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Estimating the monetary value of the deaths prevented from the UK Covid-19 lockdown when it was decided upon – and the value of "flattening the curve"

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Summary

In tackling Covid-19, the UK made a very significant decision to move from a mitigation strategy to one of suppression in mid-March 2020. As with any decision, this brings benefits and creates costs. In this paper, we seek to provide an indicative value of the benefits from the policy shift. We calculate the expected monetary value of the deaths prevented using data available when the decision was made.

We first calculate the expected number of incremental deaths prevented from Covid-19 from this policy shift to be around 159,000. The UK Government has placed great weight on preventing indirect "overflow" deaths by avoiding overwhelming the intensive care units at hospitals. We calculate that around 44,000 of the 159,000 deaths prevented come from "flattening the curve". Suppression policies also unintentionally serve to reduce mortality risks from other causes (such as influenza, air pollution and road traffic accidents), which will avert around another 30,000 deaths.

The UK Treasury currently uses £2m as the value of a prevented fatality (VPF) in economic appraisal (based on the death of an "average" aged person e.g. from a road traffic accident). If we assume that all lives are valued equally (i.e. we do not adjust the VPF for the fact that fewer life years are lost from Covid-19 deaths than from road accidents), then we calculate the monetary value of the switch to be £318 billion. This translates to around £5,000 per capita in 2018 prices, of which the monetary value of avoiding the "overflow deaths" is around £1,400 per capita (which amounts to about 4% of GDP). When we add in deaths averted from other causes, the total value of the fatalities prevented is about £378 billion, or about £6,000 per capita. This represents about 17% of GDP.

These results are of course sensitive to the assumptions we make about the number of deaths prevented, to the VPF used and about the remaining life expectancies of those whose deaths the suppression policy averts. Deaths from Covid-19 are highly concentrated in older people with lower life expectancies than the average individual. If we assume an average remaining life expectancy of five years to account for this, then the value of the switch is £60 billion, or just under £1,000 per capita. This would be about 3% of GDP.

This value can be set against the costs of the suppression policy. We do not seek to calculate these here, but the costs will include lives lost and blighted by the inability to access services, loneliness, lack of physical exercise, domestic violence, child development and nutrition, child abuse, unemployment, divorce, and suicide. A full-blown cost-benefit analysis would also need to consider the distributional consequences of the policy move, and especially the intergenerational transfers from younger to older people. In the meantime, the indicative figure of £6,000 per capita can be seen to represent a generous

estimate of the benefits of moving from mitigation to suppression at the time the decision was made.

Introduction

1.1. Every decision involves an implicit weighting of the costs and benefits of action. The decision by the UK Government to switch from a strategy of mitigation to one of suppression in mid-March 2020 was motivated by a desire to reduce the number of direct and indirect deaths from Covid-19. It also resulted in other benefits and a myriad of costs. In this paper, we calculate the (intended and unintended) benefits for mortality risks of the suppression policy.

1.2. We base our calculations of the intended benefits on data in the epidemiological model formulated by Imperial College London because this report appears to have been so influential in the government's thinking.[1] We take Imperial's projections of direct lives saved as given and use its projections for intensive care unit (ICU) bed demand to calculate the indirect deaths avoided as a result of "flattening the curve" and avoiding overwhelming the ICUs in hospitals.

1.3. Along with the intended benefit of reducing Covid-19 mortality, the decision will also result in the unintended benefit of reducing mortality from other causes due to limitations in the freedom of movement, such as air pollution, influenza and road accidents. These prevented deaths were not salient at the time the decision was made but they are real consequences of the policy shift, and so we are required to provide some indicative estimates of them.

1.4. We then calculate a monetary value for the deaths prevented by multiplying the expected number of lives saved by the value of a prevented fatality (VPF) that is used by the UK Government in economic appraisal. In principle, this overall figure should be in excess of the monetary value of the costs of the suppression policy. (To reiterate, we do not seek to calculate costs here.)

