Office for National Statistics

Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: technical report

Methodology used to calculate estimates in the Analysis of death registrations not involving COVID-19 series, particularly the September edition (analysis to 10 July 2020).

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Table of contents

1 . Introduction

This technical report provides the detail around the data and methods used in the following publications:

- Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: 28 December 2019 to 1 May 2020
- Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: 28 December 2019 to 10 July 2020

2 . Death registrations data

This section of the report covers:

- weekly death registrations data
- differences between registration and occurrence data
- other coronavirus (COVID-19) mortality data
- differences between fully coded and not fully coded datasets

Weekly death registrations data

The publications listed in Section 1: Introduction use death registration data to produce their statistics. Provisional death registrations data are used in these reports. This enables timely analysis to be completed to monitor mortality trends. However, as the data are provisional, they are subject to change.

The figures in this report are populated with more recent and updated data than earlier Office for National Statistics (ONS) publications covering the same time period. This provides more accurate, stable figures for earlier weeks that were not available in previous publications where there was a requirement for more timely data.

To meet user needs, we publish very timely but provisional counts of death registrations in England and Wales in our Deaths registered weekly in England and Wales, provisional dataset. These are presented by sex, age group and regions (within England) as well as for Wales as a whole. To allow time for registration and processing, these figures are published 11 days after the week ends.

To meet further user needs, we are providing more information in our Deaths involving COVID-19, England and Wales bulletin. This information is presented by sex and age group. We are also providing age-standardised mortality rates (ASMRs) and age-specific mortality rates for recent time periods and breakdowns of deaths involving COVID-19 by associated pre-existing health conditions.

More quality and methodology information on strengths, limitations, appropriate uses, and how the data were created is available in the Mortality statistics in England and Wales QMI.

The information used to produce these statistics is based on details collected when certified deaths are registered with the local registration office. The counts of deaths from specific conditions are updated with each weekly publication as the coding of the underlying cause is not always complete at the time of production. The doctor certifying a death can list all causes in the chain of events that led to the death and pre-existing conditions that may have contributed to the death. Using this information, we determine an underlying cause of death.

Our User guide to mortality statistics provides further information on data quality, legislation and procedures relating to mortality and includes a glossary of terms.

Differences between registration and occurrence data

Figures are based on the date the death was registered, not when it occurred. In England and Wales, deaths should be registered within five days of the death occurring, but there are some situations that result in the registration of the death being delayed. Data for death occurrences in recent periods are therefore less complete than death registrations data for the same period.

More information on how this impacts analysis of particular causes of death is discussed in Section 5: Causes of death.

Other COVID-19 mortality data

These figures are different from the daily surveillance figures on COVID-19 deaths published by the Department of Health and Social Care (DHSC) on the GOV.UK website, for the UK as a whole and its constituent countries. Figures in this report are derived from the formal process of death registration and may include cases where the doctor completing the death certificate diagnosed possible cases of COVID-19, for example, where this was based on relevant symptoms but no test for the virus was conducted. Our figures also include any deaths that occur outside hospital. Our blog Counting deaths involving the coronavirus (COVID-19) helps to explain the differences.

Differences between fully coded and not fully coded datasets

Our previous analysis on death registrations not involving COVID-19 used a fully coded database, which only included death registrations that had been processed to include information on the causes of death and other variables. This information was required for the analysis on registration type in that article. In this report, we instead use the database containing all death registrations to bring it in line with the weekly deaths, provisional dataset.

This means the numbers for death registrations will generally be higher than the previous article for more recent weeks, as all registrations are included even if not all the variables have been fully coded for the latest weeks. In addition, results for weeks in the previous report (up to Week 18) will have changed because more registration records for that period have now been coded. Table 1 shows the number of fully coded registrations for each period covered at the point of analysis for each article.

While proportional differences may seem small, they can have larger effects if the records that are not yet coded are not representative of the overall distribution. For example, if the majority of records that are not fully coded are deaths at younger ages, they could represent a small proportion of all records but a large proportion of the demographic in which their results are presented.

