Technische Hochschule Brandenburg
University of Applied Sciences

Department of Computer Science and Media

Analysis of the Impact of COVID-19 in the United Kingdom

Documentary Work

submitted by
Richard Zahn
and
Mulham Alesi
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For the Class of Predictive Analytics and
Data Security in the Connected World

Data Basis

The analysis of the impact of the COVID-19 virus on society as a whole is a difficult task, due to the lack of proper data in most countries. The Office for National Statistics (ONS)[1] in the United Kingdom provides a large amount of valuable data related to the COVID-19 pandemic. Detailed reports together with a separate Web-API[2] for data about the coronavirus build the data basis of this paper.

[1] https://www.ons.gov.uk/
[2] https://coronavirus.data.gov.uk/

Expected Overall Deaths for 2020 and 2021

The analysis starts with the investigation of overall deaths in the years before the pandemic. Figure 01 shows the death rate in the nations of England and Wales over the past century[3]. In the first part of this paper, an approach will be represented that uses this historic data to train a model. This model then tries to predict the deaths for the years of 2020 and 2021. This prediction will not consider the effect of the COVID-19 virus at all.

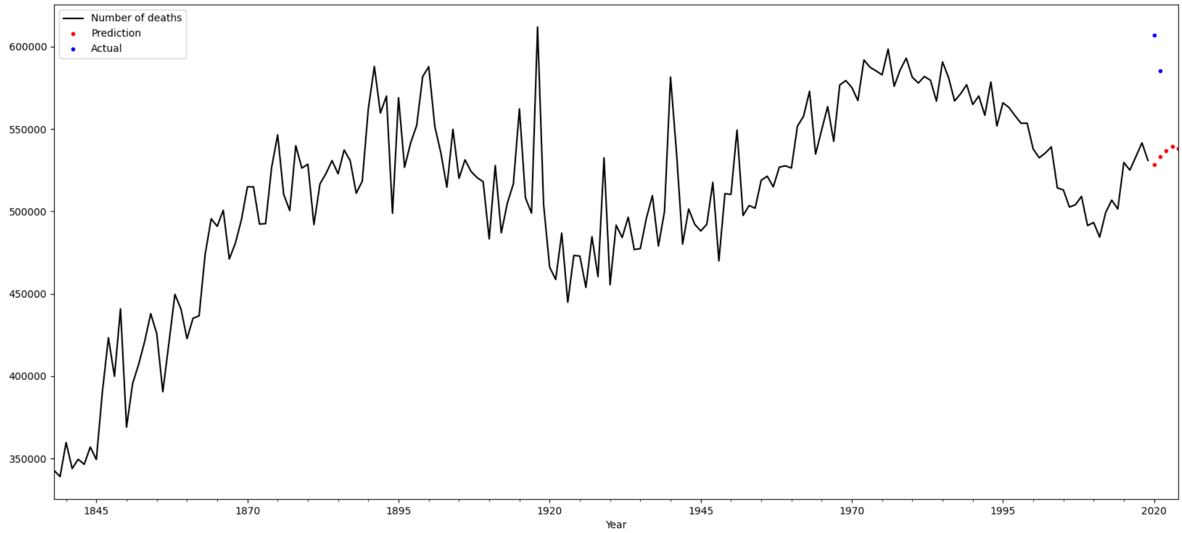

Figure 01: Overall deaths in England and Wales between 1830 and 2019 including the prediction for 2020-2024 and the actual death count for 2020 and 2021.

As figure 01 shows, an overall increasing trend in the amount of deaths can be found. This indicates that the data might be non-stationary. Working with non-stationary data limits the amount of models that can be used. In this paper, the ARIMA model was chosen as it suits the task best. It transforms non-stationary data to stationary data by the use of differentiation. Furthermore, it allows to reduce the impact of outliers with the help of a moving average. The dataset naturally contains outliers due to events, such as the two world wars, represented by the spikes in 1918 and 1940. A moving average reduces the impact of those by calculating an average of the datapoint together with a

[3] data from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/12735annualdeathsandmortalityrates1938to2020provisional

defined number of neighbours. The number of included neighbours is specified by the window size of the moving average.

Year	Prediction P	Actual A	$\Delta_{P\text{-}A}$	COVID-19
2020	528.355	607.099	78.744	73.766
2021	533.303	585.348	52.045	73.549
2022	536.892	n/a	n/a	n/a
2023	539.492	n/a	n/a	n/a
2024	538.221	n/a	n/a	n/a

Table 01: Predicted death cases compared to the actual number of deaths in England and Wales in 2020 and 2021.

