

- Complexity can be added to models where needed, for example where part of the population is clearly more exposed to infection, more vulnerable, has distinct economic importance and/or needs to be targeted for/exempted from special measures – the salient issues will be different in different countries and given uncertainties over calibration of models, unnecessary complexity should be avoided.

- These models offer some excellent insights into choices and the ranking of strategies but have limited predictive accuracy because of calibration – large economic impacts are systematically underestimated because...

- …beyond these models it is vital to consider second round economic effects linked to the recession in demand, structural changes and the need to finance the household, business and public responses to the crisis.

- **There will also be very significant economic impacts from the international downturn,** which will be affected by some local policy choices and also by local economic characteristics in any particular country.

## Accuracy and the purpose of the modelling in this note

There is great uncertainty about the dynamics of the COVID-19 epidemic even in East Asia and Europe. In the illustrative examples in this note, the dynamics are designed to be close to the centre of the wide confidence intervals that exist in more sophisticated epidemiological models. But it should be noted that the models in this note are hypothetical illustrations of what can be modelled, not calibrated models for any particular country.

**To use these modelling principals in practice, best practice would be to adopt the highest quality epidemiological model being used in a particular country and augment it with the estimates of economic, welfare and public finance impact.**

In the hypothetical projections, *R* is set at around 2.4 without any public interventions as per (Pueyo 2020). Blanket lockdowns are assumed to reduce this by about 50%, whereas a combination of ‘softer’ public health measures might achieve a 33% reduction (Flaxman et al. 2020). South Korean mode test and trace, and reinforcements with social protection are assumed to further strengthen the impacts of public health measures. The projections produce a population mortality of about 1% in the do-nothing cases in countries with a European scale aged population, less in more youthful populations – this could still be an overestimate.

**Most of the economic and public finance impact of COVID-19 turns out to be related to the public health measures rather than the disease.** There should be less uncertainty about these although there is certainly variation across countries and some uncertainty, for example, about how many workers are really removed from the active workforce by lockdowns and other restrictions.

**Estimates of the type illustrated here would be a good starting point for consideration of economic impact but the analysis can be made more accurate by introducing modelling details which are appropriate for each economy, and by further moderating the implications of the medium term financing of the crisis and of the impacts of the international recession.**

This note is written with countries *outside* the first wave of high or upper middle-income countries in East Asian and Europe in mind.

## Modelling Notes: The Basic Epidemic

The hypothetical projections in this paper rely on a simple SIR of SIERM model close to that widely used at the core of most models of viral epidemics, including in 'Coronavirus: the Hammer and the Dance' (Pueyo 2020). Equations (1) to (5) below show how infections cause the population to transfer from 'susceptible', *S* to 'exposed', *E*, to 'infectious', *I*, and then either to 'recovered', *R*, or dead, *M*. The force of infection is λ, and the reproductive rate of the epidemic is the ratio of this and the days spent infected, $d_I$, although in this version, this is complicated if there is more than one population group. The projections in this note include two population groups, under 70s and over 70s, so *W*, the WAIFW matrix (who-acquires-infection-from who), is a 2x2 matrix showing the relative probability of someone from group *i* meeting someone from group *j*. A standard WAIFW has 16 age groups and there are empirical calibrations of this matrix for many countries (Prem, Cook, and Jit 2017). The number of population groups is *p*, in this note, 2. *N* is the total population, which is normalized to 100,000 in the projections in this note.

### Modified SEIRD model

(1) $\frac{\partial S_i}{\partial t} = -\lambda S_{i,t} \sum_{j=1}^{p} W_{ij} I_{j,t} / (N - \sum_{j=1}^{p} M_{i_i})$

(2) $\frac{\partial E_i}{\partial t} = \lambda S_{i,t} \sum_{j=1}^{p} W_{ij} I_{j,t} / ( N - \sum_{j=1}^{p} M_i) - 1/d_E E_{i,t}$

(3) $\frac{\partial I_i}{\partial t} = \frac{1}{d_E} E_{i,t} - \frac{1}{d_I} I_{i,t} - \sum_{j=1}^{q} \min[h_{ij} I_i , H_{ij}]. m_{ij}/d_I - \sum_{j=1}^{q} (h_{ij}\ I_i - \min[h_{ij} I_i , H_{ij}]). m_{ij}^{*}/d_I$

(4) $\frac{\partial R_i}{\partial_t} = \frac{1}{d_I} I_{i,t}$

(5) $\frac{\partial M_i}{\partial_t} = \sum_{j=1}^{q} \min[h_{ij} I_i , H_{ij}]. m_{ij}/d_I + \sum_{j=1}^{q} ( h_{ij} I_i - \min[h_{ij} I_i , H_{ij}]). m_{ij}^{*}/d_I$

### Healthcare

Once an individual is infectious, survival and mortality is determined by exogenous risk parameters and the healthcare related parameters in equations (3) and (5). These look complex because mortality is determined by healthcare and the model includes *p* population groups and *q* types of healthcare. A proportion of the population group *i*, $h_i$, needs each level of healthcare, *j*, such that if that healthcare is available, mortality is $m_{ij}$, if it's not available them mortality is $m^*_{ij}$. $H_{ij}$ is maximum availability of healthcare level *j* for population group *i*.

The projections in this note have just two population groups and two levels of healthcare, basic and intensive. The need for intensive care is low in the under 70s and relatively low in the over 70s. Those in need of intensive care have much higher probabilistic mortality than others, which is roughly halved by actually receiving intensive care. **All these parameters can be adjusted to calibrate the model to local conditions.**

### Cost of healthcare

Part of the public finance impact of COVID-19 is the financial cost of healthcare, which includes the operating cost of care, $c_{Hj}$ for everyone who uses it,

(6) $C_H = \sum_{i=1}^{p} \sum_{j=1}^{q} \min[h_{ij} I_{ij} , H_{ij}]. c_{H,j}$

…there would also capital costs, $C_{HK}$, if healthcare is expanded, not just changes in operating costs.

# Modelling the epidemic should be sensitive to local conditions

Without extending epidemiological models of COVID-19 beyond their basic purpose there are already huge uncertainties about how the virus will behave in any setting – the disease is new and not enough is known about the force of transmission, even in China let alone in other countries (Zhang et al. 2020).

**The determinants of the epidemic's progress are not fully understood.** Age has a strong effect on survival, so demographics matter (Monnery 2020). Knowledge about treatments is evolving but survival of some patients is increased with basic or intensive healthcare. Different population densities, social and economic patterns affect transmission between groups. It is also possible that the virus is more virulent in different environments and climates. The level of infection is different in different countries on any one date – but even this is a matter of uncertainty because representative sample testing is absent in most settings – the best estimate of the level of infection can be an inference from quite limited information (Henstridge 2020).

**Because of all this, best efforts need to be made to calibrate the basic epidemiological model as accurately as possible for a particular country.** This will have a lot of bearing on how effective different COVID-19 strategies are. The importance of some of this heterogeneity is illustrated by comparing two hypothetical countries, in figures 1 and 2, in these cases with no intervention other than healthcare.