Table 1: Percentage of all death registrations that were fully coded at the point of analysis for this article and the previous article on deaths not involving the coronavirus (COVID-19)

Period	Percent fully coded for previous analysis (June 2020)	Percent fully coded for this analysis (September 2020)
Week 1 to 10	100	100
Week 11 to 18 (period of particular interest in previous analysis)	98.1	100
Week 19 to 28 (weeks new to this analysis)	N/A	99.8

Source: Office for National Statistics – Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: technical report

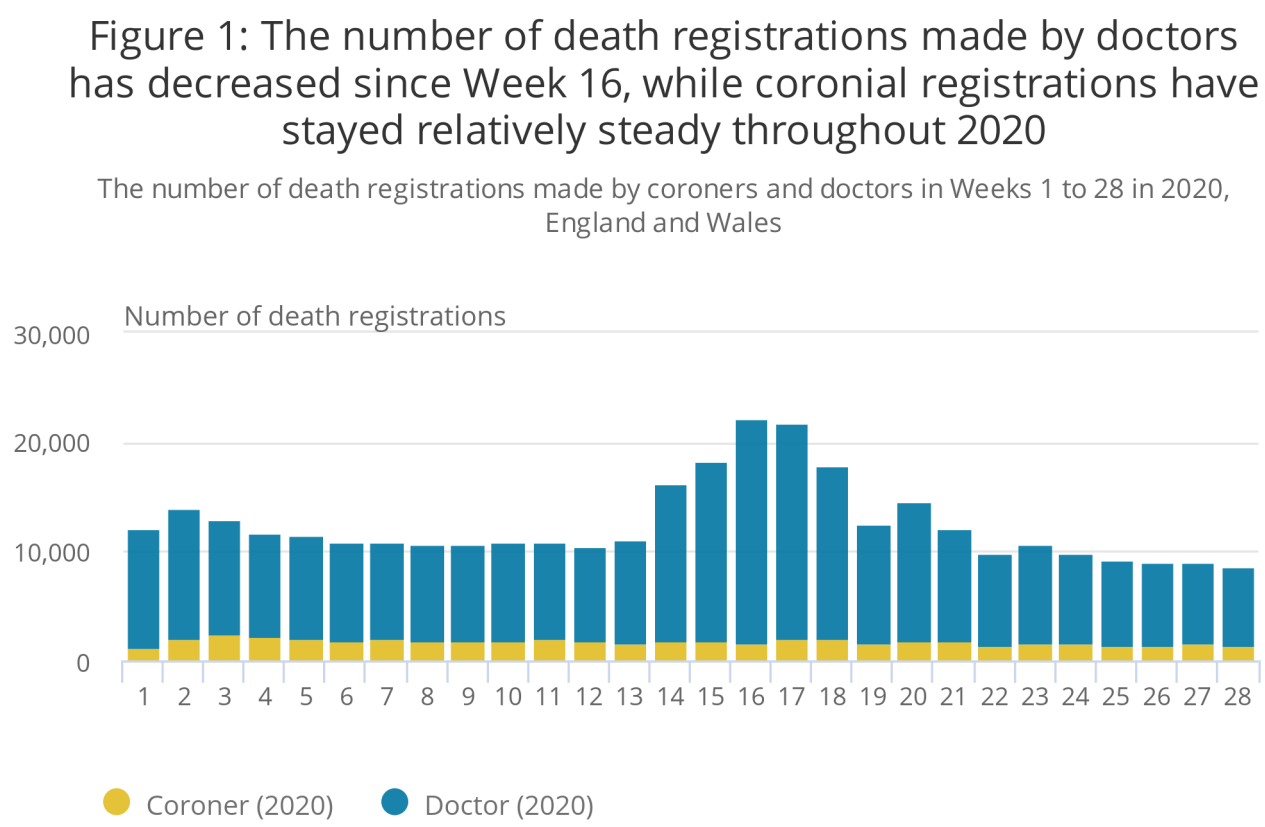
The fully coded dataset allows for breakdowns of registrations by certification type, and by doing so it is possible to look at the number of registrations made by doctors and by coroners. This was explored in the article presenting registrations to 1 May as a possible exaplanation for some of the changes in non-COVID-19 deaths. A higher proportion of registrations made by doctors would appear to increase registration efficiency, and registration efficiency could explain observing a greater number of non-COVID-19 deaths in that period.