Table 01 shows the prediction of the created model compared to the actual number of deaths in 2020 and 2021. It shows a clear difference between these two. However, when this difference is compared to the number of COVID-19 deaths of the same year, an almost exact match is found for the year of 2020. The two values are off by 5.022 (0.6%) for 2020 and 21.504 (41%) for the following year. This data is shown in columns four and five of the same table.

While the deviation for 2020 matches the actual COVID-19 deaths, the deviation for 2021 does not correlate to the deaths related to the coronavirus. Finding an explanation is difficult. One assumption is that among the COVID-19 deaths from 2020 were a lot of people who would have naturally died in 2021. This would explain why the deviation sank, while the COVID-19 deaths stayed almost the same compared to the data from 2020. This assumption cannot be verified due to the lack of data.

In an experiment to see the behaviour change of the model and if it knows of the existence of the COVID-19 pandemic, the training set for the model now additionally included the data for 2020. This new model makes a drastic change for the prediction of deaths for 2021. It changes its prediction from 533.303 to 594.731. The increase of 61.428 shows that the ARIMA method can react to anomalies quite well. The new prediction is 9.383 deaths from the actual value.

The paper assumes that the model made an accurate prediction for 2020 without the existence of COVID-19. The correlation between the deviation of the prediction and the actual COVID-19 deaths indicates that the majority of the COVID-19 victims would not have died in that year without the exposure to the coronavirus. To further examine this assumption, the next chapters will first investigate if the deviation can be explained with other deadly, unexpected events that happened in 2020 and then later the consequences of the assumption made here being true.

Adjustment of the Expected Number of Deaths

This chapter tries to manually adjust the expectation for 2020 by removing the deaths from the unique events of that year. There were no major events in 2020, except that it was an unusually hot year, in which the United Kingdom was hit by a heatwave similar to the one from 2003. The British government has put the death toll in England at 2.556 and 2.323 for the heat waves in 2020 and 2003, respectively (Public Health England, 2020). Figures *02a* and *02b* show a comparison of these two years regarding the temperature. This underlines the plausibility of the estimation. After subtracting this number from $\Delta_{P\text{-}A}$ for 2020 from the previous chapter, the difference is now down to 76.188 deaths.

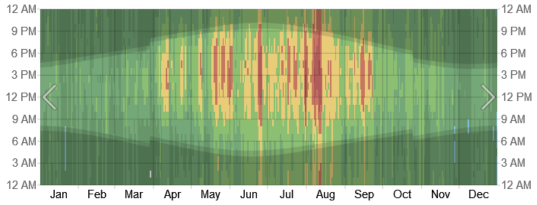

Figure 02a: A visualisation of the daily temperatures in London in 2020. (from weatherspark)[4]

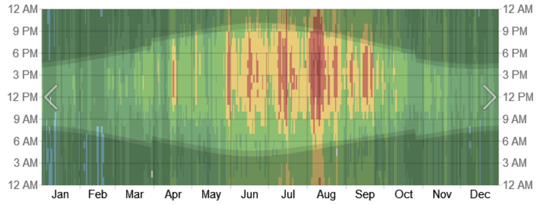

Figure 02b: A visualisation of the daily temperatures in London in 2003. (from weatherspark)[5]

[4] https://weatherspark.com/h/y/45062/2020/Historical-Weather-during-2020-in-London-United-Kingdom#Figures-ColorTemperature

[5] https://weatherspark.com/h/y/45062/2003/Historical-Weather-during-2003-in-London-United-Kingdom#Figures-ColorTemperature

Leading Causes of Deaths over the Years

This chapter tries to give an overview of the leading causes of deaths in the United Kingdom over the past years[6]. It tries to investigate possible anomalies for the year 2020.

Figure 03 shows the proportion of the leading causes of deaths. The legend is omitted since it is not relevant here.

The diagram shows almost the exact same pattern for the years 2013 to 2019. For the bar of 2020, a new section in the colour of pink is visible. This is the proportion of COVID-19. However, if this section is removed from the dataset then the exact same pattern as in the years before can be seen. This means that the anomaly of COVID-19 did not affect the normal mortality behaviour.

