Initial estimates of Excess Deaths from COVID-19

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Contents

1. Background

The novel coronavirus (COVID-19) pandemic will affect the number of deaths in the UK. This extends beyond people dying from contracting COVID-19, as there will also be impacts on the population's health and mortality due to changes in healthcare activity to tackle COVID-19, and government's other responses to the pandemic.

We have investigated the potential impacts of four categories of 'excess death', which is *any death due to the COVID-19 pandemic which would not have occurred otherwise within* ***one year***. Where possible, both the numbers of deaths expected and the years of life lost (YLL) have been estimated. Years of life lost is an important measure for understanding the extent to which COVID-19 has brought forward deaths which would have occurred in the short-term without COVID-19. These four categories of excess death are:

1. Deaths directly from COVID-19
2. Indirect COVID-19 deaths due to additional pressures on the health and social care system, unable to maintain previous standards and unable to adequately treat and care for patients with COVID-19 and other conditions
3. Deaths from changes to healthcare activity, such as cancellation or postponement of elective surgeries and other non-urgent treatments
4. Deaths from factors affecting the wider population, both direct, resulting from the pandemic and from government's Behavioural and Social Interventions to address the pandemic (BSIs); and economic (resulting from a pandemic/BSI-induced recession).

2. Summary results

We compare the current Mitigated Reasonable Worst Case scenario with poor compliance (RWC-M) from 28 March 2020 with the previous Unmitigated Reasonable Worst Case scenario (RWC-U) from 5 March 2020. The RWC-M assumes the current social distancing measures, or Behavioural and Social Interventions (BSIs), are in place for the 6 month period from the end of March until September 2020.

Note that the RWC scenarios contain large uncertainties in the characteristics of the virus and how society will respond to social distancing measures. If the RWCs overestimate or underestimate the reality of COVID-19's impact, the excess deaths estimated here will reflect that difference from the true effect.

Each of the four categories of deaths is calculated independently. There is likely to be some overlap in deaths in separate categories, and it has not been possible to account for this. The co-morbidities for increased susceptibility to COVID-19 (Category 1) also make an individual more likely to have an elective admission postponed (Category 2) and an emergency hospital admission (Category 3).

Estimates of the number of excess deaths are included in Table 1 below. The method for producing these estimates can be found in **Methodology** section on page 6.

Table 1.

Category of excess death	Mitigated RWC Scenario (28 March)		Unmitigated RWC Scenario (5 March)	
1. Deaths **directly from COVID-19** and the extent to which they are moving forward deaths that would have arisen in the short term.	**41,000 to 45,000** [i]	The current RWC scenario assumed almost **50,000** people will die from COVID-19 in 6 months; we further estimate that **41,000 to 45,000** of these people would not have died in the next year in the absence of COVID-19. These excess deaths represent **300,000 to 590,000 years of life lost**.	**420,000 to 470,000**	The RWC-U (5 March) scenario assumed **520,000** people will die from COVID-19 in the 6 months; we further estimate that **420,000 to 470,000** of these people would not have died in the next year in the absence of COVID-19. These excess deaths represent **2,800,000 to 5,400,000 years of life lost.**
2. Indirect COVID-19 deaths due to **additional pressures on the health and social care system**, unable to maintain previous standards and unable to adequately treat and care for patients with COVID-19 and other conditions.	**12,000 to 25,000 (non-COVID-19)**	The NHS is doing everything it can to mitigate risks to patient safety. It now has additional CCU capacity sufficient to treat all COVID-19 patients in this scenario. This range is from illustrative scenarios showing the impact of more patients experiencing a **slight worsening of overall care management** (12,000 additional deaths) or **short delays** (25,000 additional deaths) for non-COVID-19 hospital emergency admissions over a 6-month period. These might be because of patients delaying attending hospital from fear of COVID-19, delays in ambulance services, or resource shortages. These deaths would occur in the short-term. We further estimate that 9,600-20,000 of these people would not have died in the next year in the absence of COVID-19. **These deaths represent 76,000 to 158,000 years of life lost**.	**Large numbers of deaths (could be >1M) (COVID-19)**	These are the indirect deaths from COVID-19 patients not receiving adequate care because the demand spike is so high that there will not be enough capacity – either beds, ventilators or staff, to provide medical care for the vast majority of patients whose survival would depend on that treatment being available. **87%** would not have died in the next year in the absence of COVID-19. **These deaths represent more than 8M years of life lost.** There would also be additional deaths in non-COVID-19 emergency admissions, significantly greater than in the mitigated scenario. No estimates have been made of this.
3. Deaths from **changes to healthcare activity**, such as cancellation or postponement of elective surgeries and other non-urgent treatments	Non-urgent care is being re-prioritised to protect patients and to free up stretched NHS resources. As an upper limit, if 75% of elective care that would have been done over 6 months is cancelled, this is equivalent to around £17bn cut in expenditure, which would ordinarily be expected to increase mortality by **185,000 deaths** (**medium and long term**); or **758,500 years of life lost**. However, with reprioritisation of cases when services return to normal, the **actual mortality impact can be expected to be far smaller** than this.		In an unmitigated RWC, it could be expected that there would be a short period of time when **all elective care** would be cancelled to protect patients. Over this period the health service could not offer any safe treatment options. It is unclear how long it would take the service to return to providing a safe healthcare setting. Therefore, it has not been possible to quantify this number of deaths.	
4. Direct effect (resulting from the **pandemic** and **BSIs** themselves) and **economic** (resulting from a pandemic/BSI-induced recession)	There is insufficient evidence to estimate the precise impact of an economic downturn on the number of deaths. There is uncertainty around length of economic downturn before a recovery, and the number of overlapping areas of impact. A large body of evidence suggests that mortality rates decrease during times of recession. The most likely short-term scenario therefore, including both direct effects and a modest recession, might see a fall in mortality in the **low thousands**. A more challenging economic scenario, where we see a deep recession causing GDP to deviate from trend for a number of years, might result in **additional deaths in the low thousands** per year, assuming deprivation increases markedly. There is insufficient evidence to estimate the size of impact on deaths as a result of the BSIs. In the short-term, it is **unclear** what net impact BSIs would have on mortality. Evidence does suggest that mortality rates would decrease from a reduction in road traffic accidents and potentially air pollution, however we could see a rise in mortality from increases in domestic violence, suicide and other factors.		Due to the breadth and complexity of socio-economic factors, the counterfactual of the unmitigated RWC scenario has not been investigated critically. This is based on a variety of socio-economic impacts of recession and BSIs, which both reduce and increase mortality. Longer-term impacts depend heavily on how a recession is managed. This would persist beyond the end of a recession, for as long as the deprivation persists.	

[i] Note, the range of estimates for excess deaths is likely to be an over-estimate due to insufficient data on background mortality of COVID-19 victims. See Annex A.

3. Implications for social distancing measures

One important aspect of considering the magnitude of the different categories of excess deaths is in relation to decisions about social distancing measures. While all social distancing measures will dampen the disease's spread to some degree, different measures vary in their effectiveness and will have very different impacts on the economy.

This analysis can help to demonstrate the trade-offs that have already been made in deciding to take social distancing measures to delay the disease. It shows that up to 1 million deaths have been averted by avoiding the unmitigated RWC scenario where CCU capacity would have been breached and lives would have been lost through lack of access to medical care. In contrast, the estimate of lives lost from a recession is much lower – ranging from 600 to 12,000 additional avoidable deaths per year using current methodologies – so the benefits of government intervention far outweigh the costs.

The analysis does not quantify the individual contributions of different social distancing measures to reducing propagation of the virus, or their individual impacts on the economy. It assumes the current measures are in place for 6 months and does not factor in an exit strategy thereafter. For these limitations it cannot provide insights into the merits of individual social distancing measures; apart from to say:

- In the short term, the majority of excess deaths from COVID-19 are from the virus itself. All social distancing measures support the reduction of COVID-19 incidence and hence are contributing to minimising short-term deaths.
- More targeted measures, such as shielding vulnerable people, will have a large benefit on Categories 1, 2 and 3 but only a small negative impact on the economy (part of Category 4). Measures that can be targeted are the most desirable by these outcomes.
- There could be potential for excess deaths from negative impacts on the economy in the longer term. That suggests there is also a health dimension to considering the economic impact of social distancing measures to take into account. There is extensive work going on across government to develop this evidence and this estimation of excess deaths will be an important contribution to that.

Next Steps

This analysis provides a baseline estimate of the excess deaths from COVID-19 in two scenarios. Over time, data will become available to refine these estimates. The analysis can also be extended to inform future government thinking.

Examples of next steps are:

- Further analysis of health records for individuals who contract COVID-19 and do/do not survive, can be used to refine the calculations for excess deaths (already underway)
- New RWC planning scenarios are expected to be released when more evidence is available on the parameters affecting the pandemic.
- Data sources on how the NHS is responding to the pandemic and the economic impacts can update estimates in categories 2 and 3.
- Data on excess deaths can be monitored to identify any emerging trends and triangulate with these estimates
- As government plans evolve, including exit strategies, this analysis can be extended to incorporate a longer time horizon.

To be effective, this work would need to be developed closely with colleagues in HMT, CO and others.

4. Evidence and Methodology

The following section outlines the methodology used to estimate the number of deaths in each category. As stated above, each of the four categories of deaths is calculated independently, so the total number of deaths from each category may be an overestimate.

Category 1: Deaths directly due to COVID-19

These estimates have been produced using a methodology developed by the Office for National Statistics (ONS) in collaboration with the Government Actuary's Department (GAD). To estimate the excess deaths due to COVID-19, we assess the mortality in the infected population in two scenarios: first, with a COVID-19 infection, and second, under normal conditions. All calculations are computed separately by gender and 10-year age groups.

For both the mitigated and unmitigated RWC scenarios, he excess deaths are given by the difference in mortality between the COVID-19 RWC scenario and the expected deaths in the normal conditions:

$$\textit{COVID-19 excess deaths} = \textit{COVID-19 deaths} - \textit{expected deaths}$$

The expected deaths in the infected population are given by the number of COVID-19 infected multiplied by the standard mortality rate from the UK National life tables:

$$\textit{expected deaths} = \textit{COVID-19 infected } X\ m$$

where m is the standard mortality rate.

The mortality with a COVID-19 infection is given by adding the COVID-19 deaths and the expected survivors' deaths, multiplied by the proportion of the year free from COVID-19[ii]:

$$\textit{deaths with COVID-19} = \textit{COVID-19 deaths} + \textit{expected survivors deaths } X\ p$$

where p is the proportion of the year free from COVID-19.

The COVID-19 deaths are obtained from both of government's RWC scenarios. The expected number of survivors' deaths is calculated as the number of COVID-19 infected multiplied by the standard mortality rate minus the expected number of COVID-19 victims who would have died in the normal conditions:

$$\textit{expected survivors' deaths} = \textit{COVID-19 infected } X\ m - \textit{COVID-19 deaths } X\ m\ X\ k$$

where m is the standard mortality rate and k is a parameter to account for the higher mortality rates of the COVID-19 infected population.

Individuals in the COVID-19 infected population tend to suffer from multiple health conditions and therefore are likely to have a higher expected mortality than the general population. Therefore, under normal conditions, their one-year mortality rate is likely to be higher than the standard mortality rate of the general population. To allow for this greater risk of mortality, we scale up the standard mortality rate by the gender and age-specific parameter k. k is calculated based on the estimates of mortality rates by number of health conditions derived from Banerjee et al. (2020)[1]. See Annex A for more details.

We also estimate the years of life lost (YLL) to COVID-19. The YLL is given by the number of excess deaths time the life expectancy of COVID-19 victims. We calculate the life expectancy of COVID-19

[ii] Assuming a recovery period of 4 weeks, we have p=48/52.

victims, using mortality rates based on the hazard rates in Banerjee et al (2020).)[2]. See Annex A for more details.

This approach is likely to overstate excess deaths for several reasons. If the individuals who die due to COVID-19 tend to have many comorbidities or are particularly vulnerable, their underlying background mortality is likely to be greater than the hazard rates from Banerjee et al (2020). As a result, our approach is likely to overestimate the excess deaths.

Over the 24-week period covered by the RWC scenario, the mitigated scenario RWC-M estimates almost 50,000 people will die from COVID-19. The COVID-19 excess mortality is estimated to be over 43,000. Under alternative assumptions on underlying background mortality of COVID-19 victims, the total excess deaths could be[iii] between 41,000 and 45,000.[iv] These excess deaths represent 300,000 to 590,000 years of life lost.

Using the unmitigated RWC-U scenario assumes almost 520,000 people would die from COVID-19. The excess mortality here is estimated to be approx. 450,000; between 420,000 and 470,000, using the same background mortality assumptions as for RWC-M above. These excess deaths represent 2,800,000 to 5,400,000 years of life lost.

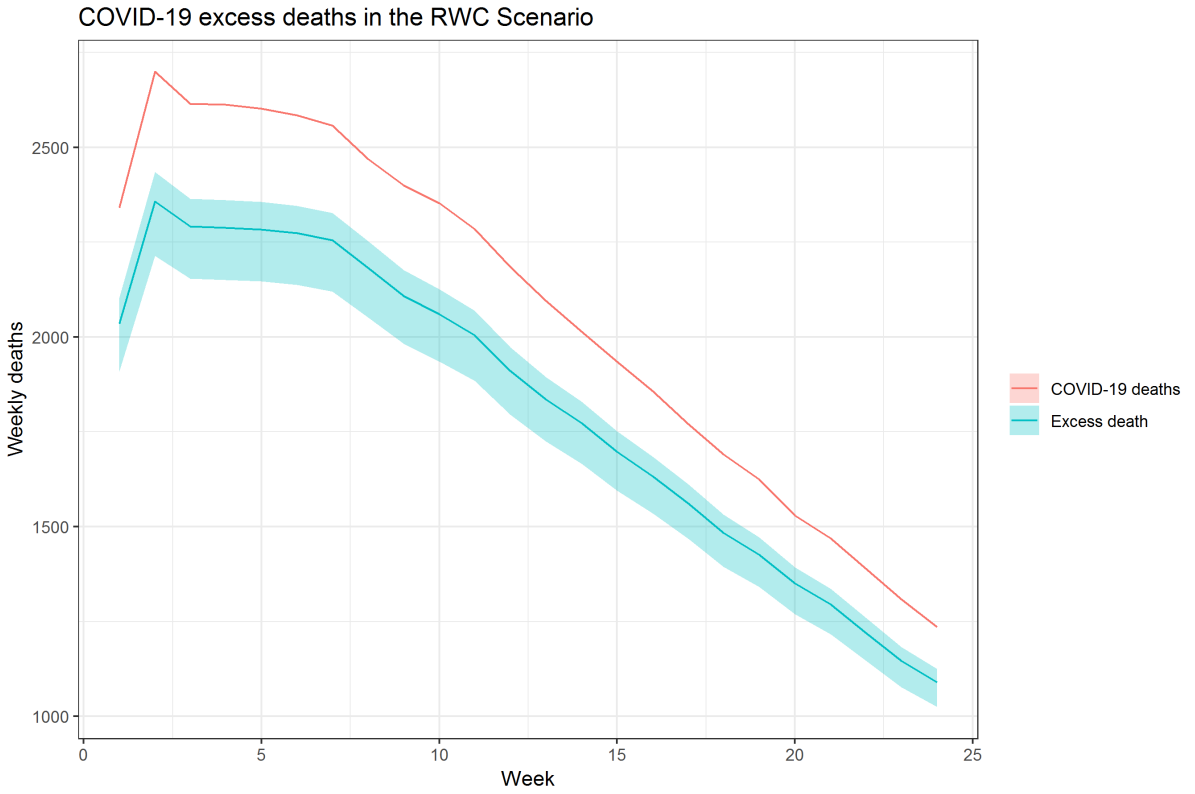


Figure 1: COVID-19 excess deaths in the RWC Scenario

[iii] Assuming that the COVID-19 victims' background mortality is four times the mortality rates from Banerjee et al (2020), the excess rates would be estimated to be 29,296.