Figure 1

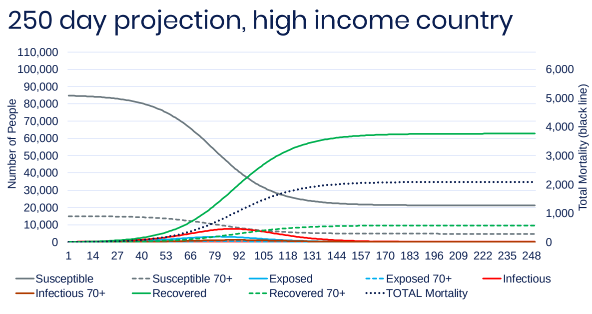



Figure 2

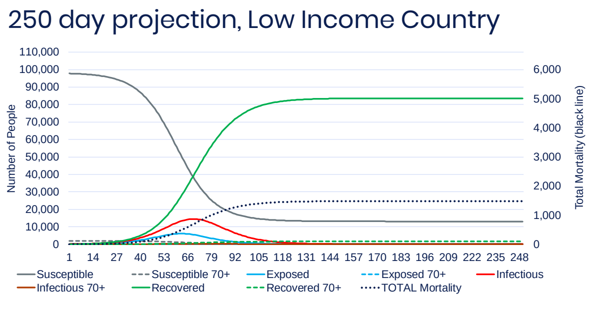



Figure 1 shows a high-income country where 15% of the population are over 70, with much higher expected morbidity and mortality in the event of an infection. This country also has a good supply of healthcare including 150 intensive care units (ICUs) per million population. Figure 2 by contrast is low income with only 2% of the population over 70, but also with only 2 ICUs per million. These are the *only* differences modelled. In the figures, the under 70s population moves from susceptible (solid grey line) through exposed and infectious (solid blue then red), and then either to recovered (solid green) or died, with total mortality across both groups in dotted black, right hand scale. In the high-income country the over 70s group is visible with dashed lines but in the low income country it is too small to see.

Better healthcare means the high-income country has lower mortality in both groups: 1% in the main population and 7.9% in the over 70s compared to 1.3% and 8.8% in the low-income country. However, the youthful population in the low-income country means that total mortality is less there, 1.5% compared to 2.0% for the high-income country. This means some policies that are optimal in the first country might not make sense in the second.

Investment in new intensive healthcare can be modelled but it is very expensive and hard to put in place in a timely way, so not very relevant for lower income countries – for other countries it is more feasible and, in many cases, stocks of ICU equipment get overwhelmed even in high income countries.

# Modelling Notes: Lockdowns

## Social Distancing and the Epidemic

'Blanket lockdown' is the policy where the whole population is asked to avoid social contact beyond a very limited group, with some exceptions. In this model, social distancing measures reduce the susceptible population over a period. If the effectively distanced population for group $i$ is $D_{i,t}$, then $(S_{i,t} - \delta D_{i,t})$ substitutes for $S_{i,t}$ in (1) and (2) above, which reduced the supply of new infections, $E$. The completeness of the reduction in transmission from distancing is $\delta$, which has maximum value 1. So, if the social distancing policy is for 80% to social distance, compliance produces effective social distancing by 60% and $\delta$ is 85% then the susceptible population is reduced by 0.6 x 0.85= 51% over the lockdown period.

It would be more accurate to model distancing as removing population from each $S$, $E$, $I$ and $R$ group pro-rata but this has little impact on results except for lockdowns in late stages of the epidemic, when the recovered and immune population, $R$, is already high.

## The Economic Impact of Social Distancing

In this model, the direct economic impact of the epidemic and also the immediate impact of social distancing measures is to reduce output by withdrawing labour from the productive economy. The 'Full Economic Cost' of a package of options is the financial costs of health, public health and social protection, $C_H()$, $C_{HK}$, $C_{PHK}$, $C_{SP}.SP$, $C_{SPK}$ plus the economic output $F()$ over the period less all the same costs in the 'do nothing' or base case.

A proportion of each population group $l_i$, will be active in the economy. So the workforce is

$$(7)\quad L = \sum_{i=1}^{p} l_i\,(S_i - D_i + (1-\sigma_i)(E_i + I_i) + R_i)$$

…such that the labour force varies as the epidemic progresses and also with distancing. $\sigma_i$ is the share of the infected population who cannot work in each population group.

Production on the supply side is:

$$(8)\quad F_t = K_t^{\alpha} L_t^{(1-\alpha)}$$

We have an observation of $F()$ and $L$ at period zero and with an observation of, or assumption about $\alpha$ such as $\alpha$=0.5, this is enough to calibrate the supply side response of removing labour from GDP. We don't need an observation of capital.

## Segmenting the population

The standard WAIFW matrix, $W$, just models cross-infection across age groups but there is no reason, subject to calibration, that $W$ cannot be used for other relevant population groups. For example rural and urban or regional workers in different economic sectors. Where relevant, an additional complication could be to introduce different labour productivity for different population groups. For example, in many low and lower-middle income countries it might be very useful to model workers as *urban-formal-sector, urban-informal-sector* or *rural.* These groups might have different mixing (and therefore transmission risk) due to density in living spaces, captured in $W$, and different average labour productivity which could be accommodated with an adaption of (7) above. (See targeted public health measures below).

This sort of flexible population segmentation is a powerful feature of the model, but it would be best to confine complications to highly relevant issues given the uncertainties in calibration.

# Lockdowns: the baseline ‘reflex’ blanket lockdown and the economic impact of further lockdowns

**Despite the heterogeneity in epidemic characteristics, and perhaps partly because of the uncertainty around these differences, very many countries introduced versions of a blanket lockdown public health policy in the second half of March 2020** (Henstridge 2020). This included countries with thousands of cases, like the UK, and also countries with only a handful of known infections and no deaths at all, like Uganda.

**Because this policy is so ubiquitous, it is referred to as the ‘reflex’ policy in this note and is treated as part of the initial, external shock, along with the disease itself.** All packages of interventions which are assessed are against the baseline of a ‘reflex’ 42-day lockdown.

Although there are local differences in the severity of lockdowns, ‘blanket lockdown’ is taken to mean a policy where the whole population is asked to avoid social contact beyond a very limited group, with some exceptions.

Three lockdowns of progressing duration are shown in figures 3, 4, and 5. The impact of the lockdown on the disease is via the removal of individuals from the susceptible population – this won’t be 100% of the population because essential workers are always exempt, and often this category is quite broad and there are many exceptional activities which are permitted. In the model we assume about half the population is effectively removed, temporarily, by the lockdown, depressing the grey ‘susceptible’ line visibly in the graphs. The lockdowns’ main impact on the epidemic is to ‘buy time’ and delay infections, clearly indicated by the rightward migration of the red ‘infectious’ curves through the figures below. Unfortunately, the total number of infections is not altered and almost no lives are saved by the end of the 250-day period.

**The blanket lockdowns are not at all cost-effective by themselves**, on our measure of ‘Full Economic Cost per Life Saved’. On the extra three weeks on top of the 42-day base case lockdown, full economic cost is equivalent to 293 years of GDP/capita for each life saved.