Figure 1 shows the number of registrations made by doctors and coroners between Weeks 1 and 28 of 2020, using the fully coded dataset. A much larger proportion of registrations were made by doctors between Weeks 14 and 21, which was most likely because of Coronavirus Act 2020 enabling changes in policy to help administration staff manage the increase in deaths during this period. The number of registrations made by coroners has since reduced to the same and lower levels than before COVID-19 was first mentioned on a death certificate.

Given the results here do not inform the trends observed in the follow-up to the first non-COVID-19 deaths report, the merits of using the fully coded dataset to present this analysis were outweighed by the not fully coded dataset' s consistency with weekly death registrations data and inclusion of additional cases.

Figure 1: The number of death registrations made by doctors has decreased since Week 16, while coronial registrations have stayed relatively steady throughout 2020

The number of death registrations made by coroners and doctors in Weeks 1 to 28 in 2020, England and Wales



Source: Office for National Statistics – Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: technical report

Notes:

1 Figures include the deaths of non-residents. 2. Based on date a death was registered rather than occurred.

3 . Calculating expected deaths

In these reports, excess deaths are defined as deaths occurring above the expected number for that week of the year. The expected number of weekly deaths is calculated using the five-year average number of deaths recorded in the corresponding week in 2015 to 2019.

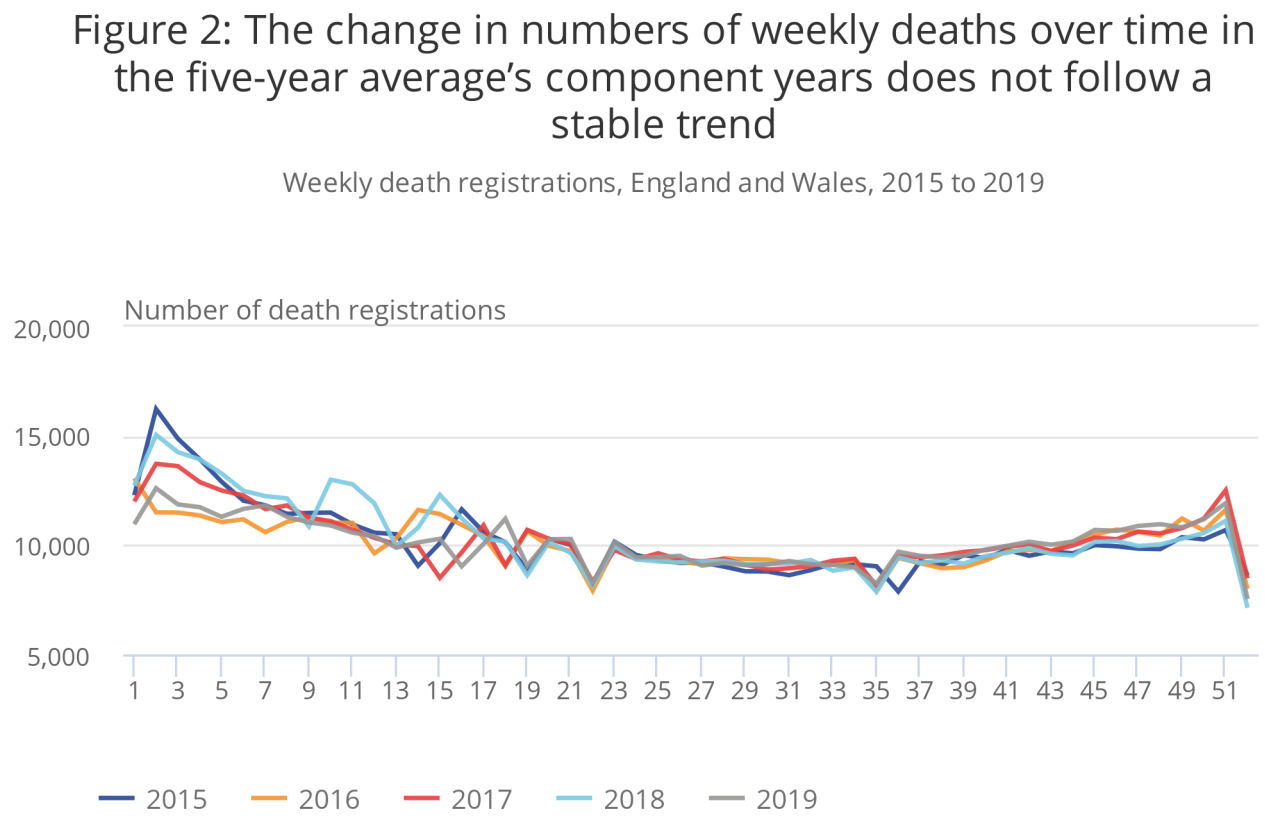
The five-year average provides an estimate of the expected number of deaths each week and is the preferred method in reports produced by the Office for National Statistics (ONS). Other definitions for excess deaths and expected deaths are used in other analyses. For example, the ONS has jointly produced analysis with the Department of Health and Social Care (DHSC), Government Actuary's Department (GAD) and Home Office, which defines an excess death as a death occurring more than 12 months earlier than expected. Public Health England calculate expected deaths using modelled estimates that account for population changes over time. Each approach has its strengths and limitations, explored later. For these reports, we have continued using the five-year average because of the importance of continuing to use a well-understood and accepted method.