[iv] Our lower bound is based on assuming the COVID-19 victims' mortality rate matches those of individuals with 3+ pre-existing conditions. Assuming that the COVID-19 victims' background mortality is four times the mortality rates from Banerjee et al (2020), the excess rates would be estimated to be 29,296.

Further information on this modelling and results is available in Annex A.

Category 2: Indirect COVID-19 deaths due to additional pressures on the health and social care system, unable to maintain previous standards and unable to adequately treat and care for patients with COVID-19 and other conditions

Mitigated RWC

Due to COVID-19, it is possible that some deaths may occur as a result of the NHS (and the broader health and social care system) being put under significant pressure, or in some scenarios actually overwhelmed, and unable to provide treatment to previous or potentially adequate, standards. The NHS has set out to maintain priority services for non-COVID-19 patients, such as emergency treatment; however, service disruption due to COVID-19, for example from low staffing levels, could put some lives at risk.

To understand where and how excess deaths may occur across the health and social care system, DHSC's single departmental plan was reviewed (see Annex E for more detail). Once potential factors were identified, evidence about these was sought, drawing upon testimony from other countries that have experienced COVID-19 ahead of the UK (e.g. Italy, China), stakeholders in the sector and timely news reports on individual hospitals and trusts as well as academic literature (where available). Given time limitations, a comprehensive literature review was not possible.

This evidence gathering process identified a number of concerns in relation to patient safety, for example low staffing levels and other service disruptions relating to COVID-19. These issues are likely to be felt across the NHS services still operating, with specific concern being expressed for **maternity**, **adult social care** and **mental health services**. However, it did not provide any evidence for a quantitative estimate of the impact on mortality for these services.

To produce a quantitative estimate of the impact on mortality for this category of death in emergency admissions, quantitative analysis was undertaken using two top down approaches (further information on this modelling and results is available in Annex B). Firstly, estimates were produced drawing upon international evidence on the impact of delays and overcrowding in emergency admissions on deaths. Secondly, estimates were produced using the distribution in standardised hospital morality to illustrate a plausible mortality impact.

Under the mitigated RWC scenario, this modelling assumes sufficient ventilated beds and workforce for all COVID-19 admissions and expected admissions for other conditions. Since the start of the outbreak, NHS England has delivered a number of interventions to increase capacity in terms of total beds and staff, and ability to administer oxygen and ventilation. Simple analysis comparing these plans for capacity increases with the mitigated RWC (poor compliance) shows the NHS in England is in a reasonable position by way of projected capacity in the short term.

Unmitigated RWC

In the unmitigated RWC the peak of the pandemic is so high that no health service could come close to providing the necessary staffing and ventilated beds to treat every patient that would require it. To estimate the additional fatalities, we make the following assumptions:

- Unmitigated RWC (5 March) assumptions are used for rates of infection by week
- Mitigated RWC (28 March) assumptions are used for hospitalisation and critical care admission rates, lengths of stay and infection fatality rate for those receiving appropriate care
- We assume the NHS makes available 30,000 non-critical and 20,000 critical care beds to treat COVID-19 patients. These are assumed to be available in time for the surge in cases.

We perform a simple calculation to determine the number of patients who would have required non-critical and critical beds if there are none available. For these patients we assume 60% mortality for patients requiring non-critical care beds, and 100% mortality for patients requiring critical care beds. Note, these fatality rates have not been clinically verified but they do give an overall approximately 4% infection fatality rate, which has been suggested by some sources to be the potential impact of an unmitigated scenario[v]. These assumptions generate an upper estimate of c. 1.2M additional COVID-19 deaths in patients unable to access the hospital care they require. Due to the large uncertainty in the clinical outcomes of untreated patients, we approximate this by saying "there could be >1M deaths".

Category 3: Deaths from changes to healthcare activity, such as cancellation or postponement of elective surgeries and other non-urgent treatments.

Mitigated RWC

The NHS is trying to reduce risks from COVID-19 to patients and increase its ability to respond to the crisis, by continuing to treat urgent elective patients, such as most cancer treatments, and de-prioritising non-urgent care, with an emphasis on risk management. This should avoid short-term deaths but there will be a longer-term knock-on impact from delaying so many non-urgent services. There may be some life-saving treatments, such as organ transplants, that need to be postponed in order to protect vulnerable patients from the risk of contracting COVID-19 and to avoid patients becoming particularly vulnerable while in their recovery phase.

We are unable to provide a detailed estimate of the impact of these changes to healthcare activity as it is unclear precisely what activity would be postponed, for how long, what knock-on impact this would have on future patient waits, and how a delay in treatment would affect outcomes. Instead, we have modelled a scenario whereby we assume 75% of elective care activity is stopped for a period of 6 months. Various evidence supports the estimate that 75% of elective care has been postponed, but it is unclear how long the postponement will be for. This activity represents around £17bn of expenditure over a 6-month period. If this activity were cancelled entirely it would result in an estimated **185,000 additional deaths**. Further methodology and discussion are available in Annex C**.** These deaths are assumed to be mostly medium and long-term.

[v] Source: Neil Ferguson, Imperial College

This is an upper-bound estimate for this scenario. The NHS will be prioritising life-saving treatments and will be hoping to postpone rather than cancel most of this treatment. However, there will be a knock-on impact on future patients as the NHS takes time to work through the backlog.

If services can be resumed quickly, most of the risk of mortality can likely be managed, but if there are continuing delays for a longer period, there could even be a proportionately greater impact than is estimated here, if long waiting lists build up and have a knock-on impact on future patients requiring healthcare.

This scenario does not account for other cuts to services that are known to have taken place already in many out-of-hospital services partially or fully, including NHS health checks, non-urgent primary care (dental and GP), de-prioritised community services, and some screening and vaccination programmes. In particular, access to GP services may also be disrupted, which will delay diagnosis of conditions and referrals for treatment. Further details of these service changes and some indication of their impact is given in Annex D. No estimate has been made of this mortality impact, but it is likely this could be significant in the longer term.

Category 4: Short-term impact on deaths as a result of the behavioural and social interventions (BSIs), plus longer-term impact from the economic downturn.

Economists in DHSC, the Home Office and ONS have investigated many areas in which a recession caused by reduced economic activity, and social changes due to BSIs, would impact mortality. This includes effects which could reduce mortality as well as those which could increase it. A list of the main areas in which mortality rates are expected to be impacted by economic and social factors is included below.

Table 2: Impacts on excess deaths from wider socio-economic factors

Factors	Impact duration	Impact on excess deaths	Confidence in estimated figures
Suicides including anxiety, depression or stress	Short and long term	Rise, minimal in short term to low hundred in long term (500).	Low – indicative figures presented
Car accidents	Short and long term	Fall, low hundreds in short term (300) to low thousand in long term (1,100).	Low – indicative figures presented
Violent crimes / homicides	Short and long term	Fall, minimal in short term to low hundred (150)	Low – indicative figures presented
Work accidents	Short term and long term	Fall, low tenths	Low – indicative analysis
Domestic accidents	Short term and long term	Small rise (low tens) in domestic accident fatalities	Low – indicative analysis
Domestic violence	Short term and long term	Rise, low tens in short and long term.	Low – indicative figures presented
Homelessness	Short and long term	Fall, low tens in short term to low hundreds in long term.	Low – indicative analysis
Air pollution	Long term	Fall, low tens of thousands (15,000 - 20,000).	Low – indicative figures presented
Exercise and diet	Long term	Net nil impact on deaths due to offsetting impacts.	Judgement based

These assessments have been compiled using findings from a literature review into the impacts of recessions, available in Annex G, and social changes due to BSIs in Annex E.

The short-term net impact from social factors resulting from a recession and BSIs is estimated to be approximately **200 – 500 fewer deaths** in the 24-week period. In the wider context, this level of improvement in mortality will be dwarfed by the rise in directly related deaths from COVID-19. This net impact is the sum of multiple estimates with high uncertainty, so is itself very uncertain and difficult to predict.

The evidence on BSIs suggests a possible increase in mortality from domestic abuse and suicide. However, the scale of impact is unclear. It should be noted that mortality from domestic abuse is very small compared to other causes of death. The impact on suicide rates would be from a

combination of economic impacts and BSIs; BSIs are leading to income uncertainty for many households, likely to continue into the future for many individuals and this may lead to increased mental anguish and potentially suicide.

The evidence also suggests a decrease in mortality from air pollution and road accidents. The benefits of a reduction in car accidents could be significant in size and occur in the short term while BSIs affecting travel are in place. The evidence suggests there could be potential short-term benefits from a reduction in air pollution, however it is unclear at this stage what the scale of impact on mortality could be. The evidence on alcohol and drug misuse is limited and the direction of impact is unclear. The resulting short-term impact of socio-economic factors resulting from a recession and Government BSIs is therefore estimated to be approximately **200 – 500 fewer deaths** in the next 24 weeks, mostly driven by the reduction in road traffic accidents and air pollution.

The longer-term impacts are more difficult to ascertain, given uncertainty around length of any recession. Three scenarios have been considered:

- A V-shaped economic recession, where the economy 'bounces back' quickly
- A U-shape, with a more gradual return to normal (note this could include a period of time where lockdown measures are gradually relaxed before having to be tightened again), and
- A more severe L-shape, where the economy does not recover in the medium-term.

The latter scenario is less likely and cannot be informed as much by previous recession data but will have great mortality consequences if it leads to sustained and entrenched increases in levels of deprivation. Investigating this effect using the Index of Multiple Deprivation and Welsh Index of Multiple Deprivation (IMD and WIMD respectively), varying both the level of GDP contraction expected and the association between GDP and IMD score, suggests this **more challenging economic scenario could lead to between 600 and 12,000 additional deaths per year, with a central estimate of 3,800**.

Information on a further review of potential factors and evidence undertaken by DHSC, ONS and Home Office to estimate health impacts is available in Annex E. The IMD and WIMD methodology is outlined in Annex H.

Annex A: Estimating excess mortality of COVID-19

Aim

The aim of this work is to estimate the excess deaths caused by COVID-19 in the reasonable worst case (RWC) scenario provided by SPI-M, SAGE and CCS on 28th March 2020.

We aim to estimate the deaths directly from COVID-19 and the extent to which they are moving forward deaths that would have arisen in the short term (defined as one year).

Methods

Input data

We use the RWC planning scenario dated 28th March as our key input for total COVID-19 weekly deaths by age and sex. We also conduct the analysis for the unmitigated RWC scenario dated 5th March. As mentioned in the main paper's Background section, this means these estimates will over- or under-estimate the actual number of deaths if the RWC does the same.

Estimating excess rates based on mortality rates

To estimate the excess deaths due to COVID-19, we assess the mortality in the infected population in two scenarios: first, with a COVID-19 infection; second, under normal conditions. All calculations are computed separately by gender and 10-years age groups.

The excess deaths are given by the difference in mortality between the COVID-19 RWC scenario and the expected deaths in the normal conditions:

$$Excess\ deaths_t = \sum_s \sum_a \left(C19D_{s,a,t} - ED_{s,a,t} \right)$$

Where $C19D_{s,a,t}$ is the number of deaths expected to occur in the infected population in the COVID-19 RWC scenario, and $ED_{s,a,t}$ is the expected deaths in the infected population under normal conditions.

The expected deaths in the infected population under normal conditions are given by the number of COVID-19 infected multiplied by the standard mortality rate from the UK National life tables. This corresponds to the expected number of deaths in the absence of COVID-19.

For age group a and gender s, the number of expected deaths under normal conditions for those infected in week t is given by

$$ED_{s,a,t} = NInfected_{s,a,t} q_{s,a}$$

where $NInfected_{s,a,t}$ is the number of people of gender s and age a who have been infected by COVID-19 in week t. It is derived by multiplying the weekly infection rates by age from the RWC scenario and the population total by age and gender. We assume that men and women are equally likely to be infected by COVID-19.

$q_{s,a}$ is the annual mortality rate for gender s and age group a in the general population, calculated based on the National life tables for 2016-2018. We calculate the average annual mortality rate by age group and gender, using the hypothetical cohort size as a weight. The resulting abridged life table is shown at the end of this annex.

We then estimate the actual deaths for the population infected with COVID-19. This is equal to the COVID-19 related deaths plus the estimated non-COVID-19 related deaths:

$$D_{s,a,t} = DeathsCOVID_{s,a,t} + \left(NInfected_{s,a,t} - k_{s,a}DeathsCOVID_{s,a,t}\right)q_{s,a}p$$

where $DeathsCOVID_{s,a,t}$ is the number of people of gender s and age a who died from COVID-19 in week t. We calculate the COVID-19 deaths by age and gender based on the death rates per 100,000 inhabitants caused by COVID-19 from the RWC scenario. We multiply the deaths rates by 2020population estimates by gender and 10-year age groups. We then attribute 60 percent of these deaths to men, 40 percent to women. Preliminary data from the UK[3] indicate that about 60 percent of those who die from COVID-19 are men. In Germany, about two thirds[4] of COVID-19 deaths are men. A similar ratio is observed in China[5]. We estimate number of deaths by age by multiplying the deaths rates by 2019 population estimates by gender.

p is the proportion of year free of COVID-19. Assuming a recovery period of 4 weeks, we have p=$\frac{48}{52}$.

$k_{s,a}$ is an age and gender-specific constant which represents the ratio in background mortality rate between COVID-19 victims and the general population. $k = 1$ would assume that COVID-19 victims have the same background mortality rate as the general population. Because they are more likely to have underlying conditions, their one-year probability of dying is likely to be larger than that of the general population.

To estimate $k_{s,a}$, we use hazard rates of dying by age groups, gender and number of underlying conditions derived by Banerjee et al (2020)[6]. Underlying conditions include cardiovascular disease, diabetes, steroid therapy, severe obesity, chronic kidney disease, chronic obstructive pulmonary disease, COPD, chronic liver disease, chronic neurological conditions, splenic disorders, immune disorders and HIV/AIDS.

For the central estimate, we derive age and gender specific multipliers by using the ratio of the hazard rate for individuals with two conditions and the standard mortality rate by single age of age. We also derive multipliers based on hazard rates for individuals with one condition and hazard rates for individuals with three or more conditions to obtain a range of estimates of excess deaths, which we report in the main table.