**Economic impact is modelled in quite a conservative way based on the immediate supply side effects of the removal of labour from the workforce.** Total output is the thick blue line in each of figures 3, 4 and 5 and is depressed where social distancing occurs. Full economic cost of a COVID-19 strategy includes the financial cost to the government of implementing the measures, but where there are blanket lockdowns, these are generally dwarfed by the impact on economic output.

## Figures 3, 4 and 5


**The impact of extending the baseline lockdown by three weeks is 1.7% of annual GDP.** This alone would be enough to cause a recession in the UK. The impact of the 126-day lockdown is to reduce GDP by 6.8%, or 10.2% including the baseline 42-days. This would cause a deep recession even in a fast-growing economy. In the model, public finances are depressed by the same percentage of annual gross revenue.

## Modelling Notes: 'Soft' Public Health, Targeted Measures, Poverty and Social Protection and Public Finance Impact

### Soft Public Health

Different public health measures might act by reducing the force of transmission of the disease, $\lambda$. So $\lambda^*$ can substitute for $\lambda$ in specified period to bring down the new infection rate in equations (1) and (2) above. The financial cost of public healthcare measures are best modelled as fixed costs for each programme, $C_{PHK}$.

### Modelling Poverty and Social Protection

One way of estimating poverty impact is to find an existing estimate of the income-elasticity of poverty in the particular country, $\pi$, $\pi<0$, such that changing poverty is related to changing output:

(9) $\Delta POV = \pi . g . POV$

…where g is the growth rate and *POV* is headcount poverty rate. However, estimates of poverty elasticity relating to long run growth may not be a good way of estimating poverty changes in response to sudden, deep shocks.

An alternative, more meaningful measure is workers' earnings, including workers who are made unemployed by the lockdown. If output is depressed by the removal of labour, the workforce's incomes will also be depressed. A conservative assumption would be that the share of output going to workers remains fixed at the historic level ω, which actually implies that the wages of those still working go up.

At a macro level, increases in access to social protection, *SP*, with social protection transfers, $SP_{tf}$ , increase income available to the workforce and if they are well targeted, should alleviate the poverty impact. So average incomes across the whole workforce is:

(10) $$y = \frac{\omega F + SP_{tf}.SP}{L_0}$$

In different scenarios, *y* alters compared to the base case where *SP* is zero.

### Modelling Targeted Measures

This note includes the modelling of a lockdown for over 70s only. This is an example of a targeted measure where distancing for one group, $D_1$, would endure for much less time than for the second group $D_2$.

As discussed above under 'segmenting the population', groups can be defined in each country to have useful characteristics: differences in transmission risk, expected morbidity/mortality with infection and on the basis of economic characteristics.

### Modelling Immediate Public Finance Impact

On the cost side there is the financial costs of health, public health and social protection including the actual transfers, $C_H$, $C_{HK}$, $C_{PHK}$, $C_{SP}.SP$, $C_{SPK}$, $SP_{tr}.SP$.

On the revenue side, revenue falls probably as a non-linear function of output, with the marginal ratio of revenue to output higher than the average ratio. If there is an estimate of the output-elasticity of public revenue it should be used but as a conservative approximation we can assume a linear relationship

(11) $$R_t = rF_t()$$

The incremental public finance impact of a COVID-19 strategy is the sum of public financial cost of measures taken plus the public revenue collected, less those costs and revenues in the base case.

# ‘Soft’ public health

**If lockdowns only buy time, very expensively, then an alternative is needed.** Vaccines or effective treatments would either interrupt transmission or reduce mortality. But in the absence of these, ‘soft’ public health measures are those which reduce transmission without closing down economic activity. These include handwashing and cough-hygiene campaigns and moderate limits to contacts which still enable most work. Importantly they also include versions of the test-and-trace measures undertaken in countries like South Korea, Singapore and Japan, all of which have controlled the epidemic without lockdowns.

## Figures 6, 7 and 8

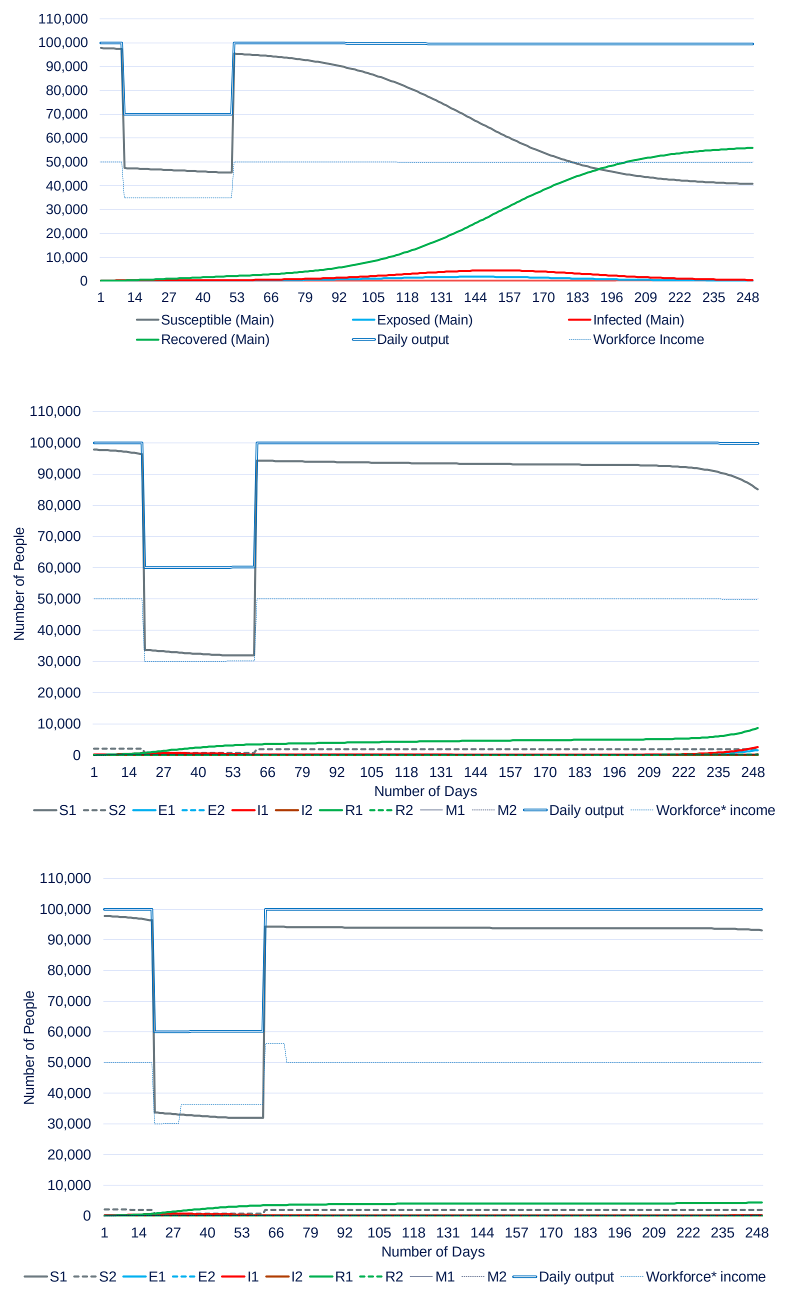


Figure 6 shows the baseline 42-day lockdown followed by 'soft' measures that reduce the force of transmission by one third. This greatly slows the spread of infection and reduces mortality from 1,463 to 977 in the 100,000 population. Figure 7 shows 'soft' measures reduce transmission by half. Within the model this reduces deaths to 254 or 0.25%, although more infections and deaths are likely to occur after the 250 days modelled.