The five-year average deaths figure is not adjusted for population growth or change in age composition. Although the long-term trend is for the population to increase, especially at older ages, the population of England and Wales has changed relatively little year-on-year over the past five years. The total population has increased by less than 1% each year, while increases in life expectancy have generally levelled off. In addition, the impact of excess winter mortality has a greater effect on the mortality rate than population change. The ONS's calculations of expected deaths consequently differ very little whether based on a five-year average or adjusted for population change.

It could be expected that we would observe a trend over time within the five years used to calculate expected deaths, but whether we would observe an increasing number of deaths each year is less clear. The numbers of deaths for each year between 2015 and 2019 are presented in Figure 2 and do not present a year-on-year change in one direction. Note that fewer deaths are registered in the first and last weeks of the calendar year because of public holidays in that time.

Figure 2: The change in numbers of weekly deaths over time in the five-year average's component years does not follow a stable trend

Weekly death registrations, England and Wales, 2015 to 2019



Source: Office for National Statistics – Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: technical report

Notes:

1. Figures include the deaths of non-residents.
2. Based on date a death was registered rather than occurred.

The accuracy of population denominators for calculating alternative estimates of expected deaths cannot be taken for granted. Populations for the current year are projections and therefore are not strictly comparable with the populations for past years (which are estimates based on observed changes). While the denominator issues are acceptable for most mortality calculations, such limitations are most likely to be important when comparing short periods of time, rather than a whole year, and when the numbers of elderly people are an important interest. These characteristics both apply to coronavirus (COVID-19) analysis.

In early weeks of 2020 (Weeks 3 to 12), the numbers of deaths registered each week were generally lower than the five-year average registrations. If in general the 2020 mortality rate was lower than the five-year average, then comparing latest weeks to the five-year average might underestimate excess deaths because the average presents more deaths than would otherwise have been expected for these weeks in 2020. However, this could also mean there were more vulnerable people still alive at the start of the coronavirus pandemic than typically for this time of year in other years, so we may have expected higher numbers of deaths in Weeks 13 to 18 to compensate, irrespective of the presence of a novel coronavirus.

One limitation with the methodology used in these reports is the changing position of bank holidays each year, which affect the numbers of registrations and can occur in different weeks in different years. For example, bank holidays fell on 10 April and 13 April in 2020 to mark the Easter break. Easter typically results in a delay in registrations because of this, and it will not fall in the same weeks in each year of the five-year average used. However, in the current circumstances, registrars are working more flexibly and often over the weekend and holidays, which has diluted this pattern of registrations for 2020 somewhat.

An alternative method of calculating the number of excess deaths is to calculate the number of deaths beyond the upper confidence limit, which could result in an underestimation of excess deaths. Other methods of comparing recorded deaths to the predicted numbers include p scores and z scores. The p score is calculated by dividing the observed excess deaths by the predicted deaths. The z score is instead calculated by dividing excess deaths by the variation in the predicted deaths.

4 . Age-standardised mortality rates

We publish the mid-year population estimates used for calculating rates; these are currently available up to 2019. For 2020 onwards, population projections are used.