We compute averages for each 10-year age group, using the size of the hypothetical cohorts from the life tables as weightsvi. The hazard rates in Banerjee et al (2020) only cover the population over 35. We use the multiplier for the 35-39 group for the younger age groups. The resulting multipliers by age and gender are presented at the end of this annex. For age groups over 30, the approach is tantamount to using the hazard rates derived by Banerjee et al (2020) ($h_{s,a}$) as the underlying mortality rate of COVID-19 victims (as $k_{s,a} = \frac{h_{s,a}}{q_{s,a}}$, so $k_{s,a}q_{s,a} = h_{s,a}$).

The excess mortality in week t is given by

$$Excess\ deaths_t = \sum_s \sum_a \left(DeathsCOVID_{s,a,t}\left(1 - q_{s,a}k_{s,a}p\right) - NInfected_{s,a,t}q_{s,a}(1-p)\ \right)$$

Note that if we assume that the proportion of year free of COVID-19 is one, then the excess mortality for age group a and gender s is simply given by $DeathsCVID_{s,a,t}\left(1 - q_{s,a}k_{s,a}p\right)$, that is the difference between the number of COVID-19 deaths and the expected number that would have died in the absence of COVID-19.

[vi] We use the size of the hypothetical cohorts from the life tables as weights instead of the population totals so that it is consistent with the derived life expectancies we use to compute years of potential life lost

This approach may overstate excess deaths for several reasons. First, the COVID-19 victims may have higher background mortality rates than implied by our approach. The hazard rates from Banerjee et al (2020) can be interpreted as the average on-year mortality rates by age group, gender and number of health conditions. If the COVID-19 victims tend to have many comorbidities or are particularly vulnerable, their underlying background mortality is likely to be greater than the hazard rates from Banerjee et al (2020). As a result, our approach is likely to overestimate the excess deaths for the RWC we are using. In the Sensitivity Analyses section, we show how the estimate of excess deaths varies if we apply a greater multiplier.

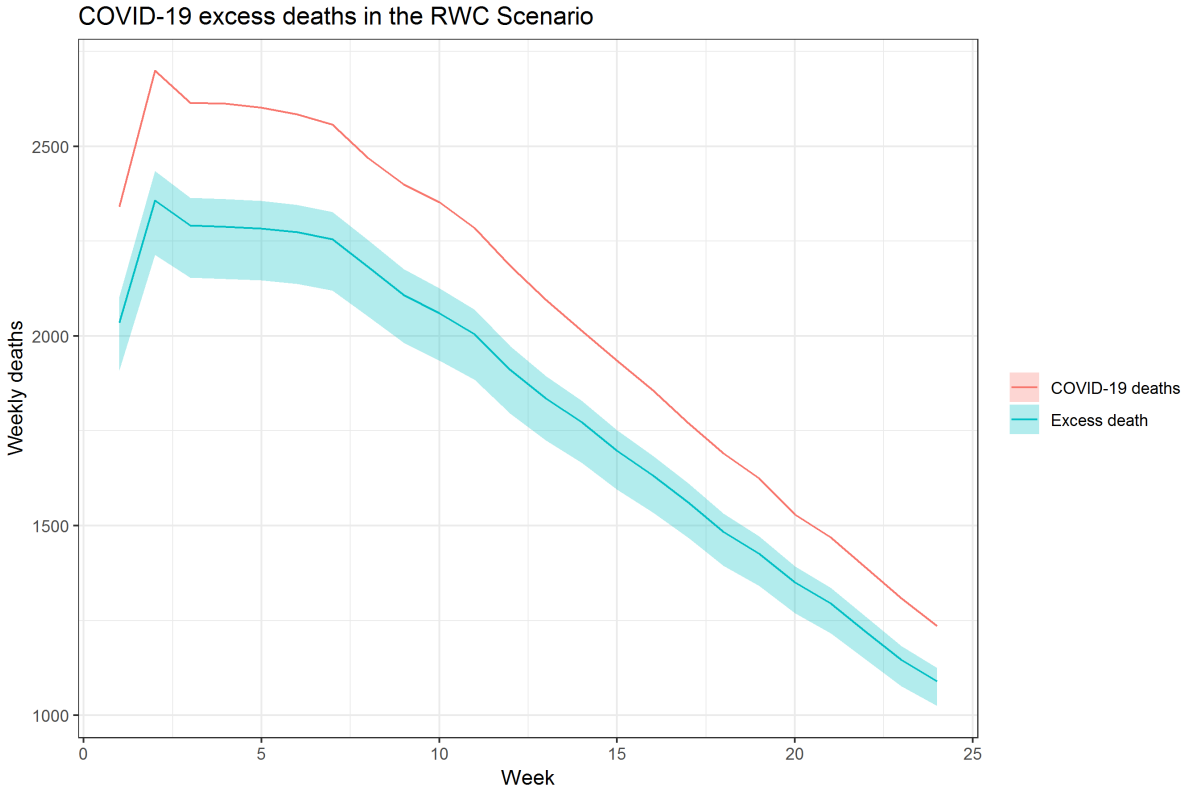
Another assumption is that COVID-19 deaths are equally distributed within each age group. This may not be the case, more deaths may happen at the upper end of the age group. This could bias the estimate of the total excess deaths as the mortality rate of those in the upper end of the band is higher than those at the lower end. This is particularly problematic for the 80+ age group, which is very large and heterogeneous in terms of mortality rate. For instance, the one-year probability of dying is 5.4 percent for an 80 year-old male, 16.5 for a 90 year-old and 26.3 for a 95 year-old.

Estimating years of life lost to COVID-19

We also estimate the years of life lost (YLL) to COVID-19. The YLL is given by the number of excess deaths time the life expectancy of COVID-19 victims.

To do so, we compute the life expectancy of COVID-19 victims, using mortality rates based on the hazard rates in Banerjee et al (2020). For each single year of age, we upscale the standard mortality rate by the factor $k_{s,a}$ used in the calculation of excess deaths. We use these upscaled mortality rates to compute life expectancy for each single year of age. We then compute average life expectancy for each 10-year age group using the hypothetical cohort size as a weight.

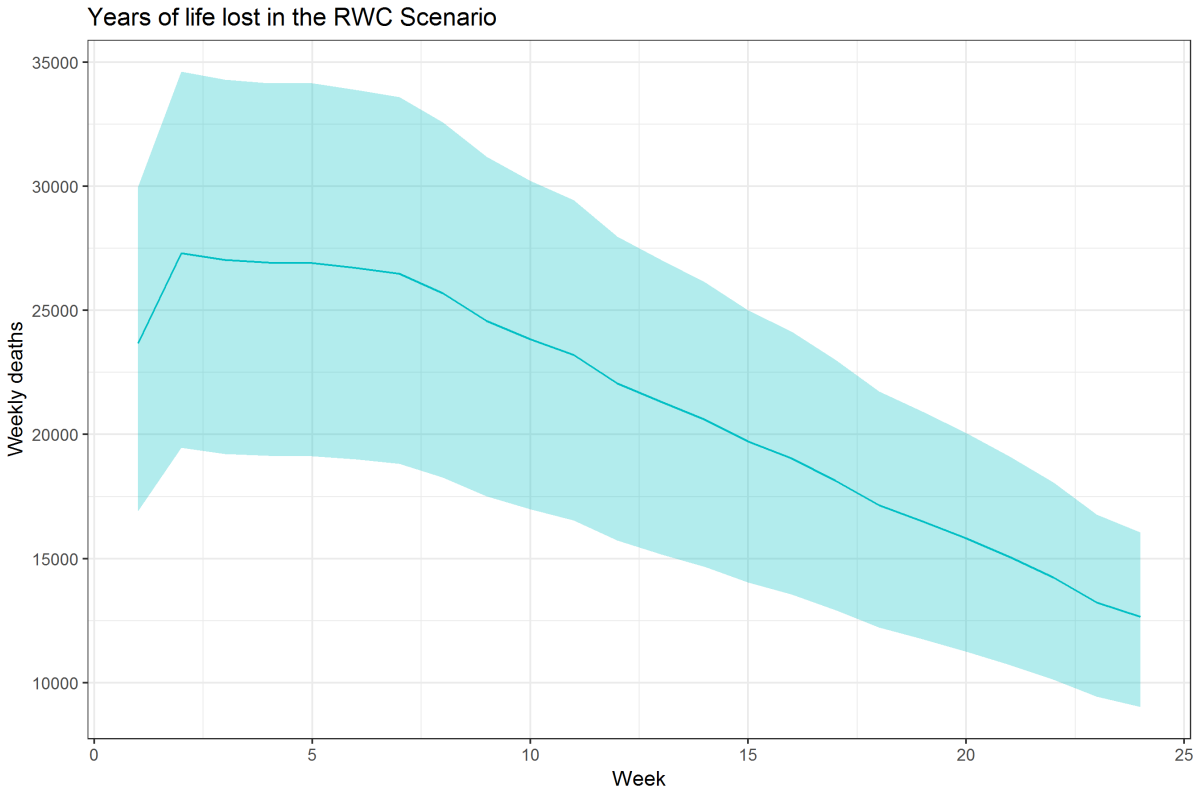
Excess deaths in RWC



The total number of deaths from COVID-19 over the period is assumed to be 50,000. The excess mortality due to COVID-19 is estimated to be 44,000. For this analysis, the background mortality of COVID-19 victims is assumed to match that for individuals with 2 pre-existing conditions. The upper and lower bound estimates for both variants of the RWC are produced by assuming background mortality matches the rate for individuals with 1 condition or 3+ conditions respectively. It is worth noting that this estimate is likely to overstate excess deaths based on the RWC being used: as COVID-19 victims tend to have many comorbidities and be particularly vulnerable, their underlying background mortality is likely to be greater than that assumed in our approach. With different assumptions on the underlying mortality rates, the excess could be much lower, as shown in the sensitivity analysis section. For example, if we assume that the COVID-19 victim's underlying mortality is four times greater than the mortality rates we use in our main approach, the number of excess deaths would be estimated to be below 30,000.

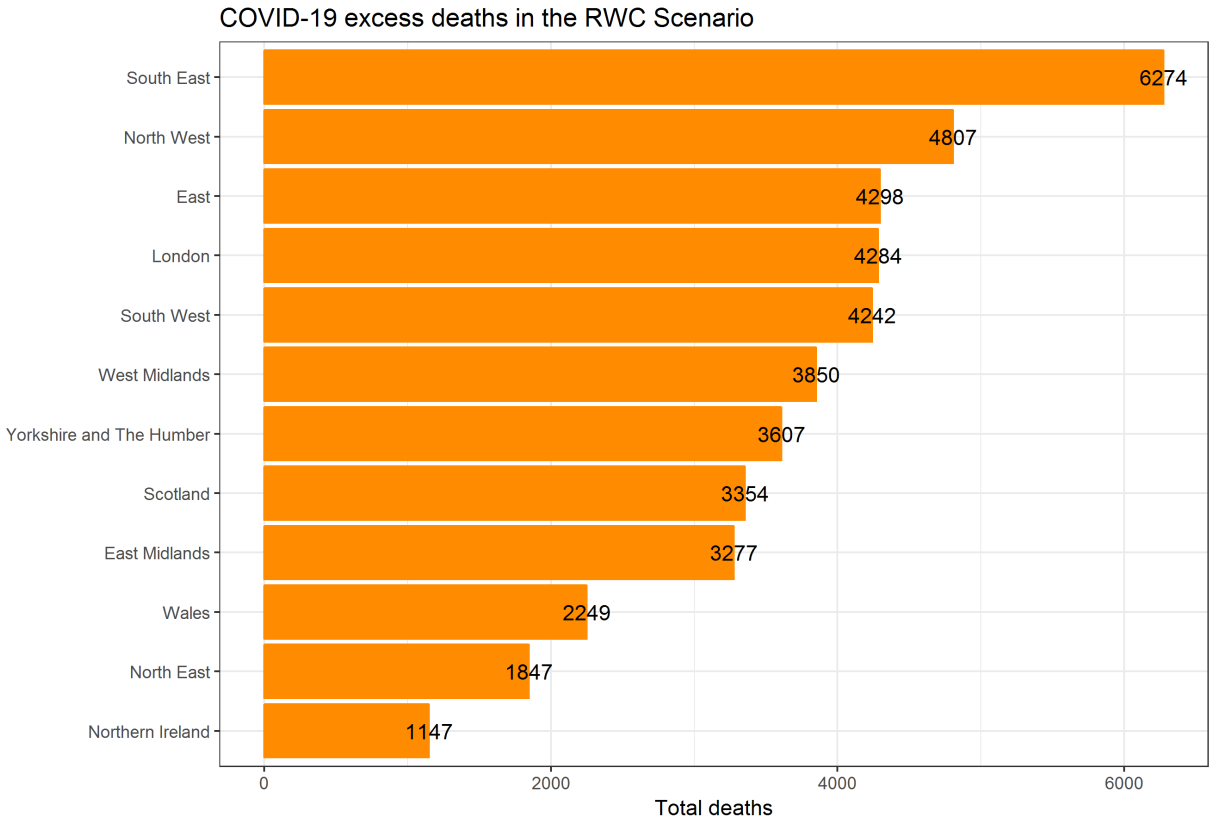
Years of life lost in the RWC

The average years of life lost for COVID-19 excess deaths are estimated to be 9.1. The total years of potential life lost over the 24 weeks period covered by the RWC scenario is estimated to be 450,000 years. Applying the same bounds as above, the years of life lost are between 303,000 and 585,000.



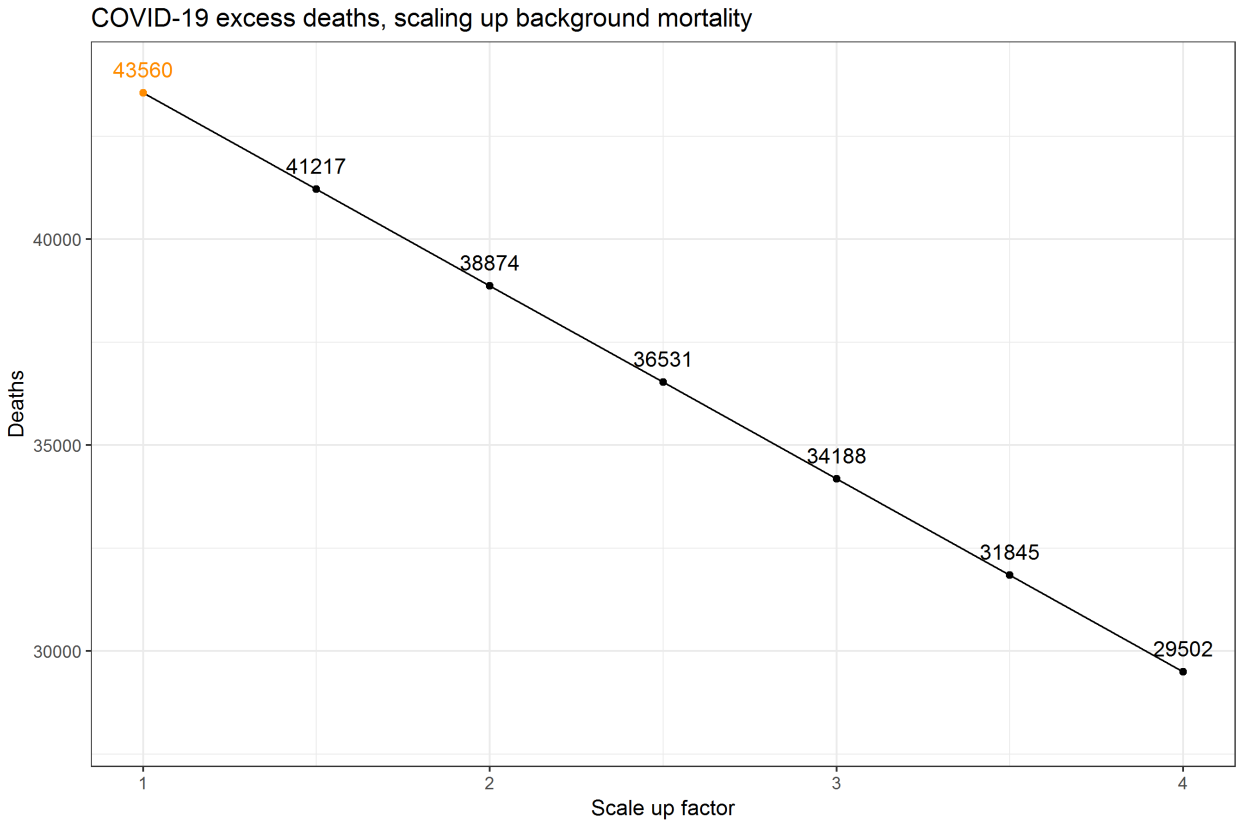
Excess deaths by region

We estimate excess deaths by UK country and regions in England. These estimates are based on the assumption that infection rates and death rates are the same across UK countries and regions. The difference in the number of excess deaths is driven by difference in the population age and sex structure and the size of each region. The RWC we are using does not go below UK level.