**These options are highly cost effective – they are assumed to be cheap to implement and they reduce economic damage compared to the base case.** So full economic cost per life saved is sub-zero.

**The question is: do such effective strategies actually exist?** They are certainly worth looking for even if the financial cost of implementing them is much higher than modelled here.

# Poverty and social protection

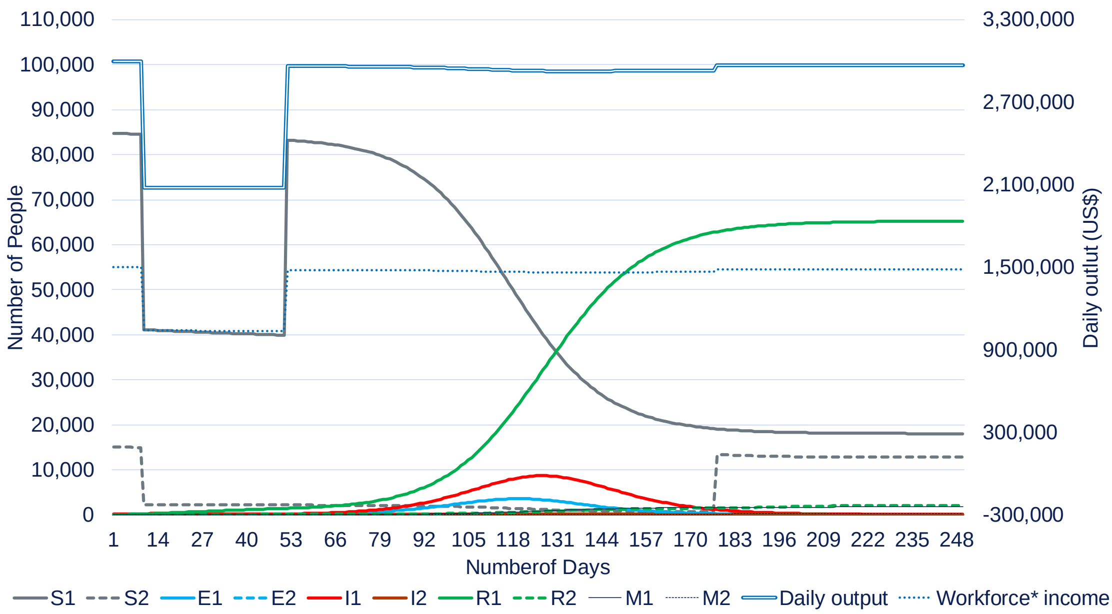
**Social protection is being considered as part of COVID-19 strategies because lockdowns cause hardship and poverty as well as economic damage.** Figures 3 onward show the share of income yielding to workers in the thin blue line – this gets depressed by the lockdown along with economic output. Extending social protection programmes risks undermining public health measures but well managed programmes could reinforce behaviours required in public health policies (Lee and Mertens 2020) (Pande et al. 2020). Figure 8 shows the combination of the strong 'soft' public health measures of Figure 7 with a social protection scheme that reinforces them even more. Under these assumptions this brings deaths down to just 79. The scheme is expensive for the government, costing the equivalent of a month of gross revenue on top of the base case impact. But this pays for itself because the full economic cost per life saved is still negative, i.e. full economic cost per life saved is still sub-zero.

**In long lockdowns, social protection might be even more necessary to prevent hardship but would be even more expensive for the government.**

# Targeting Public Health Measures

The model splits the population into different groups: in this note just the over- and under-70s, but this can be adapted. Reasons to do this are that the transmission risks, healthcare needs, mortality and also labour productivity and workforce participation may be very different across groups. This allows us to model public health measures which differentiate across groups, for example, only the over 70s lockdown. If this lockdown can be sustained it can have a strong impact on mortality in the over 70s groups. In the high-income country example in Figure 9, a very long 24 week lockdown for over 70s is visible in the depressed dashed grey line. This reduces mortality in the over 70s group from 8.0% to 1.5%, after which the main part of the population has mainly been infected and the virus does not re-emerge in the elderly group. It still leaves mortality unaffected in the under 70s however, so mortality overall is reduced by a third and remains quite high. For countries with a more youthful population, the impact on over 70s is still good but the overall impact is even less because this group is so small.

Figure 9




**Targeting vulnerable groups is potentially much more cost effective than blanket lockdowns.** The measures modelled here achieve full economic cost per life saved of 1.3 years of GDP/capita equivalent. This is simply because withdrawing the over 70s from the workforce has much less economic impact than withdrawing the under 70s.

**The model can be adapted to look at locally relevant ideas about targeted policies.** The very simple models in this note only split the population into two age groups but more age groups are possible – school children aged 6-20 are a highly relevant group because they interact very strongly in school which is why school closures are a common form of targeted lockdown. But the population can also be divided, for example, into spatial groups, e.g. capital city, other urban centres and rural areas; and/or economic groups, e.g. formal and informal non-agricultural workers plus agricultural workers. Depending on the setting, the epidemiological and/or economic consequences of targeted distancing rules for these groups, or rules which prevent the groups from interacting with each other could be extremely relevant for cost effective epidemic control.

# Public finance impact

**The public finance impact of a COVID-19 strategy is related to, but different from the full economic cost. It is vital to assess the public finance impact because the government needs to see whether it is possible, and decide by what means, to finance the strategy.**

**The public finance impact includes the financial cost of measures implemented.** Lockdowns are relatively cheap to implement. So are other public health measures. Investment in new healthcare equipment, for example for ICUs, might be very expensive if it is enough to have any appreciable impact on survival. Social protection for larger parts of the population is also relatively expensive, even more so if a scheme has to be set up or massively expanded.

**However, by far the largest potential impacts are from long blanket lockdowns, via the impact on tax and non-tax revenues.** This is modelled in a conservative, linear way, which is easy to calibrate. The 42+21 day lockdown in Figure 4 depressed GDP by 5.1% compared to a scenario without COVID-19. This is similar to the IMF's baseline forecast for Emerging Markets and Developing Economies, baseline being the least severe of the scenarios discussed in the April 2020 World Economic Outlook (IMF 2020). The longer, 18 week blanket lockdown in a low income country in figure 5 depressed GDP by at least 10.2% compared to not having COVID-19. These are very severe impacts – the 21 days alone produce a 1.7% drop in annual GDP which is similar to the single standard deviation 'growth shock' used in the Debt Sustainability Analysis for a country like Uganda (IMF 2019). So the longer blanket lockdown is more than 5 times greater than the 'growth shock' normally modelled.