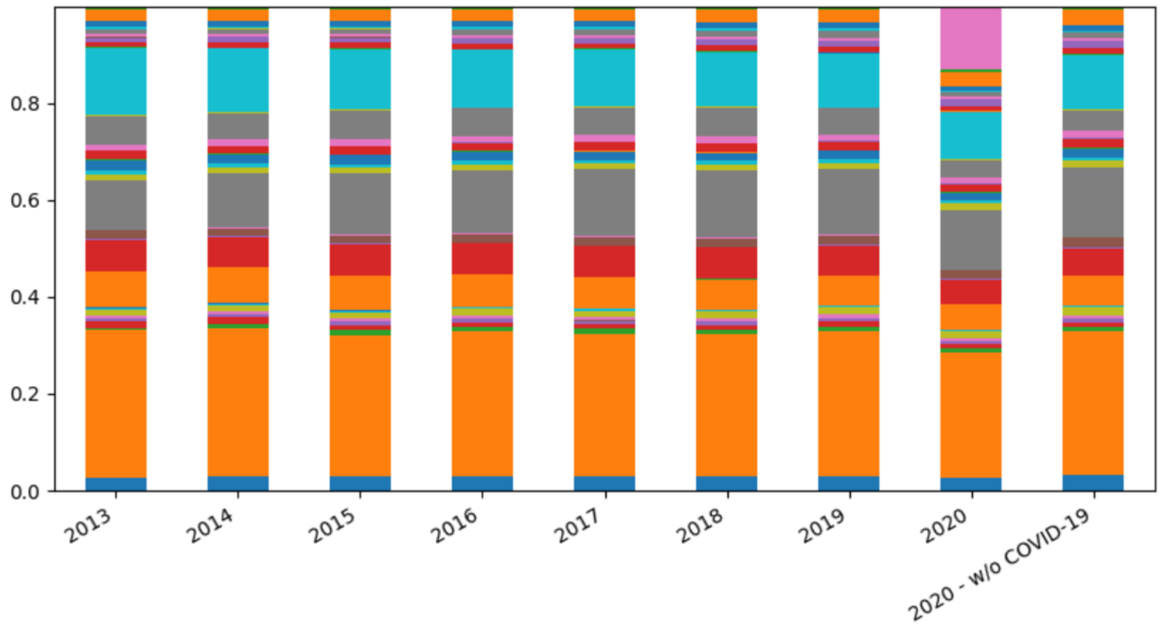

Figure 03: Visualisation of the leading causes of death from 2013 to 2020 in the United Kingdom.

[6] *Data from https://www.nomisweb.co.uk/query/construct/summary.asp?mode=construct&version=0&dataset=161*

Coronavirus (COVID-19) compared with influenza and pneumonia as a reason for death

COVID-19 and influenza are quite similar. They share some common symptoms and spread from person to person in the same way. Both viruses can spread between people who are in close physical contact (in the range of 2 metres or 6 feet). These viruses spread by breathing droplets or aerosols that are released when a person talks, sneezes, or coughs. They can also be transmitted when a person touches a surface that has one of the viruses on it and then touches their mouth, nose, or eyes. (Mayo Clinic, 2022)
This chapter presents two major statistical differences between the two viruses. These differences are based on the number of deaths in England and Wales caused by influenza and COVID-19.
The data shows that the coronavirus has caused more deaths than influenza and pneumonia in England and Wales since March 2020. Since 1929, COVID-19 caused more deaths per year than influenza and pneumonia. (Office for National Statistics, 2022)
Figure 04 depicts the number of deaths in England and Wales caused by influenza and pneumonia compared with the number of deaths caused by COVID-19 in the same area.