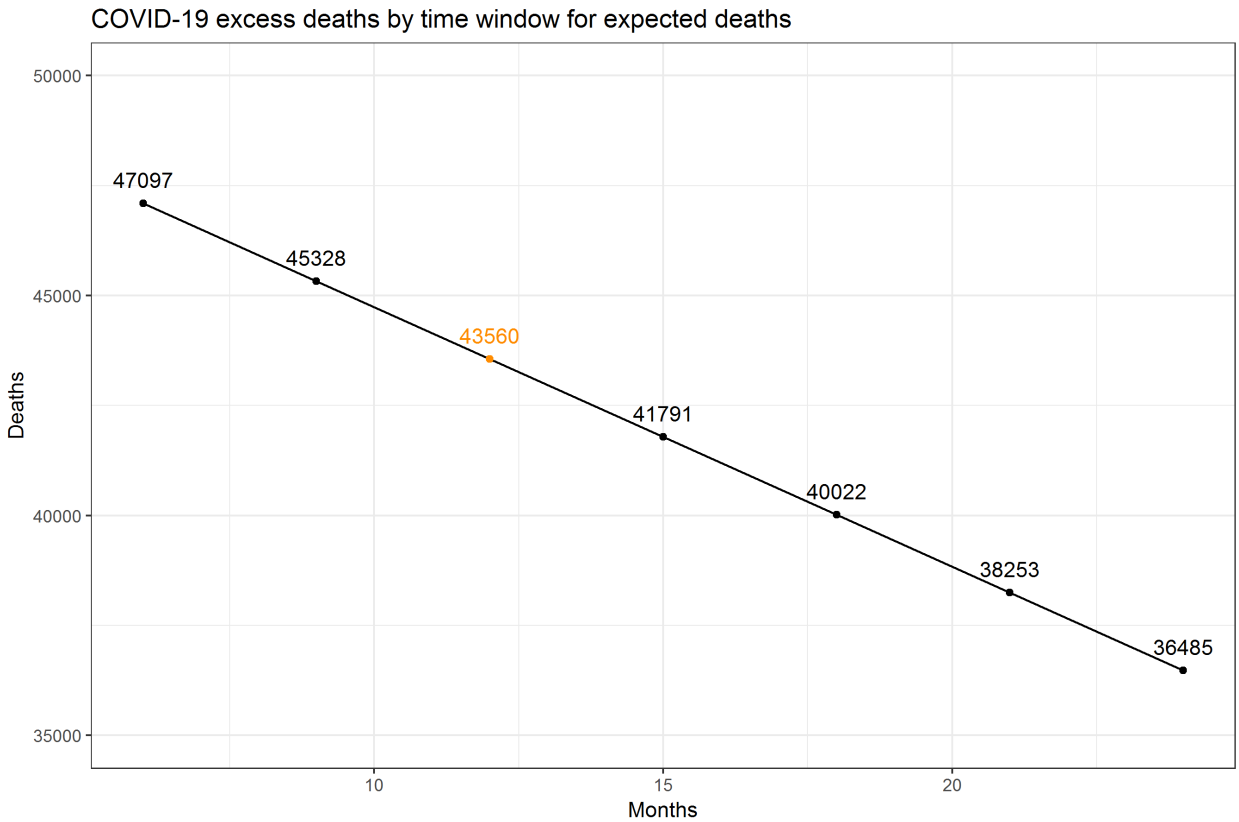


Sensitivity Analysis in the RWC

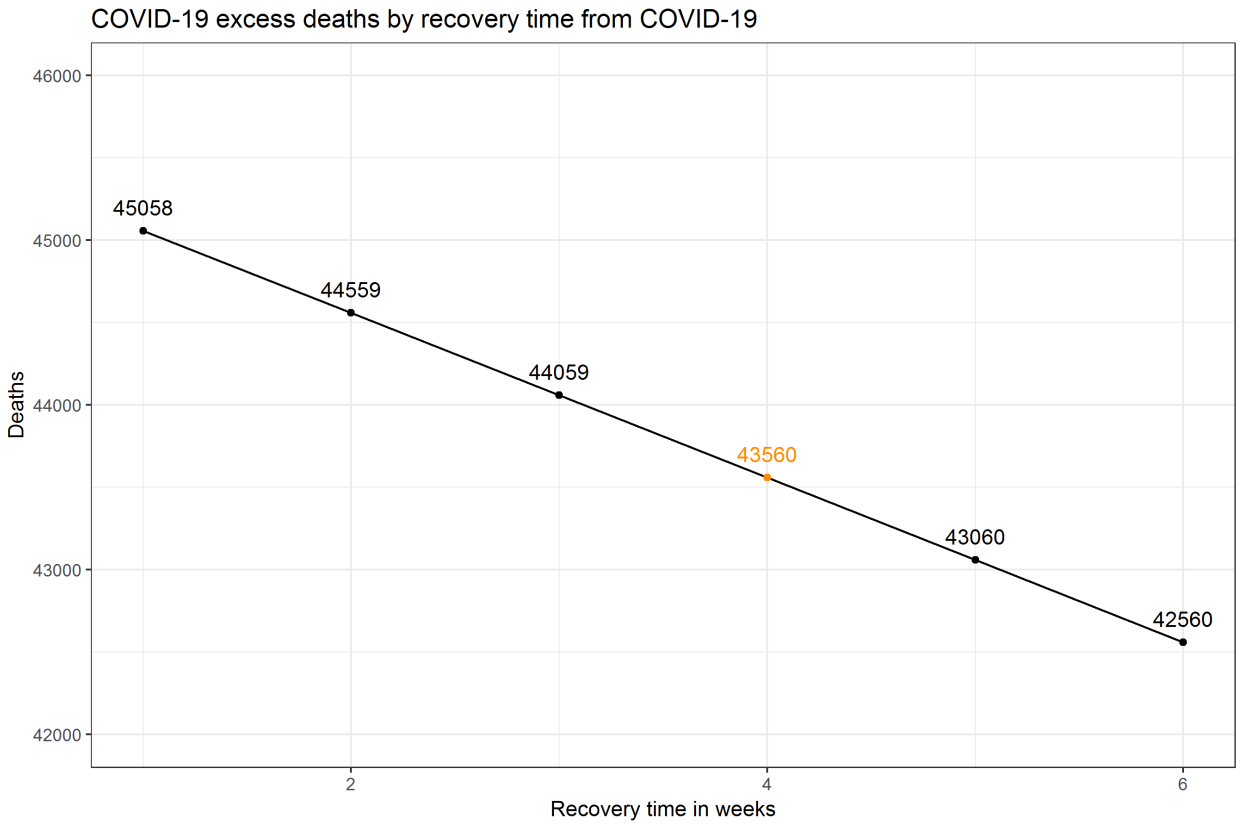
If the COVID-19 victims tend to have many comorbidities or are particularly vulnerable, their underlying background mortality is likely to be greater than the hazard rates from Banerjee et al (2020). Our approach is likely to overestimate the excess deaths. We show how the estimate of excess deaths varies as we scale up the multiplier $k_{s,a}$ by a constant. If we assume that the COVID-19 victims have twice the hazard rates from Banerjee et al (2020) for people with two underlying conditions, the excess rates would be estimated to be almost 40,000. If we assume that the COVID-19 victims' underlying mortality is four times greater, then the excess rates would be estimated to be 29,502.



In the main analysis, we define the excess deaths as the deaths caused by COVID-19 over and above the expected deaths for the infected population within one year. Here we show how the estimates of excess deaths varies depending on the time window we use for estimating the expected deaths.



For our main estimate, we assume that a recovery time from COVID-19 of four weeks. In the Figure below we show estimates of excess deaths using alternative recovery times, from one to six weeks. Our estimates are not very sensitive to using alternative recovery times.



Abridged life table, with multipliers derived from Banerjee et al (2020)

Sex	Age group	Standard mortality rate (q)	COVID-19 victims life expectancy	Multiplier (k)
Men	0.to.9	0.0005349	53.40	8.47
Men	10.to.19	0.0002083	43.94	8.47
Men	20.to.29	0.0005767	35.27	8.47
Men	30.to.39	0.0010361	27.27	8.47
Men	40.to.49	0.0022465	21.32	11.21
Men	50.to.59	0.0047852	15.53	6.67
Men	60.to.69	0.011593	11.21	4.62
Men	70.to.79	0.0291359	7.15	3.25
Men	80+	0.0862049	4.34	2.44
Women	0.to.9	0.0004545	60.01	10.46
Women	10.to.19	0.0001219	50.61	10.46
Women	20.to.29	0.0002525	41.50	10.46
Women	30.to.39	0.0005814	32.98	10.46
Women	40.to.49	0.0013725	26.03	11.43
Women	50.to.59	0.0032194	19.74	6.09
Women	60.to.69	0.0077465	13.51	4.29

Women	70.to.79	0.0205606	8.67	3.55
Women	80+	0.0744194	5.07	2.41

Note: The background mortality of COVID-19 victims is assumed to match that for individuals with 2 pre-existing conditions from Banerjee et al (2020)

Next steps

This analysis shows the sensitivity to the background mortality for COVID-19. As more data becomes available, particularly on the co-morbidities of COVID-19 victims, it will become possible to further refine this approach.

Annex B: Estimating the mortality impact from COVID-19 on non-COVID-19 emergency admissions

This note summarises two top-down approaches to estimating the mortality impact on non-COVID-19 emergency hospital admissions arising from the disruptive effect of treating COVID-19 admissions.

Estimate based on the literature

While it has not been possible within the time available to undertake anything like a comprehensive or systematic review of the literature, there are several studies that provide an opportunity for us to estimate a plausible mortality impact arising from the kind of disruption that might be caused by hospitals having to treat COVID-19 patients.

Starting with a specific subset of emergency admissions based on research undertaken in an NHS setting[7], a study found that the relative risk of in-hospital death in over-65 emergency admissions for fractured neck of femur for those experiencing more than 1 day's delay for surgery is 1.27 (after controlling for confounding factors). If we assume that responding to COVID-19 doubles the proportion of such delays from 40% to 80% and that the COVID-19 effect lasts for 6 months, the resulting number of excess deaths (based on 2018/19 volumes) would be around **300**.

Taking a more comprehensive approach but one based on research from a Canadian study[8], the relative risk of in-hospital death in non-cardiac emergency admissions delayed beyond standard guidelines was found to be 1.59. If the COVID-19 response led to such delays increasing from 20% to 50% and the COVID-19 impact lasted for 6 months, the resulting number of excess deaths (based on 2018 volumes) would be around **25,000**. This study has the strongest relevance to the knock-on impact of COVID-19 because it is due to delays as a result of availability of key staff and equipment, which are the risks identified.

Again, focusing on a comprehensive impact on all emergencies, albeit from an Australian study[9], but one based on the concept of overcrowding on admission rather than delay, the relative risk of in-hospital death 10 days after admission was found to be 1.34. If the COVID-19 response led to disruption equivalent to all emergencies being admitted in overcrowded conditions (compared to a business-as-usual position of around 50%), the resulting number of excess deaths (based on 2018/19 emergency admission volumes) would be around **7,000**.

Estimate using the distribution in standardised hospital morality to illustrate a plausible mortality impact

The Summary Hospital-level Mortality Indicator (SHMI) gives a broad measure of the variation in case-mix adjusted mortality between non-specialist acute trusts. We use this to give options for the increase that we might see in deaths relating to emergency admissions.

The indicator itself includes deaths from elective as well as non-elective admissions, so we subtract the number of elective deaths from our baseline (just under 7,000 out of approximately 288,000 for the latest available period from November 2018 to October 2019 – we assume that this doesn't affect the variation between trusts).

For each of the options, we assume that the mortality rate will increase in proportion to shifting to one of the SHMI indicator milestones and apply this change to our baseline to estimate the excess deaths.

The basic principle behind this approach is to use the existing distribution in standardised mortality across hospitals as an indication of the degree to which the effective management of admissions affects performance in terms of mortality. For example, in option 1 below, the interquartile range (which ignores the influence of outliers) could be seen as representing the plausible range of mortality impact from effective versus relatively ineffective management of admissions. If the COVID-19 impact lasts for 6 months, the impact on emergency admissions in terms of excess deaths is estimated as below, in the case of 3 different scenarios:

Scenario 1: 25th percentile mortality ratio increases to 75th percentile
For the latest information (November 18 – October 19) this means that the number of deaths would increase by 1.084/0.948 or 14.4%, leading to a total of around **20,000** excess deaths over 6 months.

Scenario 2: national average increases to 75th percentile
The average value if the indicator is 1 so this option indicates an increase of 8.4% in the mortality rate, leading to a total of **12,000** excess deaths over 6 months.

Scenario 3: national average increases to 90th percentile
The 90th percentile is 1.124, so this option implies an increase of 12.4% in the mortality rate, giving **17,500** excess deaths over 6 months.

Annex C: Deaths from changes to healthcare activity, such as cancellation or postponement of elective surgeries and other non-urgent treatments

Methodology for quantitative estimate

This paper presents an estimate of the mortality impact on non-COVID-19 patients brought about by NHS resources having to be re-deployed to the management of the COVID-19 pandemic in England.

The NHS is trying to reduce risks from COVID-19 to patients and increase its ability to respond to the crisis, by continuing to treat urgent elective patients, such as most cancer treatments, and de-prioritising non-urgent care, with an emphasis on risk management. This should avoid short-term deaths but there will be a longer-term knock-on impact from delaying so many non-urgent services. There may be some life-saving treatments, such as organ transplants, that need to be postponed in order to protect vulnerable patients from the risk of contracting COVID-19 and to avoid patients becoming particularly vulnerable while in their recovery phase.