**As discussed in the concluding section, for large impacts both the economic and public finance costs of COVID-19 strategies are underestimated in this simple model.** The sharp recovery of output at the end of the lockdown is not realistic. These impacts are good for ranking the cost effectiveness of COVID-19 strategies but where impacts are large, further estimation is needed to make plans for the post-epidemic recovery.

# Conclusions and further issues

**The main purpose of this note is to show how COVID-19 strategies vary enormously not just in terms of their impact on the epidemic but also in terms of their impact on the economy, welfare and the public finances.**

**Even with the simple, tractable model used in the note it is possible to make a useful ranking of COVID-19 strategies in terms of full economic cost per life saved.** A summary of the hypothetical strategies, compared to the base case of the 'reflex' 42-day lockdown, are shown in Figure 10.

Figure 10: Economic damage versus lives saved

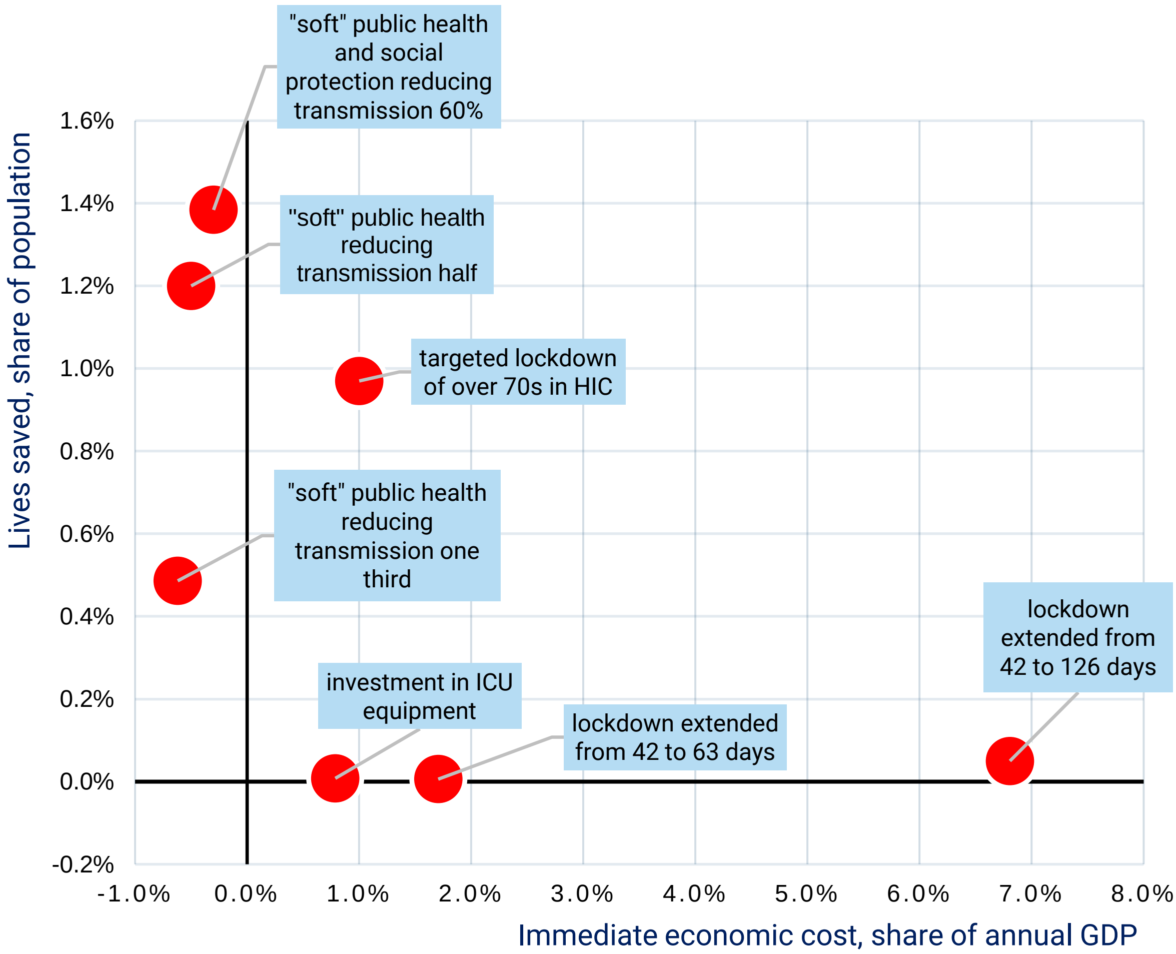



Figure 10 is a visualization of the differences between strategies in terms of cost effectiveness – the strategies shown are from the hypothetical examples used throughout this note. Top left of the graph are the relatively highly cost effective measures and bottom right are the least cost effective strategies. The long lockdowns with no other measures are by far the least cost-effective strategies and cause significant damage to economies. 'Soft' public health measures, by contrast, boost economic output compared to the base case – it must be remembered that these might cost more financially than is assumed here and they do leave the population potentially susceptible to infection when the measures eventually end. Combining social protection with softer measures is the most cost effective of all if we assume social protection reinforces the public health measures. This ignores the public finance cost of the transfer payments (since these are just redistribution). Targeted lockdowns are much more cost effective than blanket lockdowns but might not save enough lives.

## Domestic demand side repercussions could be much larger than the immediate economic impact modelled here

**Where there are long lockdowns and significant economic impact, the instant recovery of economic activity at the end of the lockdown is not realistic** – it underestimates the economic impact because it ignores how households, firms and the public sector finance their costs during the lockdown and afterwards.

**On public finance, the 'growth shock' of the longer lock downs is much larger than that modelled in debt sustainability analysis stress tests, and therefore the disruption to the public finances will be correspondingly greater.** In developing and emerging countries with quite fast-growing economies, the public finances are often quite finely balanced with fast growth funding large deficits, making such countries vulnerable to shocks and therefore very vulnerable to very large shocks. Many countries could face liquidity constraints given the scale of the financial setbacks and given that this is happening to many economies at once – see below. If they do, then re-allocation and deep cuts to previously essential expenditures may be inevitable.

**The dynamic difficulties for households financing consumption without earning income, or for businesses covering costs without doing work are proportionately similar to the problems of the public sector unless the government has used social protection and/or business support to alleviate their problems.** If the government has done this then its own financing problems will be all the greater.

## COVID-19 plus the 'reflex' policy response is hitting almost all countries and the international economy's impact on individual economies is not part of the modelling in this note

**Whether or not countries manage to avoid the worst economic impacts of COVID-19 and the associated public health measures, many other countries around the world, including the largest economies, certainly are facing severe to very severe setbacks as a result.** This knocks on to all countries, albeit in different ways.

Clearly high-trading nations will be affected by major alterations in demand and terms of trade for commodities and other goods and services – for example, oil producers have been severely hit during the opening months of the crisis with prices falling to very low levels.

**Even for countries which may have a small tradeable sector, the international impact is significant because of the financing needs created by the crisis in very many countries.** Most countries facing limited access to foreign financing before the crisis will face even more limited access after and this will curtail the options for financing the public and private responses to the crisis and lockdowns.