Calculation of mortality rates for a period of the year requires the use of linear interpolation of the annual population estimates to estimate the population at the midpoint of the period of interest, for period i. Assuming the period starts after 1 July in one year (year y) and ends before 1 July in the next year (year $y + 1$), the mid-year population estimates for these two years are used to estimate the mid-point population, $E_{i,x}$ for period i and age group x using the following formula,

$$E(i,x) = Pop(y,x) + (Pop(y+1,x) - Pop(y,x)) \times (\frac{m}{M})$$

where:

- $Pop\ (y,x)$ = mid-year population for age group x in year y
- m = number of days from 1 July 2019 to mid-point of the period
- M = number of days between the two mid-year population estimates

For the rcASMRs, it is necessary to calculate the ASMR for each week in the year. A slight variation on Eq. 1 was used to calculate the populations at each week in the year, in line with the international comparisons publication. First, the population for the first week in each year is calculated by finding the population on January 1 using the previous equation. This Week 1 population is then used to calculate the population for each week, w, in that year, $E_{x,w,y}$ using the following equation:

$$E(x,w,y) = (Pop(x,1,y) + (Pop(x,1,y+1)) \times \frac{w-1}{52}$$

where:

- *Pop (x,w,y)* = the population in week number w for age group *x* in year *y*
- *w* = the week number

Age-standardised mortality rates

ASMRs are used to allow comparisons between populations that may contain different overall population sizes and proportions of people of different ages. The 2013 European Standard Population (ESP) is used to standardise age-specific rates to a consistent population. In the report, some ASMRs are calculated for both sexes together and some for each sex separately. The 2013 ESP is the same for both sexes. The formula used is:

$$ASMR\left(G,\ i\right) = \sum_{(x,s)\in G} \left(\frac{D\left(x,s,i\right)}{E\left(x,s,i\right)}\right) \cdot 100,000 \cdot ESP\left(x,s\right)$$

where:

- *G* is the group (defined by some combination of age and sex) for which we calculate the ASMR
- *ESP (x,s)* is the standard population for age group *x* and sex *s*
- *D (x,s,i)* is the number of deaths for age group *x* and sex *s* in time interval *i*
- *E (x,s,i)* is the estimated population for age group *x* and sex *s* in time interval *i*

To compare ASMRs for a period i in the year y with annual mortality rates for year y, the ASMR for the period is annualised by multiplying by the number of days in the year divided by the number of days in the period:

$$ASMR\left(G,y\right) = ASMR\left(G,i\right) \times \frac{Y}{N}$$

where:

- Y is the number of days in year y
- N is the number of days in period i

Age-specific mortality rates

These are calculated using the population estimate E for age group x, sex s and time period i and allow comparisons between mortality rates for different age-groups and for different periods. The crude rate is also is annualised to allow comparison to annual mortality. The formula is:

$$cruderate = \frac{D\left(x,\ s,\ i\right)}{E\left(x,\ s,\ i\right)} \times 100,000 \times \frac{Y}{N}$$

Relative age-standardised mortality rates

Relative age-standardised mortality rates (rASMRs) are weekly measures of excess mortality using ASMRs that are standardised to the 2013 ESP. This measure was developed by the Continuous Mortality Investigation (CMI) and was originally described in working paper 111 (PDF, 1.07MB). Excess mortality for a particular time period is defined as the difference between the ASMR vfor that time period and average ASMR for that week in the five years from 2015 to 2019 inclusive.

To calculate the ASMR, the difference between the annualised ASMRs for the time period and the five-year average annualised ASMR for that period is calculated. This excess mortality is then expressed as a proportion of the five-year average ASMR for full years. The following formula is used:

$$rASMR(G,i,y) = \frac{Y}{N} \times \frac{ASMR(G,i,y)\ -\ \bar{A}\bar{S}\bar{M}\bar{R}\left(G,i,2015-19\right)}{\bar{A}\bar{S}\bar{M}\bar{R}\left(G,2015-19\right)}$$

where:

- $rASMR(G,i,y)$ is relative ASMR for time period i and year y
- $ASMR(G,i,y)$ is the ASMR in time period i and year y, as defined in the $Age-standardised$ mortality rates subsection
- $\bar{A}\bar{S}\bar{M}\bar{R}(G,i,2015-2019)$ is the mean ASMR in time period i, averaged over years 2015 to 2019
- $\bar{A}\bar{S}\bar{M}\bar{R}(G,2015-2019)$ is the mean annual ASMR, averaged over the full years 2015 to 2019

Relative cumulative age-standardised mortality rates

rcASMRs were also developed by the CMI and were originally described in working paper 111 (PDF, 1.07MB). Rather than use absolute values of death counts, rcASMRs sum all age-standardised weekly mortality rates between two time points.