We are unable to provide a detailed estimate of the impact of these changes to healthcare activity as it is unclear precisely what activity would be postponed, for how long, what knock-on impact this would have on future patient waits, and how a delay in treatment would affect outcomes. Instead, we have modelled a scenario whereby we assume 75% of elective care activity is stopped for a period of 6 months.

Approach and initial results

The main element of the NHS's redeployment of resources is the cancellation/postponement of routine elective activity (see Annex D for further details). It is difficult to know specifically what elective activity will be cancelled, particularly since some urgent elective activity is likely to have to continue. To estimate the overall proportion of elective care postponed, high level analysis was undertaken of the NHSE guidance that said 12,000 to 15,000 beds would be cleared by suspending elective procedures. This represents approximately 69-87% of beds that were occupied by elective patients in the period April '19 to Feb '20[vii]. We modelled a scenario that 75% of elective activity is postponed, which is consistent with this range. We modelled a scenario that this activity is postponed for a period of 6 months.

It is possible that, if social distancing measures more broadly are relaxed at some point before the end of the 6-month period due to successful management of the outbreak, a lower percentage of elective activity will need to be cancelled.

We have taken high-level categories of NHS expenditure and assumed, for the time-being, that elective activity represents half of the overall spend in areas where such a split is likely and meaningful. There are several lines of expenditure for which we have assumed no reduction in spend – for example, spending on acute and community mental health services and all pharmaceutical expenditure. This produces an estimate of the value of elective activity.

[vii] The M10 Joint Activity Report gives in the first 10 months of financial year 19/20 3,664,347 bed days were used for elective patients. As most elective patients are in hospital Mondays to Fridays we divide by 212 (number of working days in the first 10 months of 2019/20) to get beds used by electives at 17,284.

We have combined our estimate of the value of elective activity with our assumption about the proportion of elective activity that might be cancelled to arrive at an estimate of the total value of activity cancelled. This is equivalent to around £17bn of expenditure in 2020/21 prices.

To arrive at an estimate of the deaths this level of expenditure would otherwise avert[viii] (and therefore the excess deaths likely to arise were such expenditure curtailed) we use an estimate of the cost per death averted at the margin of NHS expenditure from research undertaken by Claxton et al at the University of York[10]. Deaths averted are calculated on the basis of the proportionate relationship between a given change in spending by disease and standardised years of life lost under 75, applied to all deaths in the disease area. Life year effects from these deaths averted are based on the life expectancy by age and gender by disease group compared to the mortality risk of the general population by age and gender. By analysing the relationship between NHS expenditure and mortality across 11 programme budgets and 152 sub-national NHS commissioning units they estimate the cost per death averted across all programme spending to be around £73,000 in 2008/09 prices, equivalent to around £90,000 in 2020/21 prices.

Dividing the value of cancelled elective activity by the estimated cost per death averted produces an estimate of deaths associated with this level of expenditure – equivalent to 185,000 – and therefore the mortality that might result were such activity to be cancelled permanently.

This is an upper-bound estimate for this scenario. The NHS will be prioritising life-saving treatments and will be hoping to postpone rather than cancel most of this treatment. However, there will be a knock-on impact on future patients as the NHS takes time to work through the backlog.

If services can be resumed quickly, most of the risk of mortality can likely be managed, but if there are continuing delays for a longer period, there could even be a proportionately greater impact than is estimated here, if long waiting lists build up and have a knock-on impact on future patients requiring healthcare.

Main caveats

- The estimate described above is based on an assumption that 75% of elective activity is cancelled for a period of 6 months and that, for lines of expenditure where most appropriate, elective activity represents 50% of the total expenditure.
- The cost per death averted figure used above is calculated on the basis of all expenditure, covering 23 programme budgets – i.e. it includes spending on both non-elective and elective activity. The above estimate is therefore implicitly based on an assumption that the marginal cost per death for electives is not significantly different to that for all NHS activity. If spending on urgent and emergency activity has more of an impact on mortality than elective activity, this assumption will tend to overstate the mortality impact described above.
- Furthermore, the cost per death averted is estimated at the margin of NHS expenditure and therefore is most appropriate to apply to spending at the proximity to this margin. It could be argued that spending equivalent to £17bn is significant enough to include activity beyond the margin. To the extent that the NHS will choose to defer the least urgent/valuable activity ahead of more urgent/valuable activity, some of the spending curtailed as a result of the cancellation of elective activity would be more cost-effective than at the margin. This would tend to understate the mortality impact described above.

[viii] Deaths averted do not include those averted for less than 2 years of remaining life.

Annex D: Details of service changes and indicative size of impact from deferring services

Advice has been sent out from NHSE/I to healthcare providers and commissioners, listing some specific health services to be suspended, or partially suspended, during the pandemic; the latest guidance can be found here[11]. The overarching principle of the guidance is to de-prioritise non-urgent care, with an emphasis on risk assessment. Care postponement judged to be of lowest risk should/will generally be the first to be deprioritised. Some services have been designated as services which can/will be completely stopped, these include NHS health checks, non-urgent primary care (dental and GP), non-urgent elective operations and some screening and vaccination programmes (although guidance with specifics on this is yet to be issued). Emergency admissions, cancer treatment and other clinically urgent care should continue unaffected.

Suspending 'non-urgent' care is expected to have a short-term health impact in itself, since patients not receiving treatment will have reduced quality of life whilst not receiving these healthcare services. In the longer term their condition is likely to deteriorate without treatment and some could die earlier than otherwise. Cutting screening, prevention services and primary care services will mean that life-threatening diseases will go undetected and hence untreated, resulting in more avoidable deaths. The longer the services are deprioritised for, the more impact this will have, and this will not be a linear relationship as healthcare problems will escalate over time.

For example, NHS health checks will be stopped for the duration of the pandemic. These would usually be expected to have the following impact (in 6 months): prevent at least 800 heart attacks and strokes; prevent 2,000 people developing diabetes; detect 10,000 cases diabetes and kidney disease early.

Bowel and breast cancer screening is expected to be continued, however it is possible (yet to be confirmed) that cervical cancer screening may be stopped. This covers around 70-75% of females aged 25 to 64 (approx. 15 million women). Females have a cancer incidence of around 9.36 per 100,000 person years, so within 6 months approximately 700 women would be expected to be diagnosed with cervical cancer. Generally, 5% of cancer diagnoses are diagnosed through screening. In addition, other methods of diagnosis are also far less likely to occur during the pandemic. Around 56% of diagnoses usually come from GP referrals (and non-urgent GP work is being stopped). A further 12% are usually diagnosed from inpatient admissions/outpatient treatment, again these are likely to be reduced.

Primary care services have been reprioritised, but pressures on GP services will be very significant during the pandemic. One additional pressure will be that GPs will need to manage patients in the community who would have received treatment in secondary care. This is additional pressure to GP services and access to these services is expected to be impacted. For those people not being seen for non-urgent GP/routine dental appointments/routine audiology services, there will be a worsening of conditions that would ordinarily be prevented through these services such as oral hygiene and worsening health conditions.

Across all the non-urgent services that are cut, larger waiting lists will exist when services resume so patients seeking care in the future are likely to experience far longer delays to treatment than they would have otherwise.

Annex E: Review of evidence of the factors potentially related to excess deaths across the health and social care system.

Informed by a review of DHSC's single departmental plan[12], the following annex represents an overview of where and how excess deaths might occur across the health and care system in relation to COVID-19. These are focused on the three categories of death outlined in the main body of this document which are not directly as a result of COVID-19 (Categories 2, 3 and 4).

Once potential areas and factors had been identified, evidence was sought for each of these. This process initially included referring to the EPPI-Centre's mapper of COVID-19 related publications[13]. In addition, anecdotal reports from other countries affected by COVID-19 (e.g. Italy, China) have been included. Evidence from major stakeholders in relevant areas has also been cited, such as bodies representing healthcare professionals and third sector organisations, as well as news reports about individual trust/hospital activity. The evidence below represents an overview of why and how excess deaths may occur; however, a comprehensive literature review was not possible due to limited time and therefore the evidence may not be exhaustive or representative.

Category 2: Indirect COVID-19 deaths due to additional pressures on the health and social care system, unable to maintain previous standards and unable to adequately treat and care for patients with COVID-19 and other conditions

It is possible that some deaths may occur for individuals with health issues that require treatment in a critical care unit (CCU). This may be due to:

a) *Lack of CCU capacity*

COVID-19 patients who are hospitalised are likely to need ventilator equipment and treatment in CCUs. Without increasing capacity in the NHS, CCU bed capacity would be breached. However, the NHS has mitigated this risk by rapidly increasing CCU capacity. Therefore, we assume there to be negligible number of deaths due to lack of CCU beds in the mitigated RWC.

b) *Poorer outcomes, as a result of understaffing, lack of bed capacity, equipment or patients' reluctance to enter hospitals.*

Understaffing/ demands on staff specialities: It is possible that patients attending urgent care in hospitals may receive a poor quality of healthcare service as a result of staff and resources being diverted to treat patients with COVID-19.

There is anecdotal evidence of this in other countries; for example, doctors in Italy cited concerns about the impact of anaesthetic staff due to their involvement in helping patients' airways, and this could mean they are less available for help with other urgent care such as appendicitis or blood clots.[14]

There is also evidence in the UK of impacts on NHS staffing levels as a result of COVID-19. For example, the Royal College of Physicians has suggested that around one in four NHS doctors are off work sick or in isolation[15]. There could also be an impact on all aspects of the health care system due to staff sickness or self-isolation, including maternity, mental health provision and adult social care, and indeed patient ability to attend appointments if they are self-isolating. For example, one care home provider has stated that 11% of their total workforce are self-isolating[16]. The Royal College of Midwives suggests that the proportion of vacant posts has

doubled from 1 in 10 in the last three weeks to 1 in 5, due to a combination of COVID-19, self-isolation and existing staff shortages[17].

Lack of equipment: More recently, there have been reports of medical staff in some trusts in the UK refusing to see patients or restricting services due to a lack of personal protective equipment (PPE)[18][19].

Patients' reluctance to attend hospital: Recent data from PHE suggests that attendances to emergency departments in England have fall significantly since the COVID-19 lockdown. There were 89,584 attendances in the week after the lockdown (23rd to 29th March), 25% lower than 120,356 attendances in the previous week; this compares to 136,669 attendances in the same week (23rd to 29th) in 2019.[20] All indicators had decreased in attendances, apart from pneumonia.[21]

Particular concerns have been reported about fewer people coming to hospital when they are having a stroke; similarly, there are reports that attendances for myocardial infarction at emergency departments have decreased, despite ambulance calls for chest pain increasing[22].

Decreases in emergency department attendances have also been observed in Australia, Canada and Europe. Possible reasons for these decreases in attendances include:

- There is less occurrence of disease, because of the reduced contact between people and less trauma because of lower vehicle use. However, there are also concerns about increases in domestic violence (see section on domestic violence below).
- Disease and illnesses are being managed differently; it has been suggested that patients could be being treated in other ways, avoiding going to hospital, for example by using video consultations with GPs.
- People are staying away from hospitals, remaining at home with diseases that need to be treated because of concerns about catching the virus and overcrowding in hospitals. Doctors in Italy have reported patients with myocardial infarction (heart attack) or heart failure arriving later at hospital; they suggest that patients want to avoid going to hospital due to overcrowding with patients with COVID-19, and therefore by arriving later their clinical conditions are worse[23].

Category 3: Deaths from changes to healthcare activity, such as cancellation or postponement of elective surgeries and other non-urgent treatments

Some non-emergency treatment may be postponed as a result of changes to the healthcare services in preparing for COVID-19. This may result in worsening health and could, in some cases, lead to early death.

Urgent elective care is being prioritised (e.g. most cancer treatments) and is still going ahead, and some services are moving out of a hospital setting where possible. However, non-urgent surgery and many other healthcare services are being temporarily suspended. Postponing non-urgent elective care could in some instances result in more emergencies in the short term, and in the medium and long term there will be some cases of faster deterioration of health conditions and hence mortality.

For example, some trusts have suspended organ transplants due to the additional risks for patients with COVID-19[24]. This could have implications for patients' conditions in the short, medium and long term. There are also concerns about provision of screening services; at present, screening and

immunisation services are still under review and more comprehensive guidance on their provision during COVID-19 is due to be available soon. One trust has cited concerns that lab testing facilities may be impacted or reprioritised to COVID-19[25]; this could mean delays in screening, diagnosis and treatment, and therefore worsening prognoses and mortality in the long-term.

Category 4: Short-term impact on deaths as a result of the behavioural and social interventions (BSIs), plus health impacts from the economic downturn.

The Department for Health and Social Care, The Home Office and The Office for National Statistics agreed on the key socio-economic factors in which the Covid-19 pandemic and the Government's BSI's could impact mortality. The three departments investigated these areas to find evidence linking changes in levels to mortality, and the scale of the mortality impact – with headline results presented in the **Methodology**.

The analysis focused on the short-term impacts on mortality but included assessments of a long-term recession and/or lockdown. Attempts have been made to quantify the impacts where possible. In several places the evidence was insufficient such that economists had to make a reasonable judgement on what impacts could occur. There are also some limitations mentioned for some of the areas where there was inadequate data to provide a quantitative estimate of the impact of mortality.

This section provides a literature review on related evidence for each factor as well as a brief methodology on any analysis undertaken.

Summary of impact:

The table below summarises the impact on mortality from major factors and complements the table presented in the **Methodology** section for category 4. We have identified several other factors which may have an impact but it has not been possible to robustly quantify these due to a lack of evidence on direction and magnitude of effect.

Factor	Mortality impact	Number of monthly deaths (without BSI's)	Quality of evidence	Short or long term impact
Air pollution	Fall	2,333-3,000 from long-term exposure.	Moderate	Short and long term
Road accidents	Fall	150	Moderate	Short and long term
Suicide	Rise	510	Moderate	Short term
Domestic Abuse/Violence	Rise	20	Moderate	Short and long term
Alcohol misuse	Unclear	630	Weak	Long term
Drug misuse	Unclear	240	Weak	Short and long term
Adult social care	Rise	N/A	Weak	Short and long term

Other infectious diseases	Fall	N/A	Weak	Short term
Smoking	Unclear	6480	Weak	Short and long term
Child abuse	Unclear	N/A	Weak	Short and long term
Rough sleepers	Unclear	N/A	Weak	Short and long term
LGBTQ+	Unclear	N/A	Weak	Short and long term
Access to community pharmacy	Unclear	N/A	Weak	Short and long term
Employment and the economy	Unclear	N/A	Weak	Short and long term
Physical activity	Unclear	N/A	Weak	Short and long term
Diet	Unclear	N/A	Weak	Short and long term

- Evidence suggests a possible increase in mortality from domestic abuse and suicide. However, the scale of impact is unclear. It should be noted that mortality from domestic abuse is very small compared to other causes of death. Changes to suicide rates would be from a combination of economic impacts, the emotional response (e.g. anxiety, bereavement) to the health impacts of the virus itself, and BSIs.
- Evidence suggests a decrease in mortality from air pollution and road accidents. The benefits of a reduction in car accidents could be significant in size and occur in the short term while BSIs affecting travel are in place. The evidence suggests there could be potential short-term benefits from a reduction in air pollution, however it is unclear at this stage what scale of impact on mortality could be.
- Evidence for the impact on deaths from alcohol and substance misuse is unclear.