The full cyclical impacts of crisis and the international economy's impact are beyond the scope of this note and the model described here but should be assessed as early as possible in the decision-making processes around the choice of COVID-19 strategy as well as in order to plan the recovery.

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# Annex: Full-sized graphs

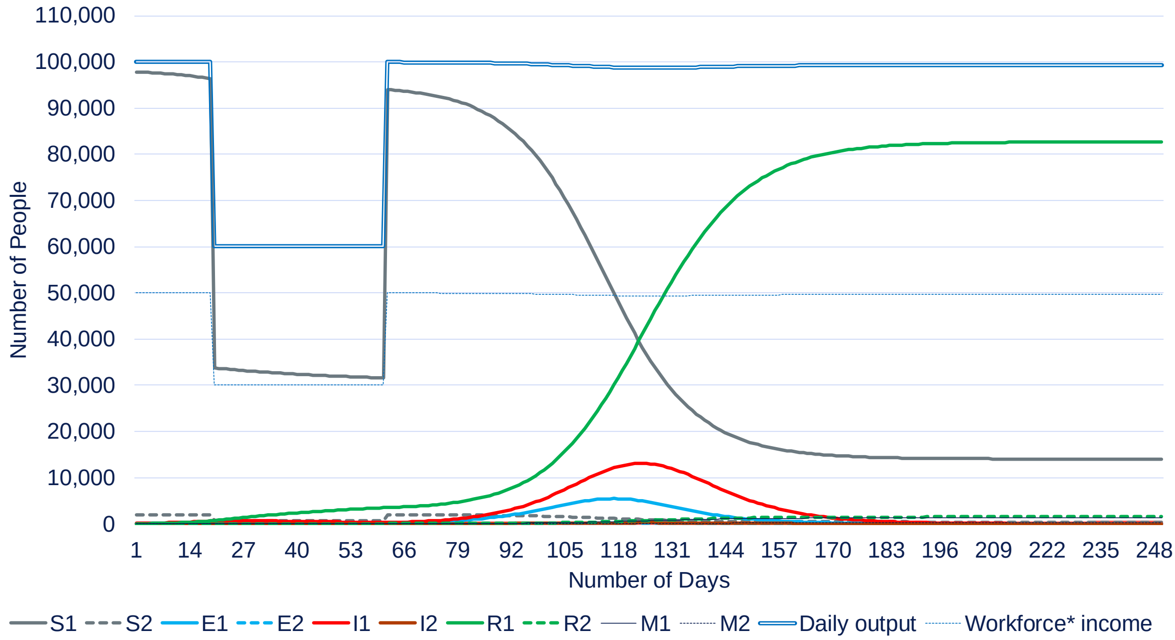
Base Case – the Figure 3 scenario forms the base case for other projections except for Figure 9. This is a population of 100,000 with GDP/capita of just US$365 (i.e. US$1/day, - almost all real countries have higher income in 2020). There are 2 ICUs per million people. The over 70s are 2% of the population. The base case response is a 42-day blanket lockdown which achieves the equivalent of a removal of 51% of the population from the susceptible group.

In Figures 4-8, data in the results tables at the bottom of each graph are a comparison with this baseline.

Figure 9 is a high-income country with high baseline mortality despite high healthcare – the scenario involves a long lockdown for over 70s.

## Figure 3

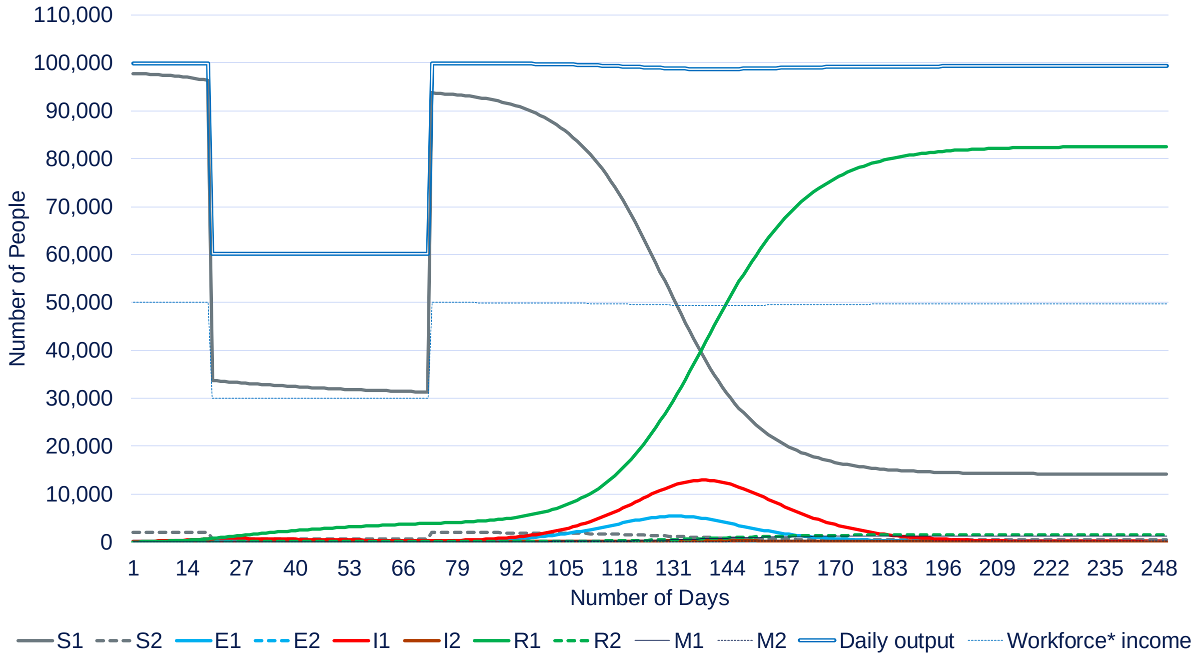
## 250-day projection, hypothetical low income country with 'reflex' response of a 42-day lockdown




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 24.8m | Mortality group 1 | 1.3% |
| Full Economic Cost | - | Mortality group 2 (70+) | 8.8% |
| Net Public Finance Impact | - | Excess mortality | 1472 |
| Full Econ Cost/Life Saved | - | Lives Saved re Base Case | - |