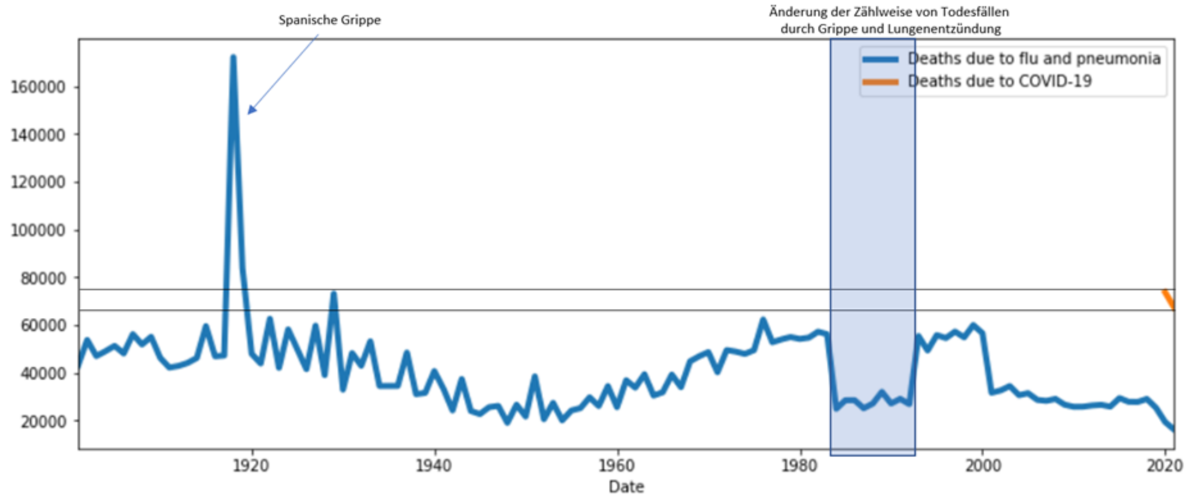

Figure 04: Number of deaths caused by influenza and pneumonia in England and Wales compared to the number of deaths caused by COVID-19.

Deaths due to COVID-19 were more evenly distributed across age groups than deaths due to influenza and pneumonia. But in both cases, most deaths were among the elderly.

Statistics indicate that the average age of deaths caused by COVID-19 during the entire coronavirus pandemic was lower than for influenza and pneumonia. As illustrated in Figure 05, the average age of death caused by COVID-19 is about 78, whereas the average age of death due to influenza is around 84. (Office for National Statistics, 2022)

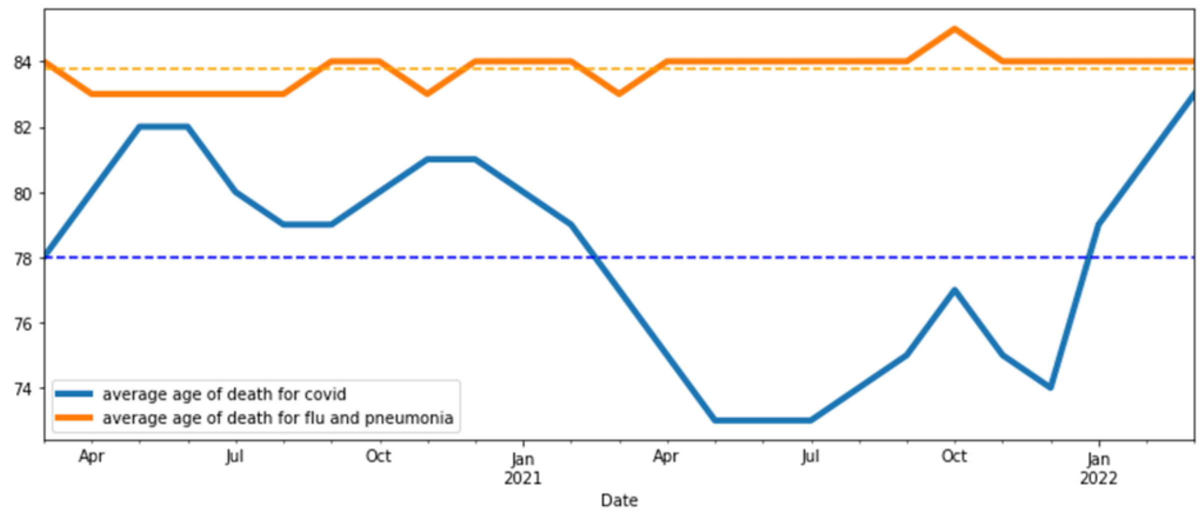

Figure 05: Average age of death for COVID-19 compared with influenza and pneumonia between March 2020 and March 2022

Analysis of the Effectiveness of Lockdowns

Besides yearly and weekly death numbers, daily deaths are also of interest for this analysis. Figure 06 presents the daily deaths in England and Wales, where COVID-19 was the leading cause of deaths[7]. The red areas represent nationwide lockdowns in the United Kingdom[8]. The graph shows a similar pattern inside the first and the third lockdown. The number of deaths keeps increasing for a certain period of time after the beginning of the lockdown. After that, the death rate drops drastically. In both cases, the time between the beginning of the lockdown and the local maximum of the curve is 13 days. The following part tries to find an explanation for this observation.