Overall economic impact on mortality:

1. **A large body of evidence suggests that mortality rates fall during times of recession, and rise during economic booms, exhibiting a procyclical relationship with GDP.** Early studies find a strong procyclical relationship between economic growth and total mortality.[26] One study of US state data for 1972-1991 indicates that a one percentage point rise in the unemployment rate is associated with a 0.50% decrease in the total mortality rate[27].

2. **However, recent studies suggest that mortality has become less procyclical and less linked to economic conditions.** Another study of US state data found a smaller fall in mortality of 0.19% when extending the analysis through to 2006.[28]

Air pollution

Air pollution is expected to have the largest impact on excess deaths amongst all our identified factors. Air pollution is the top environmental risk to human health in the UK and one of the greatest

threats to our health after cancer, heart disease and obesity. It affects people of all ages, but particularly at the beginning and later stages of life.

The relative risks of mortality associated with long-term exposure to air pollution are higher than those reported from time-series studies examining the health effects associated with short-term variations in air pollution. It is estimated that long-term exposure to man-made pollution in the UK has an annual effect equivalent to between 28,000 and 36,000 deaths[29], a monthly range between 2,333 and 3,000 deaths.

The short-term reduction in air pollution could have positive health impacts. The evidence from time-series studies indicate the effects of short-term changes in air pollution concentrations. The health effects associated with short-term episodes of elevated levels of pollutants in the UK have been quantified through varies studies[30,31,32]. One UK study[33] looking at the spike in air pollution in 2014 (10 days), showed that around 600 deaths were brought forward from short-term exposure to particulate matter, representing 3.9% of total al cause (excluding external) mortality during these days. Estimates from the same time period in other years showed that this is 2.0 to 2.7 times the mortality burden associated with typical urban pollution levels of particulate matter (PM). Exposure to particulate matter over shorter time periods has been associated with increases in respiratory and cardiovascular disease events, potentially leading to increased risk of mortality and hospitalization, and exacerbation of conditions such as asthma[34,35,36,37,38,39,40], and therefore short-term reduction in air pollution could have positive health impacts.

Reduction in air pollution can be a result of BSIs and reduction in economic activity. Evidence shows that there has been a significant improvements in air quality following BSIs[41] in most cities but there have been some rises in rural areas. The evidence notes that detailed analysis is required before the exact causes of the pollution declines can be pinpointed. It is important to note that different pollutants have different impacts on health. Early indications from Defra suggest that exposure to some pollutants have decreased where others have stayed the same or increased slightly. There are many factors that affect pollution levels - including local weather, new regulations and human activity. Therefore, at this stage it is unclear what the scale of the impacts on mortality are in the short-term.

Note there are outstanding concerns with this estimate voiced by Public Health England and the Department for Environment, Food and Rural Affairs, but no alternative estimate has yet been provided.

Road accidents

It is likely that BSIs would lead to a reduction in economic activity and therefore road use, however no clear evidence to support it. The economic literature consistently reports that during recessions, road traffic and related deaths typically fall. A study conducted by He (2016)[42] found that during the recent Great Recession, for each percentage point increase in the unemployment rate, motor-vehicle fatalities decrease by 2.82%.

Anecdotal reports from the US[43] shows that there has been a reduction in traffic collisions, however as there is a time lag in the data it is not clear what the picture is for the UK. Current estimates from DfT indicate that levels of traffic have fallen by 73% between 5th – 29th March 2020 (latest available data) which could impact the number of fatalities from road accidents. It is likely that BSIs would lead to a reduction in economic activity and therefore road use, however no clear evidence to support it. In addition, there is a time lag with an incident occurring[44], it being reported to the police and the incident being processed. If police forces have been redeployed to other areas, there may

be a lag in cases coming through. Deaths from road accidents are around 150[45] per month and are likely to significantly fall following BSIs.

Our approach to estimate the impact on excess deaths from a fall in road deaths is set out below:

- Our baseline for the annual number of road deaths (1,870) in GB from June 2019 is sourced from Department for Transport (DfT) official road safety statistics[46]. We divided this to obtain a monthly estimate.
- We estimated the impact on excess road deaths in GB from socio-economic changes resulting from COVID-19.
- DfT road traffic count data shows a 73% fall in road traffic between 5-29 March 2020.[47]
- DfT data obtained from police reports indicates a very sharp decline in casualties and fatalities from road accidents in March 2020. Although a lag of 2 months is expected on data reporting.
- It's not plausible to assume a one-to-one proportionate relationship between road traffic levels and road deaths, although it is likely that a fall in road activity leads to fewer road accidents and in turn fewer road fatalities. Thus, we assume a 30% fall in monthly deaths with current indications of a 73% fall in road traffic holding in our scenarios.
- This assumption is based on our judgement that road deaths are expected to fall significantly – resulting from lockdown measures, rise in people working from home; and a fall in economic activity.
- DfT agrees less traffic is likely to lead to a fall in road accidents, and in turn fewer deaths with this cause. However the 30% estimate is produced by ONS for illustrative purposes.

Psychological impacts

A review of the psychological impact of quarantine (covering 24 papers[48]) found that most studies reported negative psychological effects including post-traumatic stress symptoms, confusion, and anger. Stressors included longer quarantine duration, infection fears, frustration, boredom, inadequate supplies, inadequate information, financial loss, and stigma. Some researchers have suggested long-lasting effects. The review showed that most of the effects come from a restriction of liberty through stricter quarantine measures, and that voluntary quarantine is associated with less distress and fewer long-term complications.

Studies looking at the psychological impacts of Covid-19 in the initial stage of the epidemic in China shows that increasing amount of people rated their psychological impact from the outbreak as moderate to severe[49]. None of the studies showed death/suicide as an outcome of negative psychological effects however this could be due to participants not being followed over time.

Evidence from China[50] demonstrated that low levels of social capital were associated with increased levels of anxiety and stress; increased levels of social capital were positively associated with increased quality of stress. This suggests a potential inequalities aspect; however, it is a small sample and cover the early stages of self-isolation following the epidemic.

Further evidence from South Korea[51] on the impact on staff suggests that following a fatal infectious disease outbreak, nurses experience high levels of PTSD and show high intention to leave; supervisor support had a strong buffering effect. Impacts on mental health were seen in Saudi Arabia[52], where health workers were anxious of spreading the disease to family members, China[53,54] where front line staff felt anxious and stressed and Italy[55] which reported suicide incidents of two nurses.

Anecdotal evidence suggests that changes to routines and care plans can cause significant stress to some (e.g. those with autism), and suggestion that disruption in contact with MH services may have

a similar effect. There have also been reports[56] of the impact of public health advice on hand washing on those with compulsive hand washing tendencies.

Evidence[57] also shows that of adults who reported attempted suicide, about a fifth had sought help from friends/family/neighbours (21.7%) and therefore, those with depression and/or anxiety and/or psychotic disorders could be impacted significantly by social distancing measures. Mental health conditions have been shown to be at a higher risk of attempting and completing suicide, with more than 90%[58] of suicides and suicide attempts having been found to be associated with a psychiatric disorder.

The evidence suggests that BSIs could impact those with pre-existing mental health conditions, as disruption to services and general stress surrounding the pandemic would affect their ability to cope with the condition. There could be negative psychological impacts on staff dealing with the epidemic. There has also been an increase in demand of mental health services due to BSIs[59].

Further, evidence suggests that typically a worsening of economic conditions could also lead to worsening of mental health. There is strong evidence that job loss has negative effects on individuals' health. Unemployment can cause a reduction in wellbeing and deterioration in mental health both through the income mechanism and directly.[60]

Suicide

Evidence suggests that impact on suicide could result from:

- Direct BSIs
- Economic impact

The number of deaths by suicide rises during times of recession, and falls during economic booms, revealing a countercyclical relationship with GDP. Suicides can increase through two mechanisms: the induction pathway and the displacement pathway. In the former, economic crises lead to psychological vulnerability in the population, which induces suicide in persons who are otherwise unlikely to engage in self-destructive behaviour. In the displacement pathway, economic crises trigger suicides that would have occurred eventually. The relationship between macroeconomic conditions and suicides has strengthened over time – a one percentage point growth in unemployment is associated with a 0.9% rise is suicides in 1976 compared to a 2.4% growth in 2009.[61]

There is some evidence that the effect of long-term unemployment on mental health can makes job losses more entrenched. This vicious cycle, known as hysteresis, occurs during periods of high unemployment (after a major economic shock). Those potentially most affected by job losses are not able to find employment quickly, and the effect on their mental health is magnified. A study of unemployment in Spain during the Great Recession points to such an effect and finds negative impacts of unemployment on mental health and, to a lesser extent, death rates.[62]
Research[63] looking at quarantine measures used in a hospital in Taiwan during the SARS outbreak showed that confinement to small area for a prolonged period could drive staff to suicide. Although the study looked at a specific type of quarantine, it is evident that stricter quarantine measures could increase fear and mental stress which could increase the number of suicides/attempted suicides.

There have been reports[64] of suicides in other countries however it is not clear whether the suicide was committed due to lockdown measures or other reasons. It can be assumed that suicide rates

may increase due to negative psychological impacts from BSIs and the economic impacts from a recession. Research shows that with more than 90%[65] of suicides and suicide attempts having been found to be associated with a psychiatric disorder, and therefore one part of the rise in suicide rates could be due to mental health issues. Suicides can increase through two mechanisms during a recession: the induction pathway and the displacement pathway. In the former, economic crises lead to psychological vulnerability in the population, which induces suicide in persons who are otherwise unlikely to engage in self-destructive behaviour. In the displacement pathway, economic crises trigger suicides that would have occurred eventually. The relationship between macroeconomic conditions and suicides has strengthened over time – a one percentage point growth in unemployment is associated with a 0.9% rise is suicides in 1976 compared to a 2.4% growth in 2009.[66]

Whether any rise in suicide rates are from those with existing mental health conditions or those with new mental health issues following the BSIs and an economic downturn is unclear. Reports from the US[67] show an increase in demand for suicide prevention services and anecdotal evidence from the UK shows similar trends in demand or suicide prevention services. It is unclear what the scale of impact could be, but deaths from suicide are around 510[68] per month.

Our approach to estimate the impact on excess deaths from suicides is set out below:

- There were 6,507 suicides in the UK in 2018.[69]
- Evidence from Ruhm (2015) showed that the annual raise in suicide could be as high as 2.4% per 1% increase in unemployment.
- A study into the effects of quarantine (Lancet – Rapid review) found that one of the key impacts on anxiety and depression during a quarantine was its length. With this reasoning, we have applied a 0.8% increase to suicide rates over 6 months and a 2.4% increase for the subsequent months after that period – per 1% increase in unemployment.[70] While there are obvious flaws with this approach, it captures the fact that suicides are more likely with deterioration of mental health, and this is correlated with the length of social restrictions.

Domestic violence

There have been concerns that instances of domestic violence could increase with the introduction of BSIs. With school closures, there could also be an increase in children witnessing domestic abuse/violence at home. In addition, disruption in services due to the measures could impact the number of cases.

Recently, more than 25 organisations helping domestic violence victims in the UK have reported an increase in their caseload[71], with Refuge citing a 25% increase in calls and online requests for help since the lockdown[72]; this may be due to heightened domestic tensions, cut off escape routes, pressure on other services and awareness campaigns. This echoes reports from China which indicated an increase in domestic abuse due to BSIs (social distancing, self-isolation and school closure) [73].

Visits to the UK-wide National Domestic Abuse helpline website for information were 150% higher than during the last week in February[74]. Organisations supporting domestic violence victims have also reported having to reduce service delivery, due to technical issues, inability to meet victims and staff sickness[75].

Whether any of cases of domestic violence would lead to mortality is unclear. Potential reasonings for an increase in domestic abuse/violence:

- Isolation at home
- Working from home
- Limited access to face to face support services

Deaths from domestic homicide are around 20[76] per month. Given the very few cases per month on domestic homicide, doubling the number of deaths would be negligible in the number of total deaths. Although the reports indicate that the level of domestic abuse/violence may increase, historical statistics show that only a small proportion of these incidents lead to death.

Our approach to estimate the impact on excess deaths from domestic violence related deaths is set out below:

- Figures from police report data across the UK show an annual figure of 173 deaths attributed to domestic violence.[77]
- A BBC article reports that domestic violence calls have increased by 25% since the start of the virus outbreak - a figure taken from the charity Refuge [78]
- Applying that quantifiable increase in activity related to domestic violence would lead to approx. 20 additional deaths per year.
- It is unlikely that a 25% rise in domestic violence incidents would equate to the same proportionate rise in deaths from domestic violence. However, given the small scale of number of deaths involved, the impact is minimal compared to other pressures on mortality from COVID-19 and BSIs.

Alcohol use

BSIs can impact alcohol use in different ways:

- Reduction in social drinking and possible alcohol poisoning due to closures of pubs, bars and restaurants.
- Those who are alcohol dependent and drink at home may see no issues with supply as alcohol remains available through supermarkets.
- An increase in alcohol consumption for those who are dependent on alcohol due in order to cope with the challenges of covid-19. Research[79] does highlight a small increase in incident alcohol use disorders. Individuals with a history of alcohol use disorders are more likely to report drinking to cope with the traumatic events.

Mortality from alcohol specific deaths tend to be from longer-term conditions, therefore it unclear whether short term changes to those socially drinking would impact mortality in the short-term. It is most likely that any changes to mortality in the short-term would be from changes in consumption of those who are alcohol dependent. Reduction in social drinking could have impacts on mortality in the long term. It is unclear whether alcohol services have been impacted from the measures. If services are disrupted this could impact mortality rates from resources being re-allocated or services being offered over the phone. Alcohol specific deaths are around 630 per month[80].

Drugs

The European Monitoring Centre for Drugs and Drug Addiction[81] have outlined some short-term risks of Covid-19 which include the risk of overdose increasing amongst those using drugs who have

Covid-19 symptoms or have tested positive, impact on those that use drugs who have a underlying chronic medical condition, sharing drugs using equipment may increase the risk of infection and risks of disruption in access to drug services, clean drug-using equipment and vital medications.

Recent increases in drug poisoning deaths have been due to Cocaine (increase in supply and purity). In theory, issues in supply of cocaine due to social behavioral interventions could reduce the number of deaths however no evidence or insight is available on drug supply in the UK. Reports from the US[82] indicate that people may be forced into abstinence because of supply chain disruptions, potentially suffering lethal withdrawals or overdosing when using again. In addition, disruption in drug addiction/misuse services could impact mortality rates.

Deaths from drug poisoning related to drug misuse 240[83] per month.

Homelessness

One group at particularly significant risk from COVID-19 is the homeless and rough sleeping population. Government has intervened to support this group including measures to provide accommodation. The Government has also acted to prevent a rise in homelessness by introducing rent and mortgage breaks schemes.

Due to Government action in supporting the homelessness, we expect the number of excess deaths amongst this group to fall in the short and long term scenarios. Preliminary intelligence from the Ministry of Housing, Communities and Local Government (MHCLG) suggests around 90% of the 6,000 people who had previously been sleeping rough or in shared sleeping spaces have been offered accommodation suitable to allow them to self-isolate. However at this stage it is difficult to quantify the magnitude of the expected fall in excess deaths for this group.