## Figure 4

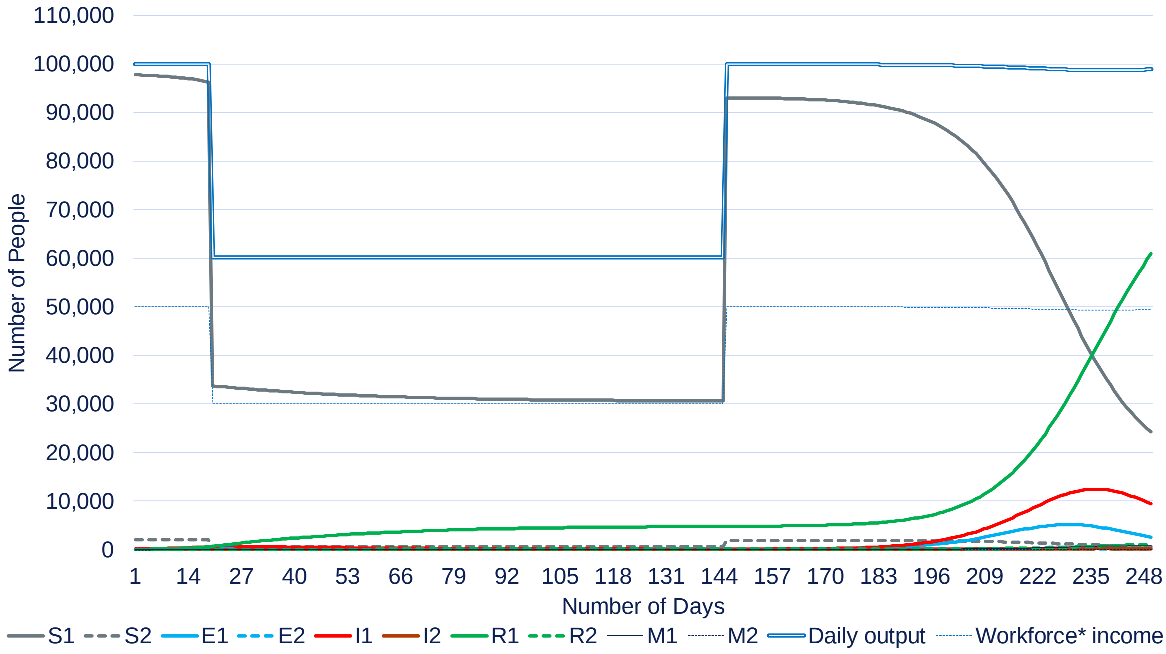
### 250 day projection, hypothetical low income country with lockdown extended from 42-to 63 days




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 22,980,260 | Mortality group 1 | 1.3% |
| Full Economic Cost | 622,292 | Mortality group 2 (70+) | 8.7% |
| Net Public Finance Impact | 97,718 | Excess mortality | 1,457 |
| Full Econ Cost/Life Saved | 293 years of GDP/capita | Lives Saved re Base Case | 6 |

## Figure 5

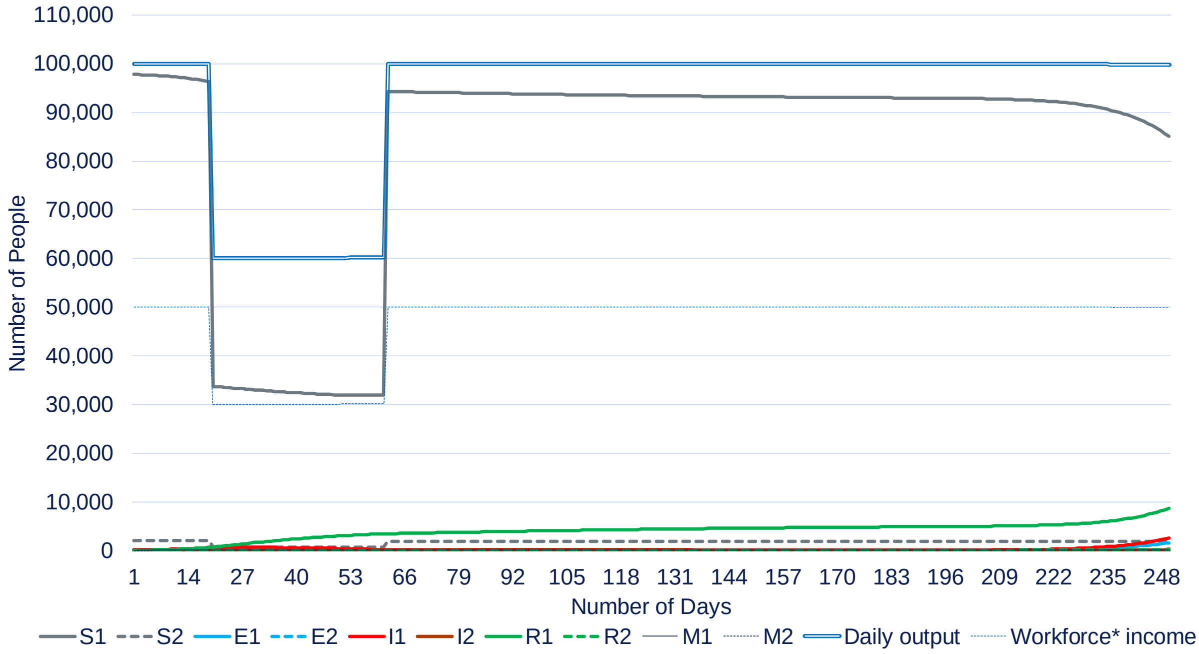
## 250 day projection, hypothetical low income country with lockdown extended from 42-to 126 days




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 21,129,389 | Mortality group 1 | 1.3% |
| Full Economic Cost | 2,484,267 | Mortality group 2 (70+) | 8.4% |
| Net Public Finance Impact | 386,453 | Excess mortality | 1,413 |
| Full Econ Cost/Life Saved | 135 years of GDP/capita | Lives Saved re Base Case | 50 |

## Figure 6

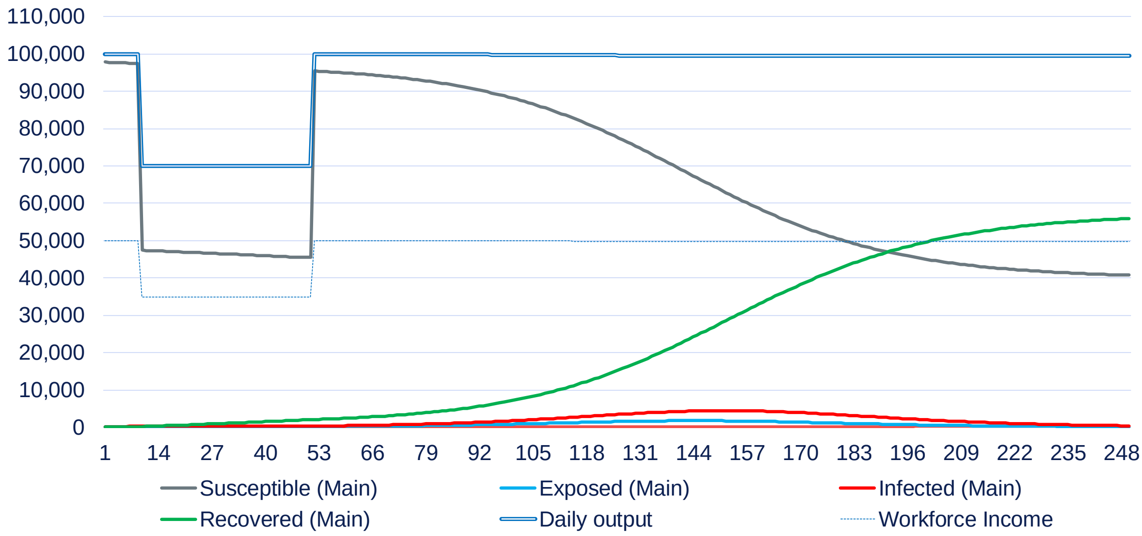
## 250 day projection, base case lockdown followed by 'soft' public health that reduces transmission by one third