2. Reductions in mortality

2.1. We calculate that the "optimal" mitigation scenario would have resulted in 338,000 deaths while the suppression scenario is calculated to result in 20,000 deaths.[2] All deaths under the suppression strategy are direct deaths since ICUs are not overwhelmed in this scenario. The difference between the two strategies is 318,000,

[1] It is worth noting that the Imperial model is only one model using the data at the time of the government decision to switch. Furthermore, as this is a pandemic in-progress, all projections are susceptible to becoming outdated quickly. An analysis by the Institute for Health Metrics and Evaluation (IHME) using more recent data projects a different total number of deaths (66,000) by August than Imperial, for example. We take the Imperial projections as the basis for our calculations because they were so influential in the government decision in mid-March.

[2] The Imperial model presents three different suppression policy options, with the associated deaths ranging from 5,600 to 120,000. Even though the paper does choose one estimate over the others, Ferguson stated that a strategy of suppression was likely to lead to fewer than 20,000 deaths, hence we use this number.

and so this represents the total number of deaths avoided by switching from a strategy of mitigation to one of suppression.

2.2. Some of the deaths from Covid-19 would have occurred in the next 12 months. Neil Ferguson from Imperial College has suggested that this could be anywhere between one-half and two-thirds.[3] We take the lower bound and assume that 50% of patients who would have died from the mitigation strategy would have been in the all-cause mortality figures in the UK in the next year. This means that suppression was expected to result in around 159,000 fewer incremental deaths.

2.3. One of the main factors influencing government policy was the "overflow" deaths in a scenario of mitigation due to ICUs in hospitals being overwhelmed. This is the rationale behind "flattening the curve" of the peak in infection and death rates. We calculate that the optimal mitigation policy has prevented 44,000 incremental deaths that would have resulted from ICUs being unable to meet demand. See Table 1 for a summary.

2.4. In order to calculate the "overflow" deaths in the mitigation scenario, we calculate the number of new Covid-19 patients and non-Covid-19 patients in need of ICU beds every day and compare this inflow of patients with the available ICU bed capacity on that day. At the time the decision was made in mid-March 2020, there were no official guidelines for the allocation of ICU beds when capacity is exceeded, so we randomly assign ICU beds between Covid-19 patients and other patients in need of ICU beds when the number of incoming patients exceeds available capacity. In line with the Imperial report, we assume that Covid-19 patients stay in the ICU for 10 days on average. Based on our review of the literature, we assume that non-Covid-19 patients stay in the ICU for 6.25 days on average.[4]

2.5. For the number of new Covid-19 patients in need of ICU every day, we rely on the Imperial College estimates of ICU bed demand in the "optimal" mitigation scenario of a combination of case isolation, home quarantine and physical distancing of those over 70 and others most at risk of severe diseases. We do not have access to the data,

[3] Ferguson told the Science and Technology Committee that the overlap "might be as much as half or two thirds of the deaths we see, because these are people at the end of their lives or have underlying conditions." We do not have access to the calculations underlying these numbers; however, we take the numbers as given from Ferguson considering his membership in the Scientific Advisory Group for Emergencies (SAGE) which advises the government on the course of action for Covid-19.

[4] Ridley & Morris (2007) have shown that a regular ICU patient stays in the ICU for an average of 5 days. We adjust this number up by 25% to account for the fact that the ICU patients who will be coming in during the Covid-19 outbreak will be more serious patients who will need an ICU bed as a result of non-elective circumstances since elective surgeries will be cancelled. There is evidence in the literature to show that patients needing an ICU bed due to non-elective circumstances stay in the ICU for longer. To the best of our knowledge, a direct comparison of the average length-of-stay (LOS) of these two types of patients does not exist. However, Weissman (1999) has shown that the average LOS at a hospital where most ICU patients were there due to non-elective circumstances was 25% higher compared to other hospitals, hence we take this to be our adjustment factor.

so reproduce it using the same method as Greenstone & Nigam (2020) who reproduced the data for the US. We assume that ICU bed demand over time follows a normal distribution and reproduce the Imperial College data by taking the centre of the peak as occurring on the 5th of June. We take the ICU demand per 100,000 people as being 94 at the peak and the standard deviation as 18 days. This allows us to plot a normal distribution curve for the five-month mitigation period and reproduce the underlying data.