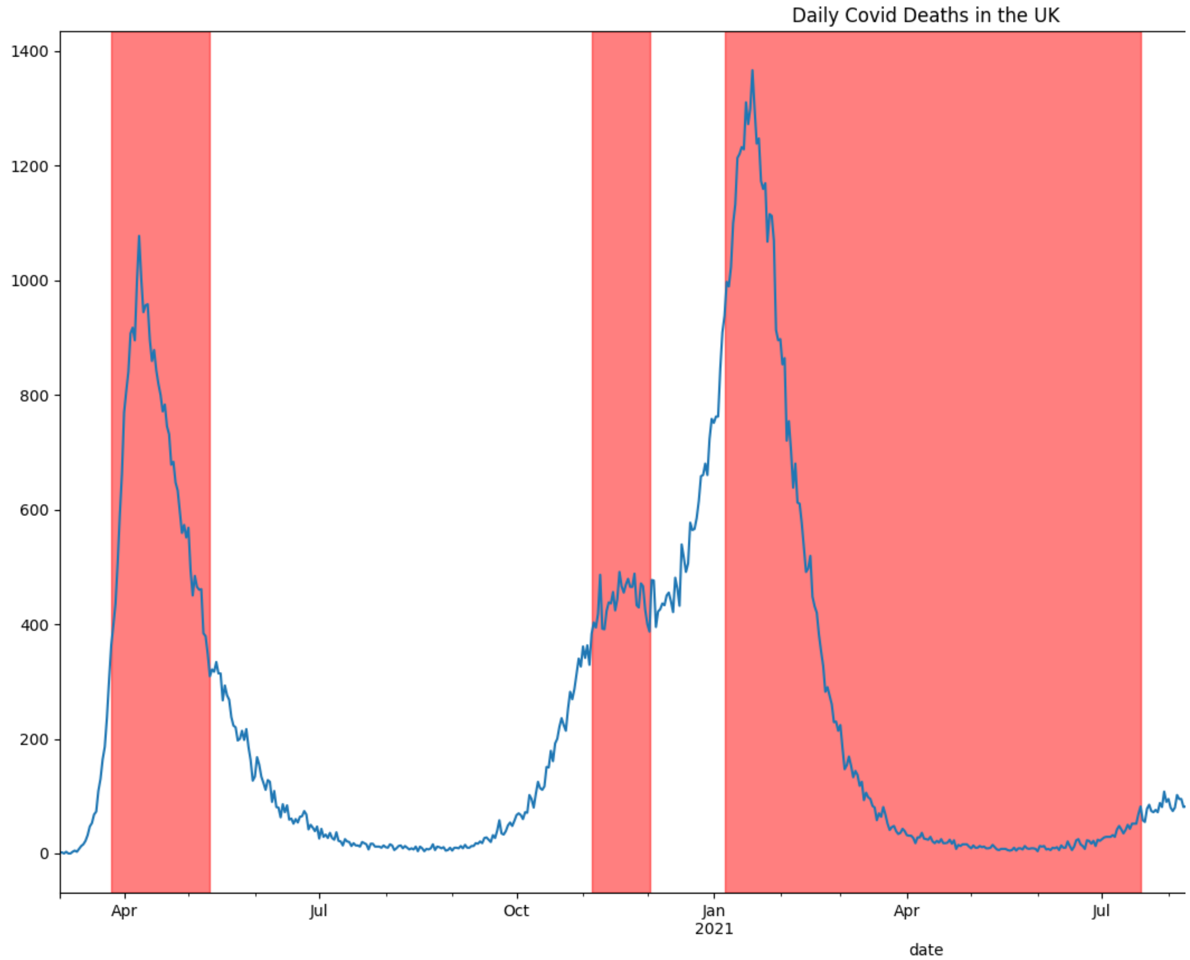

Figure 06: Daily COVID-19 deaths in England and Wales between March 2020 and August 2021.

[7] data from https://api.coronavirus.data.gov.uk/v2/data?areaType=nation&metric=newDeaths28DaysByDeathDate&format=csv

[8] data from https://www.instituteforgovernment.org.uk/charts/uk-government-coronavirus-lockdowns

One of the expected impacts of a lockdown is an immediate decrease in new infections, since less people are going outside and are exposed to the virus. However, being exposed to the virus does not mean that one is immediately infected. The time between the exposure and the development of first symptoms (the start of the infection) is described by the concept of the incubation time. The British government published a study on the incubation time of the coronavirus, in which they have specified the average duration as 5 to 6 days (Sutherland et al., 2021).
As Figure 06 reports a drop of deaths, it is important to investigate the time between exposure and death. That time is defined as the incubation time plus the time between the first symptoms and the death. Numbers for the latter are once again provided by the British government and shown in table 02 (Harrison et al., 2020).