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 23,661,642 | Mortality group 1 | 0.9% |
| Full Economic Cost | -21,395 | Mortality group 2 (70+) | 5.5% |
| Net Public Finance Impact | -33,206 | Excess mortality | 977 |
| Full Econ Cost/Life Saved | -0.12 years of GDP/capita | Lives Saved re Base Case | 486 |

## Figure 7

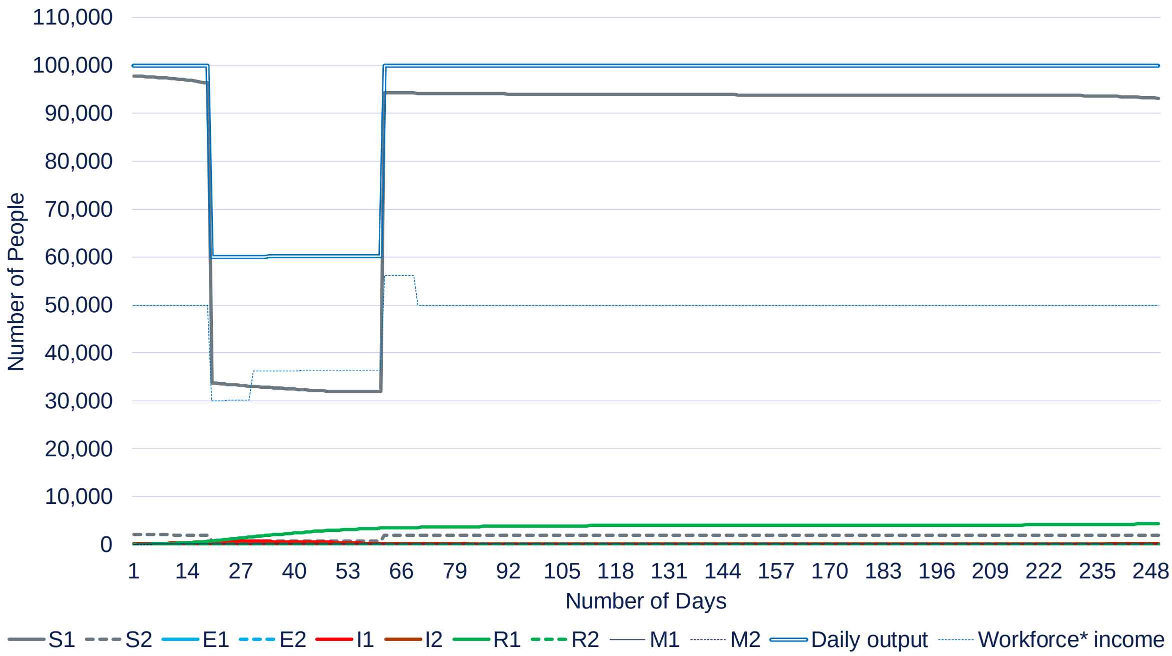
## 250 day projection, base case plus 'soft' public health which reduces force of transmission by half




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 23,718,426 | Mortality group 1 | 0.2% |
| Full Economic Cost | -175,300 | Mortality group 2 (70+) | 1.4% |
| Net Public Finance Impact | -72,433 | Excess mortality | 254 |
| Full Econ Cost/Life Saved | -0.4 years of GDP/capita | Lives Saved re Base Case | 1209 |

## Figure 8

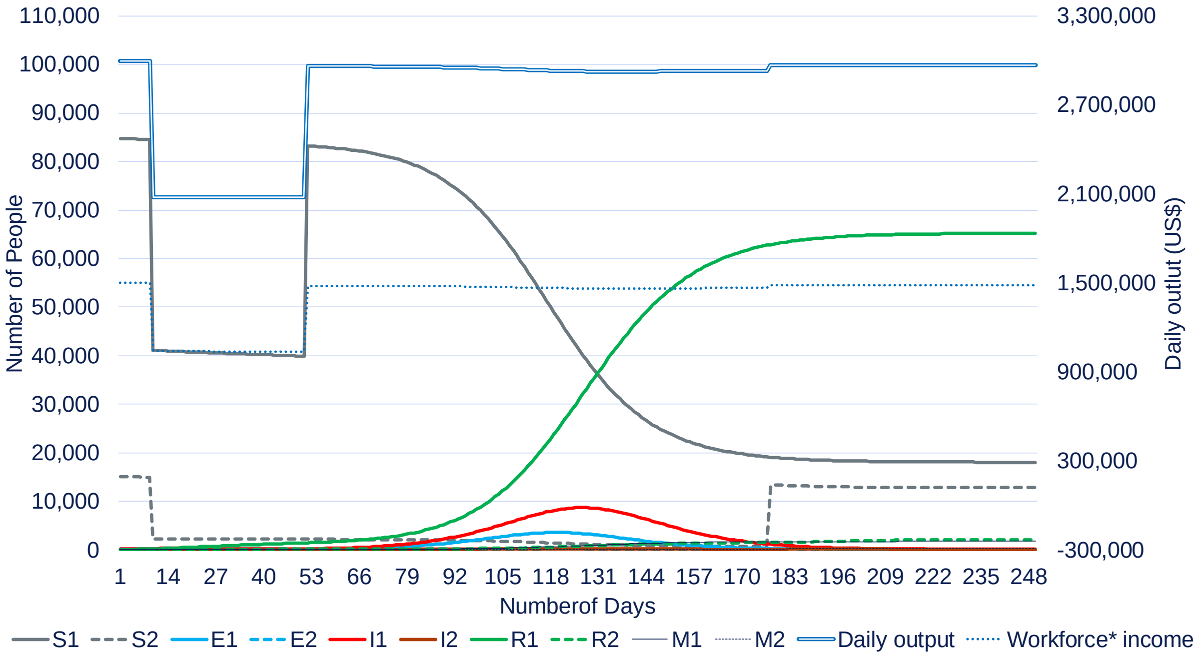
## 250 day projection, base case plus ‘soft’ public health reinforced with social protection messaging which reduces force of transmission by 60%




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 23,730,415 | Mortality group 1 | 0.1% |
| Full Economic Cost | -108,681 | Mortality group 2 (70+) | 0.4% |
| Net Public Finance Impact | 591,878 | Excess mortality | 79 |
| Full Econ Cost/Life Saved | -0.22 years of GDP/capita | Lives Saved re Base Case | 1384 |

## Figure 9

### 250 day projection, high income country with 168 day lockdown for over 70s only




| | | | |
|---|---|---|---|
| Output US$ in 250 days | 701,753,500 | Mortality group 1 | 2.0% |
| Full Economic Cost | 14,320,432 | Mortality group 2 (70+) | 1.4% |
| Net Public Finance Impact | 6,750,854 | Excess mortality | 1896 |
| Full Econ Cost/Life Saved | 1.28 years of GDP/capita | Lives Saved re Base Case | 1025 |