2.6. We calculate that, on average, a cumulative total of 2,500 non-Covid-19 patients will need an ICU bed on any given day. We calculate this number by relying on past ICU occupancy numbers.[5] Assuming an average length of stay of 6.25 days for these patients leads to 400 new non-Covid-19 patients needing an ICU bed every day.

2.7. We find that, under these circumstances, 210,000 Covid-19 patients and 15,000 non-Covid-19 patients in need of critical care are denied ICU beds. Assuming that being given an ICU bed leads to an absolute increase of 40% in the survival rate for Covid-19 patients and 30% for non-Covid-19 patients means that a total of 88,000 patients die due to being denied ICU treatment.[6]

2.8. The decision to "lock down" the country means severe limitations on the freedom to move, which will result in the unintended benefit of reducing mortality risks from other causes, most notably air pollution, influenza, and road traffic accidents. Every year around 38,000 people die from air pollution, 20,000 people die from influenza, and about 2,000 from road traffic accidents. In order to calculate an illustrative value for the benefits of the policy shift, we assume that half as many people will die from

[5] In January 2020, NHS had an ICU bed capacity of 4,123, of which 3,423 were occupied. The number of patients needing an ICU bed due to non-Covid-19 reasons will be lower during the Covid-19 outbreak than before the outbreak due to cancelled surgeries and the limitations in the freedom of movement. Since the number of surgeries cancelled due to Covid-19 is not available for the UK, we use the United States ratio of 3:1 unavoidable to avoidable ICU patient ratio from Greenstone & Nigam (2020) to estimate the total number of unavoidable ICU patients. We conclude that once the previous occupancy of 3,423 is cleared, a cumulative total of 2,500 patients will need an ICU bed on any given day during the Covid-19 pandemic. In line with Ferguson et al, we assume a Covid-19 surge capacity of 5,000 and combine this with the capacity for non-Covid-19 patients because we ultimately allocate the total capacity between the two types of patients.

[6] In line with Ferguson et al, we assume that Covid-19 patients have a 50% survival rate in the ICU. We follow Greenstone & Nigam (2020) in assuming that the Covid-19 patients have a 10% chance of survival outside of the ICU, which gives a change in the survival rate of 40% when the patients are treated in the ICU. Based on a review of the literature and assuming that the non-Covid-19 patients coming into the ICU during the pandemic will be more serious patients than the average ICU patient before the outbreak due to elective surgeries being cancelled, we estimate that the incoming non-Covid-19 ICU patients have a 60% chance of survival with treatment and 30% without, which means a 30% change in the survival rate.

suppression compared to mitigation i.e. 30,000 fewer deaths.[7] We acknowledge that this is far from being a precise estimate.[8]

3. Monetising the benefits

3.1. It is common practice in policymaking to perform a cost-benefit analysis (CBA) and compare the benefits of a course of action to its costs in order to decide whether a policy is worth it or not. Monetary values act as a common metric in allowing for a comparison between costs and benefits. In order to arrive at a monetary value in scenarios with changes in the probability of death, the value of a prevented (VPF) is used. The VPF is based on how much an individual is willing to pay for a reduction in the probability of death.[9]

3.2. The current VPF figure in the UK is £2m.[10] Multiplying this figure with the lives saved by switching from mitigation to suppression results in around £318 billion in intended benefits from avoiding deaths from Covid-19, which is about £5,000 per capita. The value of avoided overflow deaths makes up about £88 billion of this, or about £1,400 per capita. When we add in the benefits from indirect deaths prevented, the total value of the fatalities prevented is about £378 billion, or about £6,000 per capita. This represents about 17% of GDP. See Table 2 for a summary.