Violent Crime and homicides

We expect that under a lockdown with BSI's in place and a recession, homicides are expected to fall, albeit by a marginal amount relative to overall number of excess deaths.

Our approach to estimate the impact on excess deaths from homicides is set out below:

- Last year there were 671 deaths from homicide in England and Wales.[84]
- Between the year ending March 2009 and March 2010 (that is following the last recession), homicides fell by 7%.[85]
- Assuming the same rate of fall in homicides as the last recession and factoring in the impacts of lockdown, we assume a 10% fall in mortality in the short- and long-term scenarios. This is based on a judgment call.

Work Accidents

Work accidents are expected to reduce under BSIs, with more workers staying at home or being furloughed. Some of this impact may be offset with a rise in work accidents for those workers in key sectors who face additional work pressure. On the whole, we expect work-related accidents and deaths to fall while BSIs are in place. In the absence of evidence of how work accidents are impacted by COVID-19 and BSI measures, we have undertaken illustrative analysis as set out below:

- The number of fatal work accidents in the UK is relatively small at only 147 per year.[86]
- Given the rise in people either working from home or are furloughed we'd expect deaths from work accidents to fall. But some workers are still working as normal such as those in Government identified 'key' sectors.

- The analysis assumes that there is likely to be a tiny fall (low tenths) in work related fatalities in both the short term and long-term scenarios.

Domestic Accidents

There are currently approximately 6,000 deaths due to domestic accidents every year.[87] With more people working from home and staying at home while under BSIs, we expect domestic accidents to rise and deaths from domestic accidents to rise alongside. There is little evidence on the direction or magnitude of change in domestic accidents and deaths from more people staying at home for longer periods. Based on reasoning we assume that the longer BSIs are in place, the more deaths will be expected from home accidents. This could be offset if people, in the face of lockdown measures, put additional safety measures in place at home.

Based on judgement, we expect a small rise (low tens) in domestic accident fatalities in both the short and long term.

Other potential factors

There are several other factors which may be affected by the changes in socio-economic levels and the introduction of behavioural-social interventions as a result of COVID-19. These include smoking, the impact on specific vulnerable groups, child abuse, access to community pharmacy, employment and the economy, adult social care, physical activity, diet and other infectious diseases.

a) Smoking

The direction of effect on smoking rates as a result of the behavioural-social interventions is unknown. Social distancing and people staying and working at home (and therefore not attending smoke-free working environments) could mean an increased rate of smoking, which could have impacts on mortality in the longer term. The Centers for Disease Control and Prevention in the United States suggests that stress during an infectious disease outbreak can mean increased use of tobacco[88]. However, there is also evidence[89] that smoking reduces during economic downturns, which is likely due to an income channel through which people buy fewer health-damaging goods when income falls. Despite this, there is evidence that this effect has become less strong over time for some health behaviours. Deaths attributed to smoking are around 6,480[90] per month.

b) Vulnerable groups

Some vulnerable groups may be particularly affected by the social distancing measures.

For example, the charity Crisis has raised concerns that rough sleepers may be at higher risk of infection due to pre-existing health conditions and challenges in washing their hands or self-isolation[91]. However, the government has instructed local authorities to find accommodation for all rough sleepers. Despite this, as of 30th March 2020 there were reports of thousands of rough sleepers still unhoused[92].

There have been some reports of young people who identify as LGBTQ+ moving back in with parents who do not accept their sexuality or gender identity during the lockdown and are unable to move out due to strains on their finances[93]. There is anecdotal evidence of such individuals experiencing isolation in their homes as a result or say they are "putting up with the abuse". We do not have evidence of the scale of this issue, or the implications for mortality; however, there has been some suggestion that individuals who identify as LGBTQ+ may be at higher risk of mental health issues and suicidal thoughts[94,95]. The Mental Health Foundation suggests the higher prevalence of mental ill health may be related to discrimination, isolation and homophobia.[96]

c) Child abuse

Social distancing measures could impact the delivery of local services. Reduced interaction with these services which would help to identify issues of child abuse could therefore be impacted. Current estimates show that in 2018/19, Childline[97] provided 250,281 counselling sessions to children and young people; of these, 19,847 (8%) had abuse (neglect, physical, sexual or emotional) as the main concern. In particular, 3% of counselling sessions were about physical abuse concerns. The NSPCC reported ONS data which indicates that child homicides are most commonly perpetrated by the child's parent or step-parent (42%).[98] Currently there is not strong evidence to show the impact on local services from BSIs.

d) Community pharmacy

Individuals' access to pharmacies and therefore medication for their health conditions may be impacted by social distancing measures; if people are self-isolating, they may not be able to attend the pharmacy to purchase their medication. News reports cited an example of this from rural Wales, although this was dated 17th March 2020[99]. This issue may be somewhat mitigated by the NHS Volunteer Responders scheme[100] and the potential impact on mortality is unknown.

e) Employment and the economy

Reduced economic activity is associated with less road traffic as fewer workers drive to work and fewer goods are transported. As such, there are fewer transport accidents and less air pollution, both of which lead to a reduction in mortality during recessions. The number of deaths caused by cardiovascular disease, transport accidents and air pollution fall during times of recession, and rise during economic booms, exhibiting a procyclical relationship with GDP[101].

Leisure time increases with fewer working hours, making it less costly to undertake time-intensive health-benefitting activities. In addition, avoiding hazardous workplace conditions, job-related stress and the physical exertion of employment may improve health. There is also evidence that individuals spend more time socialising and caring for relatives during recession periods[102]. Although this effect may not be as strong as it has been in previous recessions. One study suggests that increased leisure-time exercise during periods of economic weakness is more than offset by reductions in work-related physical exertion.[103]

There is some evidence that the effect of long-term unemployment on mental health can makes job losses more entrenched. This vicious cycle, known as hysteresis, occurs during periods of high unemployment (after a major economic shock). Those potentially most affected by job losses are not able to find employment quickly, and the effect on their mental health is magnified. A study[104] of unemployment in Spain during the Great Recession points to such an effect and finds negative impacts of unemployment on mental health and, to a lesser extent, death rates.

f) Adult Social Care

There are potential implications for adult social care staff in terms of self-isolation and sickness; this could have implications for the concentration of care and the ability to escalate medical/care needs. This would include those living in care homes and those living in their own homes. As noted above, MFA, who run 160 care homes, stated that 11% of their total workforce are self-isolating[105]. In addition, for dependent adults supported by informal carers, they could be left vulnerable if their informal care is impacted through, for example, carers needing to self-isolate due to COVID-19.

g) Physical activity

There may be positive impact on health as a result of increased physical activity as people take the opportunity to use their one instance of daily exercise. However, there is also the possibility that people will become more sedentary whilst staying home. The evidence is limited, and the direction

of the effect and the implication for mortality is unclear. It is also possible that physical activity may interact with the reduction in road traffic accidents; with fewer vehicles on the road, instances of pedestrian or cyclist deaths may decrease.

h) Diet

There may be implications for mortality from poor diet as a result of people being unable to purchase fresh food due to stock availability and/or stockpiling and/or self-isolation. However, there may be improvements to diet as a result of reduced consumption of take-away food high in fat, sugar and salt. Obesity related deaths would be linked to other health conditions.

There have been some anecdotal reports from China during COVID-19 of individuals dying from starvation as a result of isolation[106].

i) Other infectious diseases

With the introduction of social distancing it is also possible that there may be a reduction in some infectious illnesses, such as sexually transmitted diseases, flu, measles, and tuberculosis, which will reduce demand on some health services and in some cases prevent deaths from these conditions.

Annex F: COVID-19 recession scenarios – health effects

This note considers three economic trend scenarios and the resulting inference for mortality. These assessments have been compiled using findings from a literature review which should be read alongside this note (see Annex G). The use of scenarios is important given the considerable uncertainty on: COVID-19 development, policy, public following, and the slowly emerging body of evidence.

The uncertainty extends to the effect that the government's suppression measures will have on the economy. As such, we present a range of scenarios. As time progresses and we gather further data, we will be able to improve our understanding of the likelihoods.

Impacts presented below are qualitative and speculative; we can aim to model and quantify deaths and wider health effects given more time.

Variables we consider within each scenario

Each scenario is constructed by changing the assumptions around how a number of the factors below play out:

- Length of recession – over how many quarters the economy experiences negative growth
- Depth of recession – the magnitude of negative growth experienced during the recession
- Recovery – the magnitude of positive growth following the recession.

There are some other variables that we also consider:

- Extent and length of unemployment
- Behavioural response
- Direct impact of government suppression measures on recession effects.

Impacts we consider

We consider the impact of each scenario on overall mortality and health, as well as the factors that make these up. *Internal impacts* are those occurring to individuals who become unemployed or experience a loss in income (for example, a deterioration in mental health); *external impacts* are more general and result from the loss of overall economic activity (for example, fewer transport-related fatalities).

Overview of scenarios

Scenario	Variables and Assumptions	Impact
V-shaped recession Short recession lasting six months; quick 'bounce-back' recovery following easing of suppression measures.	Deep but short recession with rapid growth back to trend after six months. Unemployment rises but limited as most jobs furloughed. Healthy behaviours increase.	Balance appears to be on health increasing and mortality decreasing. *Internal impacts* Mental health for some individuals may deteriorate, and the number of suicides may increase. *External impacts* There may be some decrease in transport fatalities and pollution-related deaths, although this may mostly be down to the suppression measures themselves.
U-shaped recession Temporary (but more protracted) reduction in national income. Slower recovery. Possibly 'W-shaped' i.e. a limited recovery while some measures are eased, before being re-introduced.	Longer recession (24 months or more) with slower recovery to trend. Some longer-term unemployment. Government measures to limit severity of unemployment is successful in some areas but not all.	Some of the negative factors become exacerbated, but the balance is still likely to be towards a decrease in mortality. *Internal impacts* Mental health may deteriorate further, particularly for those in sectors experiencing high unemployment. The number of suicides is expected to increase. *External impacts* Further decrease in transport and pollution fatalities.
L-shaped recession Long recession, taking years for GDP to recover to trend (if at all).	Severe recession which takes years to return to trend growth. Long-term unemployment.	Increase in deprivation for large areas of society. It's possible that at this point, the (largely positive) effects of the *external impacts* are overpowered by the (largely negative) effects of the *internal impacts*. *Internal impacts* Some significant deterioration in physical and mental health due to long-term unemployment. *External impacts* Further decrease in transport and pollution fatalities. Some

		deterioration in healthcare quality may counteract this.

V-shaped

Description of scenario: short recession lasting six months with a quick and strong recovery following the easing of suppression measures. In this scenario, there is no general loss of productive capabilities growth; an increase in spending from suppressed demand leads to growth returning to trend. The reduction in income (both nationally and individually) is for the most part temporary.

Total mortality likely decreases as a result of the recession.

Evidence suggests:

- There would likely be a decrease in traffic fatalities due to fewer people travelling to work. The reduction in traffic will be larger than in a standard recession due to lockdown measures encouraging working from home, and there being effectively no travel for social reasons.
- Deaths resulting from respiratory problems due to air pollution would also likely decrease due to lower vehicle use, and less pollution produced by firms. Again, this would be magnified by the direct social distancing measures which reduce travel and production.
- Suicide deaths would likely increase, and this effect could be particularly strong as many of the social supports typically available may be less accessible due to enforced social isolation resulting from social distancing measures.
- Available evidence suggests that there may be a rise in non-transport accident fatalities and cancer deaths.

There would likely be a small positive effect on health. Some reduction in heavy drinking and smoking would likely be observed due to an income effect. Also, there could potentially be some improvements in physical exercise, but this may be mitigated by lockdown measures. These benefits are somewhat offset by the deterioration of physical and mental health of those who become unemployed. However, this is likely limited as most jobs are furloughed.

U-shaped

Description of scenario: longer recession (24 months or more) driven by long-term suppression measures. Fiscal and monetary measures do not counteract the effect of the suppression as desired. Possibly 'W-shaped' i.e. a limited recovery is seen while some measures are eased, but the virus attack rate and death rate increase again, requiring a re-introduction of some suppression measures.

Total mortality likely still decreases as a result of the recession, although this is less clear.

Evidence suggests:

- Unemployment in those sectors facing a drop-off in social consumption takes time to recover. Greater and longer-term unemployment in these sectors leads to a greater deterioration of physical and mental health than in a V-shaped recession scenario.
- Lockdown measures mostly counteract the positive behavioural effects associated with the previous scenario, negating some of the health improvements. The overall health picture therefore appears bleaker than in the V-shaped scenario.

L-shaped

Description of scenario: COVID-19 and the associated suppression measures induce a long recession, taking years for GDP to recover to trend (if at all). This scenario would include significant unemployment, loss of income and production capabilities.

Of the three scenarios, the effect on mortality is likely to be the most negative, although that is uncertain.

Evidence suggests:

- Long-term unemployment may lead to a 'vicious circle' of mental health and skills mismatch effects. Here, suicide deaths would likely be particularly high.
- This more serious macroeconomic crisis may also lead to those of a working age at the time suffering worse general health in later life.

Annex G: Literature review of the possible effects of a COVID-19-induced recession on health outcomes

The direct effect of COVID-19 on the economy and subsequent government measures to delay the peak are likely to cause an economic recession in the UK. The impact of this recession – both its duration and magnitude – will need to be considered when designing suppression measures. This paper makes use of existing literature and research to summarise the effects of recessions on mortality and other health outcomes. We cite quantitative impacts where possible (with sources) so these can be used as needed in the wider modelling work.

The paper does not consider the direct effects of the suppression measures on health (e.g. the mental health impacts of being more isolated), or other effects from the pandemic itself. The evidence included should be considered in the round as part of the wider programme of work.

The overall effect of a recession on mortality and life expectancy

1. **A large body of evidence suggests that mortality rates decrease during times of recession, and increase during economic booms, exhibiting a procyclical relationship with GDP.** This goes against initial research on the subject – which suggested that a drop-in income would have a negative effect on life expectancy[ix]. Early studies find a strong procyclical relationship between economic growth and total mortality.[x] One study of US state data for 1972-1991 indicates that a one percentage point rise in the unemployment rate is associated with a 0.50% decrease in the total mortality rate[xi].

2. **However, recent studies incorporating more current data suggest that mortality has become less procyclical.** A follow-up study using state-level data for 1977-2010 failed to find a significant relationship between unemployment and the total mortality rate.[xii] Another study of US state data finds that a one percentage point increase in the state unemployment rate was associated with a 0.40% reduction in total mortality from 1978-1991, but a smaller 0.19% decrease when extending the analysis through to 2006.[xiii]

3. **Disaggregating the causes of death reveals different factors pushing in different directions.** The shift in the observed relationship between macroeconomic conditions and total mortality reflects these specific trends. Deaths caused by cardiovascular disease and traffic accidents appear to be procyclical, but less so than in the past. On the other hand, the relationship between macroeconomic conditions and deaths from non-transport accidents has switched from being strongly procyclical to sharply countercyclical. Cancer fatalities appear to be countercyclical in studies using more recent data, and earlier studies find no relationship with macroeconomic conditions.[xiv] The next section looks at this in more depth.