Age in years	Median time between symptoms and deaths in days
<18	2
18 - 39	4
40 - 49	8
50 - 59	8
60 - 69	7
70 - 79	8
80 - 89	7
90+	7

Table 02: Median time between symptoms and deaths for COVID-19 in days in 2021 in the United Kingdom.

Here, the time is divided by age groups and is set to 7 or 8 days for most age groups. The duration for the younger part of society is set much lower with 2 and 4 days. However, this part of the population has the least amount of COVID-19 deaths, as illustrated by figure 07[9]. This figure presents the weekly covid deaths of 2020 split into age groups.

[9] data from https://www.ons.gov.uk/datasets/weekly-deaths-age-sex/editions/covid-19/versions/94

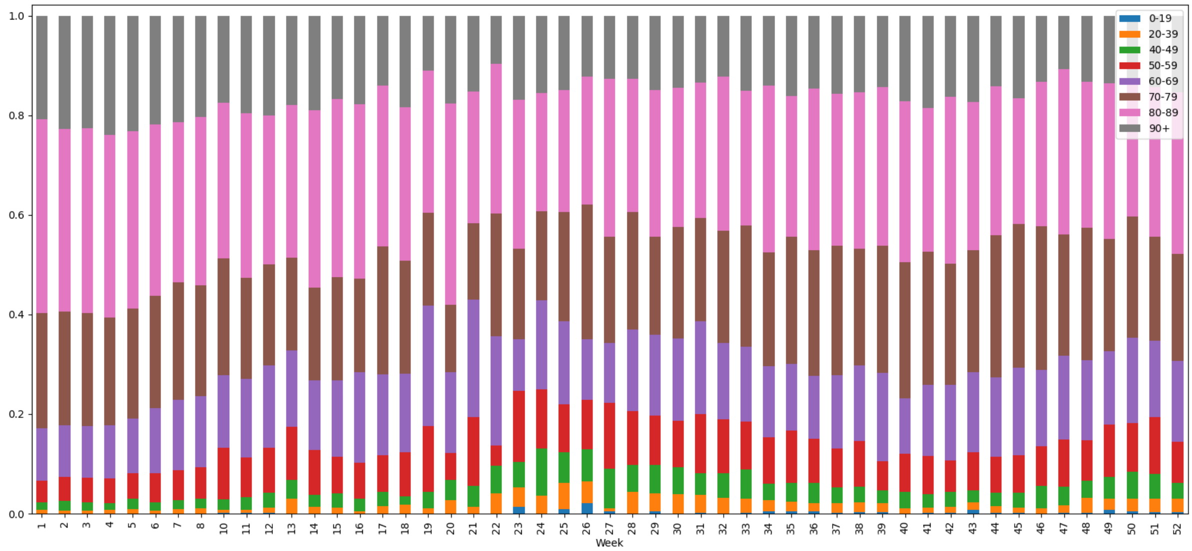

Figure 07: Weekly COVID-19 deaths in England and Wales in 2020, split into age groups.

To obtain a model as accurate as possible, the values from table 02 are weighted. The proportions of deceased people in the respective age group for weeks two to four are being used as weights. The chosen weeks represent the first weeks of the third lockdown.

After the application of the weights, the average time between the first symptoms and the occurrence of death lays at 7.3 days, as shown in table 03. Since the data for figure 07 uses age groups of the size ten, the age groups of <18 and 18 - 39 have been adjusted to <20 and 20 - 39.

Age in years	**Deaths per age group during week 2, 3 and 4 in percent *(average)***	**Weighted median time between symptoms and deaths in days**
<20	0	0
20 - 39	0.7	0.028
40 - 49	1.6	0.128
50 - 59	4.7	0.376
60 - 69	10.5	0.735
70 - 79	22.9	1.832
80 - 89	37.5	2.625
90+	22.1	1.547
	Sum:	~ 7.3

Table 03: Weighted time between symptoms and deaths in days in 2021 in the United Kingdom.

Using this data, the time between exposure and death can be calculated. The incubation time together with the time between symptoms and death is about 13 days, explaining the drops seen in Figure 06.

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