4. Sensitivity analysis

4.1. We examine the sensitivity of our "overflow" deaths model by considering alternative assumptions for four parameters: the ICU lengths-of-stay (LOS) for Covid-19 and non-Covid-19 patients and the ICU mortality for Covid-19 and non-Covid-19 patients. We also show how sensitive the results are to different assumptions about the reductions in mortality from other causes, such as air pollution, influenza, and road accidents. Table 3 shows the results of this analysis.

4.2. Our sensitivity analysis shows that the overall monetary benefits are somewhat insensitive to assumptions in our model, with the total monetary benefits of all deaths avoided ranging from £322.3 to £433.6, when the parameters are adjusted upwards or downwards by as much as 50%. The case is the same for overflow deaths, which only

[7] Shilling & Waetjen (2020) have estimated that traffic accidents have fallen by 50% in California since the start of the lockdown, which we apply to the other impacted deaths. It is worth noting that there might be an overlap between those at most risk of dying from influenza and those that die from Covid-19 but we take this overlap to be negligible.
[8] We also acknowledge that many of the deaths prevented from air pollution will occur in the future and therefore should be subject to discounting. Given the uncertainty around the number itself, we have done this here, and can in this sense be seen to be giving the benefits from the suppression policy the "best shot".
[9] For example, if an individual is willing to pay £1,000 to avoid a 0.1% chance of dying, then the value of a prevented fatality is calculated by dividing the £1,000 by 0.001, which in this case leads to a VPF of £1,000,000.
[10] The official VPF figure used by the government is £1,958,303 in 2018 prices; however, we round this figure up to £2,000,000 in our calculations.

show a high sensitivity to the Covid-19 ICU mortality parameter, with the total overflow deaths ranging from around 16,000 to 72,000 when this parameter is changed by 50%.

4.3. The monetary value of the benefits would be considerably lower if we account for the fact that many of the deaths prevented from Covid-19 are older people. We calculate that the average number of life years gained per death prevented from Covid-19 is five.[11] The VPF is based on an expected loss of about eight times this. Using the baseline data for deaths prevented, and assuming a five year loss for deaths prevented from Covid-19, influenza and air pollution and an average life expectancy loss for deaths prevented from road traffic accidents[12], then the monetary value of the deaths prevented using a VPF of £2m would then be £60 billion, or around £970 per capita.[13] This would be about 3% GDP.

4.4. Another alternative we consider is a VPF based on the value of a quality-adjusted life year (QALY) used by the UK's National Institute for Health and Care Excellence when it appraises new technologies. Paulden (2017) has shown that NICE uses a QALY value of around £50K when appraising end-of-life technologies (as compared to standard thresholds of £20-30K). The context of Covid-19 makes the £50K value highly relevant here. Applying a VPF based on a £50K QALY adjusted for life expectancy leads to a monetary benefit of £50 billion, or around £730 per capita.

4.5. We note that a wide range of values for the VPF exist.[14] An alternative VPF of £9m has been suggested for the UK.[15] If we apply this figure to the age-adjusted VPF, then the benefits of the suppression policy would be about £290 billion or around £4,500 per capita. See Table 4 for a summary.

5. Conclusions

[11] Using the mortality rates provided by Ferguson et al. for different age groups in the population and assuming that the average age of the group falls in the middle of the age band gives us an average age of 75 for Covid-19 deaths. Taking the average life expectancy in the UK to be 80, we reach a life loss of 5 years. The average in an age band is likely to fall below the middle of the band but this is likely compensated by the calculation not accounting for any underlying health problems in the younger deaths, which would decrease their life expectancy.

[12] Using the mortality rates by age group for influenza from Public Health England (2019) and the mortality rates by age group for air pollution from GBD (2020) and assuming that the average age of the age group falls in the middle, we calculate that the life expectancy loss for these deaths are between 3-8 years, which we take to be 5 years in our calculations.

[13] We use the Treasury's discount rate of 1.5% in our calculations.