[ix] See Brenner (1971, 1979). This research has been widely criticised on technical grounds (see, for example, Kasl, 1989 and Gravelle et al., 1981).
[x] See Johansson (2004) and Gerdtham and Ruhm (2006) for studies of OECD countries; Ruhm (2007) and Miller et al. (2009) for consideration of US states; Tapia Granados (2005), Buchmueller et al. (2007) and Economou et al. (2008) for European-focused studies; and Lin (2009) for consideration of Asian nations.
[xi] Ruhm (2000)
[xii] Ruhm (2015a)
[xiii] Stevens, et al. (2011)
[xiv] Ruhm (2015a)

Disaggregated Factors

4. **The number of deaths caused by cardiovascular disease, transport accidents and air pollution fall during times of recession, and rise during economic booms, exhibiting a procyclical relationship with GDP.** A one percentage point increase in unemployment is predicted to reduce deaths from heart and cerebrovascular disease by approximately 0.2% and 1.1% respectively. Transport fatalities appear to be procyclical, although this may have weakened over time. A one percentage point rise in the unemployment rate was estimated to lead to 2% reduction in 2009 compared to a more than a 3% decrease in 1976.

5. **Suicides are one important exception – the number of deaths by suicide rises during times of recession, and fall during economic booms, revealing a countercyclical relationship with GDP.** Suicides can increase through two mechanisms: the induction pathway and the displacement pathway. In the former, economic crises lead to psychological vulnerability in the population, which induces suicide in persons who are otherwise unlikely to engage in self-destructive behaviour. In the displacement pathway, economic crises trigger suicides that would have occurred eventually. The relationship between macroeconomic conditions and suicides has strengthened over time – a one percentage point growth in unemployment is associated with a 0.9% rise is suicides in 1976 compared to a 2.4% growth in 2009.[xv]

6. **Some recent studies suggest that deaths from cancer and non-transport accidents increase during times of recession, also exhibiting a countercyclical relationship with GDP.** This contradicts earlier evidence which indicates that these factors were either acyclical, or weakly procyclical.[xvi] A study using more recent data finds that although a one percentage point rise in unemployment was estimated to have had no effect on lung cancer deaths in 1976, it was associated with a 0.8% rise in 2009. There has been a secular change in deaths resulting from non-transport accidents. A one percentage point rise in unemployment was associated with a 2.5% reduction in non-transport fatalities in 1976 but an increase of 2.3% in 2009.[xvii]

7. **Although total mortality rates are procyclical, there is strong evidence that job loss has negative effects on individuals' health.** Research on the 1990s recession in Sweden finds that, following the recession, all-cause mortality was slightly raised among individuals who suffered unemployment.[xviii] Unemployment can cause a reduction in wellbeing and deterioration in mental health both through the income mechanism and directly.[xix]

8. **However, there is some evidence that harmful behaviours – like heavy drinking and smoking – decrease in economic downturns, although by less than they used to.** Several studies identify reductions in drinking, obesity and smoking during economic downturns.[xx] This is likely due to an income channel through which people buy fewer goods health-damaging products when incomes fall. However, research suggests that this effect has become less strong over time, with

[xv] Ruhm (2015a)
[xvi] See Ruhm (2000), Neumayer (2004), Tapia Granados (2005), and Miller et al. (2009)
[xvii] Ruhm (2015a)
[xviii] Vagero and Garcy (2016)
[xix] Flatau et al. (2002)
[xx] See Freeman (1999), Ruhm and Black (2002), Ruhm (2005), Gruber and Frakes (2006) and Xu (2013)

some evidence of obesity, alcohol abuse and teenage drug use increasing in recent downturns.[xxi] Other studies have found evidence of lifestyles becoming healthier after the severe 2008 financial crisis in Iceland due to increased prices of imported goods which are detrimental to individuals' health.[xxii]

9. **Health-enhancing activities such as exercise and social interactions can increase due to changes in individuals' own work hours.** Leisure time increases with fewer working hours, making it less costly to undertake time-intensive health-benefitting activities. In addition, avoiding hazardous workplace conditions, job-related stress and the physical exertion of employment may improve health. There is also evidence that individuals spend more time socialising and caring for relatives during recession periods.[xxiii] Again, however, this effect may not be as strong as it once was. One study suggests that increased leisure-time exercise during periods of economic weakness is more than offset by reductions in work-related physical exertion.[xxiv]

10. **Evidence suggests that 'external' factors that fluctuate with the economy may be more important than these behavioural changes in driving the aggregate pattern.** Reduced economic activity is associated with less road traffic as fewer workers drive to work and fewer goods are transported. As such, there are fewer transport accidents and less air pollution, both of which lead to a reduction in mortality during recessions. Evidence also suggests that labour market changes in recessions raise the quality and quantity of healthcare workers, also reducing mortality in recessions. One study suggests that women aged over 65 comprise a large proportion of cyclical mortality, and mortality fluctuations among this cohort are primarily driven by employment changes in the working-age population. This suggests that 'external' factors may dominate work-related factors, since most mortality is not of those in work. Healthcare quality appears especially important; research suggests that staffing improvements in bad times reduced mortality rates for elderly nursing home residents.[xxv]

Exacerbating factors

11. **It doesn't seem that longer recessions produce more negative outcomes (although the research here is limited).** There is little evidence for individuals' health deteriorating further over an 'unemployment spell'.[xxvi] Evidence suggests that, rather than psychological wellbeing either deteriorating or improving consistently through the period of unemployment, the unemployed move through fluctuating stages in their health.[xxvii] However, one study shows the chance of suicide increasing with the duration of unemployment[xxviii].

[xxi] See Charles and DiCicca (2008) and Arkes (2009); Dávlos et al. (2012); and Arkes (2007) respectively.
[xxii] Ásgeirsdóttir et al. (2014, 2015)
[xxiii] Edwards (2011)
[xxiv] Colman and Dave (2011)
[xxv] Stevens, et al. (2011)
[xxvi] Nichols et al. (2013)
[xxvii] Flatau et al. (2002)
[xxviii] Milner et al. (2013).

12. **Serious macroeconomic crises outside the usual 'business cycle' may cause a more negative effect.** This suggests that the depth of any recession may be a factor. Research into macroeconomic crises – those causing a drop in GDP of 0.95% or more compared to the previous year – has found significantly worse self-reported health outcomes in the longer term for those who were of working age at the time.[xxix] Other studies, however, find that economic crises affect mortality rates in the same way as less severe downturns: they lead to improvements in physical health.[xxx]

13. **There is some evidence that the effect of long-term unemployment on mental health can makes job losses more entrenched.** This vicious cycle, known as hysteresis, occurs during periods of high unemployment (after a major economic shock). Those potentially most affected by job losses are not able to find employment quickly, and the effect on their mental health is magnified. A study of unemployment in Spain during the Great Recession points to such an effect and finds negative impacts of unemployment on mental health and, to a lesser extent, death rates.[xxxi]

Why this time might be different

14. **There are a significant number of unknowns, for example the extent to which the economy will 'bounce back'.** We don't know if the economy will experience a V-shaped recession or worse. If worse, some of the more severe, hysteresis-style effects discussed above may take hold. Some of the decrease in consumption during the recession will be deferred (and so compensated for afterwards), but some will not. Equally, some sectors and regions of the economy may be more severely affected than others.

15. **It is possible that government suppression measures will directly influence some of the recession-induced effects discussed above.** The evidence already discussed suggests that healthy behaviours can increase during periods of recession, but social distancing measures and the closure of gyms might make this less possible. Equally, measures causing a reduction in travel may mean that any effect of a recession on traffic fatalities is negligible versus a non-recession counterfactual.

16. **The degree of isolation in this episode is leading to other impacts across society, such as a significant reduction in deaths from air pollutants.** While the other work in this programme is considering these impacts separately, it is important to note the wider impacts that the recession can have on mortality and ill-health. Marshall Burke from Stanford University suggests the reductions in air pollution in China caused by this economic disruption likely saved twenty times more lives in China than have currently been lost directly due to infection with the virus in that country.[107]

[xxix] Antonova et al. (2017)
[xxx] Ruhm (2015b)
[xxxi] Farré et al. (2018)

Mitigating factors

17. **The pandemic is not happening in a vacuum – the monetary and fiscal measures announced by the government will mitigate against some of the negative effects discussed above.** For example, the scheme to pay the wages of furloughed workers will effectively 'freeze' employment in some instances, meaning the negative health outcomes from a recession due to unemployment might not be as important.

18. **Monetary and fiscal policy can offset the fall in social consumption, but only partially, because the drop in consumption is focused on specific sectors.** Typical government policy responses are not set up to support sectors such as hospitality, travel, sport and leisure, etc.

19. **Further monetary and fiscal measures are available but will depend on how COVID-19 transmission and the economy evolve in the short-term.** A few macro-modelling studies of pandemic scenarios suggest interest rates will rise in response to a significant increase in inflation, more so as people stay off work longer.[xxxii] However, it remains difficult to see how rates will rise in the face of potentially large falls in economic output.

[xxxii] Keogh-Brown et al. (2009)

Annex H: Excess avoidable deaths due to increased deprivation

The Index of Multiple Deprivation for England (IMD) and Wales (WIMD) splits the population geographically into LSOAs by levels of deprivation, from the most deprived areas to the least deprived. From this, we see clear correlations between levels of deprivation and many elements of health: life expectancy, self-reported health, and mortality as some examples. We also see associations between areas which have lower income, higher unemployment and poorer health. This suggests increases in deprivation – which could occur with any prolonged increase in unemployment, irrespective of whether a recession occurs – may impact avoidable mortality rates in the country. As such, published ONS data on avoidable mortality stratified by IMD and WIMD decile group can inform how numbers of avoidable deaths could increase if an economic downturn from COVID-19 or government's BSIs is prolonged enough to increase levels deprivation.

To estimate this effect, we have used a model in which every LSOA has its IMD score increased (becomes more deprived) as a result of contractions to GDP.

- The central GDP contraction estimate used is 6%. This is approximately what was observed in the UK during the 2007-09 recession[108]. To achieve a range of estimates, we have also tested scenarios +/-4% from the central estimate. These limits were chosen because a contraction of approx. 2% seems to be an optimistic scenario quoted by commentators about current events[xxxiii].
- The central estimate of elasticity between GDP and IMD score is -1.0: a 1% contraction in GDP corresponds with a 1% increase in IMD score. To provide a range of estimates here, alternative elasticities of -0.5 and -2.0 have been tested, where change in GDP has half and double the effect on IMD score respectively.
- These values are fundamentally arbitrary, and can be refined through further research of the literature on these relationships.

If an LSOA's IMD score changes sufficiently to move from one decile group of LSOAs to another, the new (higher) avoidable mortality rate for that decile group is applied to their population. In this way we can estimate an increase in avoidable mortality associated with a reduction in GDP. This methodology does not allow LSOAs in the most deprived decile group to experience an increase in their avoidable mortality rate; the possible impact of changing this assumption is explored in sensitivity analysis below.

Applying age-standardised avoidable deaths in England[109] and Wales[110] in 2017 to the corresponding mid-year population estimates, stratified by 2015-based IMD and 2014-based WIMD decile group estimates and for males and females separately, the table below shows the number of additional avoidable deaths expected for different values of GDP contraction and GDP-IMD score elasticity. This produces an increase of between 0.5% and 8.9% avoidable deaths in England and Wales combined as a result of the negative economic impact from COVID-19 and associated BSIs, with a central estimate of 2.8%. This is between 600 and 12,000 additional avoidable deaths per year, with a central estimate of 3,800 per year. Following this methodology's assumptions, this proportion of additional avoidable deaths would persist until GDP recovered.

[xxxiii] E.g. KPMG's estimate of a 2.6% contraction if the pandemic can be contained by this summer: https://home.kpmg/uk/en/home/media/press-releases/2020/03/covid-19-brings-uk-economy-to-temporary-standstill-but-upturn-expected-in-2021.html

Table: Estimates of the number of additional avoidable deaths in England and Wales, using 2015-based IMD, 2014-based WIMD and 2017 mid-year population data

	GDP contraction		
	2%	**6%**	**10%**
-0.5 elasticity GDP-IMD score	600 (0.5%)	1,900 (1.4%)	3,200 (2.4%)
-1.0 elasticity GDP-IMD score	1,300 (1.0%)	3,800 (2.8%)	6,300 (4.7%)
-2.0 elasticity GDP-IMD score	2,500 (1.9%)	7,500 (5.6%)	12,000 (8.9%)

There are several important points to consider when interpreting these estimates:

- This approach does not increase the avoidable mortality rate for the most deprived decile group, where we would also expect to see increases in avoidable deaths. To investigate the impact of this decile group's avoidable mortality also increasing, any LSOA whose IMD score increases beyond the current maximum (the upper bound of decile group 1) when adjusted becomes part of a new 11th group. The age-standardised avoidable mortality rate for this new group is estimated by extrapolating the change in the rate between decile groups 1 and 2. In the base case, this leads to only 30 additional avoidable deaths, and no change at 1 decimal place to the corresponding percentage increase of 2.8%. Very few LSOAs move into this new high-deprivation group: the IMD score distribution is positively skewed with a long upper tail, such that only two LSOAs in England move beyond the current maximum IMD score. Further analysis could expand upon how the avoidable mortality rate for the most deprived LSOAs could be increased with this methodology; but given the small effects for this sensitivity analysis, and lack of evidenced mortality rate for the new high-deprivation group, this has not been explored further in this analysis.

- It could be expected that less deprived populations are less affected by the economic impacts of COVID-19. With this method, a proportional increase in IMD score was uniformly applied to all LSOAs, irrespective of their starting decile group. In the base case, we observe that additional avoidable deaths occur in the three most deprived decile groups, with the number of avoidable deaths falling in decile groups 4 to 10 due to a net decrease in population size in these groups as IMD scores are inflated.

- This analysis relies on ONS's definition of "avoidable deaths". This definition includes causes of death such as road traffic accidents and suicides, which are explored elsewhere in this paper and will not all be expected to increase due to COVID-19 and BSIs. Considering any long-term impacts of those types of death alongside the IMD-based estimates will double count those excess deaths. In addition, most causes of death are defined as being "avoidable" for people less than 75 years old, so the results may not be generalisable to people older than this.

- It is worth noting that the most deprived areas also experience low social mobility, and therefore 'accrue' poor health over time. People who move into a worse-off economic group

from a less deprived one will not necessarily have the same health characteristics as others in that group. In this way, using changes in IMD score to estimate changes in avoidable mortality will likely produce an overestimate – but this does not mean there is not a great burden of poverty on affected individuals.

- These estimates are based on age-standardised avoidable mortality rates. It could be that different age groups are affected differently by an economic downturn, which is not accounted for in this analysis. For example, the working age population will be most impacted by increases in unemployment; and the older population will be most impacted by austerity measures which impact healthcare and social security. Further analysis could improve the estimates so specific domains of the IMD are impacted, to simulate these age effects.

- WIMD scores by LSOA are not publicly available, so we have assumed that the relative change in the size of the population in each decile group when IMD scores are inflated is the same in Wales as it is in England.

- HMT accept the 6% change in GDP is broadly similar to current averages of external forecasters' estimates of annual GDP change. These results assume any effect on GDP remains low, while many external estimates assume a V-shaped recession with rapid recovery within a year. HMT's analysis and literature reviews suggest recessions have a negative impact on mortality and morbidity in the longer term.

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