[14] A review by Viscusi and Aldy (2003) has shown that estimates for VPF, referred to as the value of a statistical life (VSL) in the paper, range from 0.5 million (2000 USD) to 21.7 million (2000 USD).

[15] Philip Thomas from the University of Bristol has suggested a switch from VPF to a judgment or j-value in the UK and has estimated the j-value to be around £8.6 million in 2016 prices, which we convert to 2018 prices in our calculations. The Bristol figure uses a "revealed preference" method which relies on the choices of individuals compared to the official UK figures which use a "contingent valuation" method which relies on the stated preferences of individuals.

5.1. We calculate that the UK government decision in mid-March to switch from a strategy of mitigation to one of suppression in response to Covid-19 had the intended benefit of preventing 159,000 additional deaths from Covid-19. 44,000 of these come from arguably the most salient part of the policy, which was to “flatten the curve”. The decision will also have led to the unintentional benefits of preventing deaths from other causes (air pollution, influenza and road traffic accidents). We have assumed this to be 30,000 (half the number of deaths otherwise) but acknowledge that this is far from being a precise estimate.

5.2. Applying the official VPF figures to these benefits puts the monetary value of the policy at about £378 billion, or about £6,000 per capita. If we account for the fact that deaths from Covid-19 are concentrated in older people, and value life years gained, then then the value of the benefits is around £1,000 per capita.

5.3. Covid-19 is a pandemic in progress, of course, and the true extent of its impact will only be revealed in the long-term. What our analysis does show, however, is the monetary value of the expected benefits from mortality risk reduction when the UK moved from “optimal” mitigation to “optimal” suppression, and the fraction of this accounted for by the benefits from not overwhelming the NHS. About one-quarter of the expected benefits come from “flattening the curve”.

5.4. A limited number of other studies have also looked at the monetary valuation of different Covid-19 strategies, but these mostly focus on the US. Thunström et al have estimated that physical distancing in the US generates a benefit of $5 trillion, which translates to about £12,000 per capita in the UK or £3,400 in age-adjusted terms[16], while Greenstone and Nigam have found that physical distancing in the US leads to a benefit of $8 trillion, which translates to about £20,000 per capita.[17] The differences between their numbers and ours are explained by: a) the VPF used in the US is higher (generally above £8m); b) these studies take “uncontrolled” outbreaks as their alternatives whilst we use an “optimal” mitigation scenario; and c) they do not account for an overlap between all-cause mortality and Covid-19.

5.5. These figures should ultimately be compared to the costs of the suppression policy. The Office for Budge Responsibility (OBR) recently forecast that, as a result of Covid-19, real UK GDP could fall by 35% in the second quarter of 2020 and unemployment could increase by more than 2 million. We do not seek to calculate the full costs here, but they will include lives lost and blighted by the inability to access services, loneliness, lack of physical exercise, domestic violence, child abuse, unemployment, divorce, and suicide. A full-blown cost-benefit analysis would also need to consider

[16] Thunström et al do no provide an age-adjusted result in their paper. We calculate it by using their discount factor of 5% to arrive at the yearly utility underlying their VPF, assuming an average life expectancy of 5 years and discounting the yearly utility by the UK Treasury’s rate of 1.5% to reach the age-adjusted result and allow for comparability with our results.

[17] The studies do not provide per capita values, which we calculate using OECD US population figures.

the distributional consequences of the policy move, and especially the intergenerational transfers from younger to older people.[18]

5.6. In the meantime, the indicative figure of £6,000 per capita can be seen to represent a generous estimate of the benefits of moving from mitigation to suppression at the time the decision was made.

[18] The Green Book recommends that additional sensitivity analysis be conducted "where the possible effects of an intervention being examined as part of an appraisal are long term and involve very substantial or irreversible wealth transfers between generations."

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Tables

Table 1: The incremental Covid-19 deaths and other deaths in the mitigation and suppression scenarios assuming a 50% overlap with all-cause mortality

	All deaths	Covid-19 deaths					Other impacted deaths
		Total Covid-19	Direct deaths	Overflow deaths			
				Total Overflow	Covid-19 patients	Non-Covid-19 patients	
Mitigation	228,815	168,815	125,000	43,815	41,403	2,412	60,000
Suppression	40,000	10,000	10,000	0	0	0	30,000
Difference	188,815	158,815	115,000	43,815	41,403	2,412	30,000

Table 2: The monetary valuation of the incremental Covid-19 deaths and other deaths in the mitigation and suppression scenarios

		All deaths	Covid-19 deaths					Other impacted deaths
			Total Covid-19	Direct deaths	Overflow deaths			
					Total Overflow	Covid-19 patients	Non-Covid-19 patients	
Monetary value (2018 GBP)	Total	377.6	317.6	230.0	87.6	82.8	4.8	60.0
	Per capita	5,928	4,986	3,611	1,376	1,300	76	942

Table 3: Sensitivity analysis for parameters impacting death outcomes

	Assumption		Covid-19 overflow deaths avoided	Other deaths avoided	Monetary value of Covid-19 overflow deaths avoided (2018 billion GBP)	Total monetary value of all avoided deaths (2018 billion GBP)
Covid-19 ICU LOS	Decrease by 50%	5	35,688	30,000	71.4	361.4
	Base case	10	43,815	30,000	87.6	377.6
	Increase by 50%	15	46,945	30,000	93.9	383.9
Non-Covid-19 ICU LOS[19]	Decrease by 50%	3	48,916	30,000	97.8	387.8
	Base case	6	43,815	30,000	87.6	377.6
	Increase by 50%	9	42,877	30,000	85.8	375.8
Covid-19 ICU mortality[20]	Decrease by 50%	25%	71,802	30,000	143.6	433.6
	Base case	50%	43,815	30,000	87.6	377.6
	Increase by 50%	75%	16,129	30,000	32.3	322.3
Non-Covid-19 ICU mortality	Decrease by 50%	20%	45,322	30,000	90.6	380.6
	Base case	40%	43,815	30,000	87.6	377.6
	Increase by 50%	60%	42,308	30,000	84.6	374.6
% of deaths prevented for other deaths	Decrease by 50%	25%	43,815	15,000	87.6	347.6
	Base case	50%	43,815	30,000	87.6	377.6
	Increase by 50%	75%	43,815	45,000	87.6	407.6

Table 4: Sensitivity analysis for VPF assumptions

	Assumption[21]			Covid-19 deaths avoided	All deaths avoided	Monetary value of Covid-19 deaths avoided		Monetary value of all deaths avoided	
						Total (2018 billion GBP)	Per capita (2018 GBP)	Total (2018 billion GBP)	Per capita (2018 GBP)
		Avg life VPF	5-year VPF						
VPF – adjusted for age[22]	Low VPF	1,495,792	239,132	158,815	188,815	38.0	596	46.4	729
	Base case	2,000,000	319,740	158,815	188,815	50.8	797	62.1	974
	High VPF	9,205,820	1,471,734	158,815	188,815	233.7	3,669	285.6	4,484

[19] Counterintuitively, the number of overflow deaths increases as the LOS of non-Covid-19 patients decreases; this is due to an increased rate in the inflow of patients as the calculations for the inflow of patients is based on the lengths of stay. There is not the same effect in the Covid-19 ICU LOS as we take the inflow of Covid-19 patients on any day as given from Ferguson et al.

[20] Overflow deaths increase as the ICU mortality decreases because the overflow deaths are the patients who would have survived had they been given an ICU bed

[21] We calculate the low VPF by relying on a QALY of £50,000, assuming an average life expectancy of 40 years and discounting at the Treasury's rate of 1.5%. The base case VPF is the rounded up official UK figure while the high VPF figure is the figure suggested by Philip Thomas from Bristol University.

[22] We do not adjust car accidents for life expectancy; we apply the average life VPF to them.