The cumulative ASMR (cASMR) is the sum of weekly ASMRs up to that point in the year:

$$cASMR\left(G,w,y\right) = \sum_{i=1}^{i=w} ASMR\left(G,w,y\right)$$

In this report, rcASMRs are calculated cumulatively for weeks from Week 1 2020 until Week 28 2020 and are relative to the 2015 to 2019 average cASMR for that time period. This difference is then expressed as a percentage of the average cASMR for the final week of the year in the previous five years, equivalent to the average annual rate. The following formula is used:

$$rcASMR(G,w,y) = \frac{cASMR(G,w,y) - \bar{c}\bar{A}\bar{S}\bar{M}\bar{R}(G,w,2015-19)}{\bar{c}\bar{A}\bar{S}\bar{M}\bar{R}(G,52,2015-19)}$$

where:

- $cASMR(G,w,y)\ is\ cumulative\ s\tan dardised\ mortality\ rate\ in\ week\ w\ year\ y$
- $\bar{c}\bar{A}\bar{S}\bar{M}\bar{R}(G,w,2015-19)\ is\ mean\ cASMR\ to\ week\ w,\ averaged\ over\ 2015\ to\ 2019$
- $\bar{c}\bar{A}\bar{S}\bar{M}\bar{R}(G,52,2015-19)\ is\ mean\ ASMR,\ averaged\ over\ the\ full\ years\ 2015\ to\ 2019$

5 . Causes of death

The ONS's analysis of non-COVID-19 death registrations by cause of death focuses first on leading causes of death, and then specific causes which are expected to be impacted by COVID-19, or related to the leading causes which present interesting patterns. These additional causes were identified with support from colleagues at City, University of London.

Deaths are cause coded using the World Health Organization's (WHO) International Classification of Diseases (ICD). Deaths are coded to the tenth edition of the ICD (ICD-10) using IRIS software (version 2013). Cause of death reported here represents the final underlying cause of death for registrations 28 days old or older. This takes account of additional information received from medical practitioners or coroners after the death has been registered.

Deaths considered unexpected, accidental or suspicious will be referred to a coroner who may order a post-mortem or carry out a full inquest to ascertain the reasons for the death; the investigation is known as an inquest and can take months and sometimes years. The amount of time it takes to complete an inquest creates a registration delay: a lag between the date of death and the date of death registration. This means that there are some deaths that have occurred but have not been registered yet.

Some causes of death are much more likely to require an inquest than others, and as such we do not yet have sufficient data to observe how their numbers have changed in recent months. These causes include deaths due to homicide, domestic abuse, suicide and road traffic accidents. At a future date when more data are available, analysis on these data can be completed and presented. It is difficult to know when these data will be complete enough for analysis because we do not know if changes to the registration process resulting from Coronavirus Act 2020 will impact the typical delays for these causes.

In some cases, not being able to present a certain cause yet may skew the results available to present. For example, leading causes for younger adults are historically causes with longer registration delays. This may mean death registration data are underestimating total deaths for those age groups.

More information on registration delay, including which causes of death experience longest delays, can be found in our impact of registration delays release. More information on leading causes of death by age can be found in our Deaths registered in England and Wales: 2019.

Specific causes of death were investigated in these reports either because they are leading causes or because they are associated with a specific trend observed in the data. Analysis in these reports has used the Office for National Statistics's (ONS's) leading causes of death ICD codes. These were used to produce the data tables of deaths involving certain causes.

In analysis of non-coronavirus (COVID-19) deaths to 10 July 2020, causes of death discussed in the main report are presented in Table 2. Causes of death that were excluded from the report and data tables because of insufficient data are presented in Table 3.

Table 2: Causes of death in England and Wales presented in analysis to 10 July 2020

ICD-10 codes	Cause of death groups
C23-C24	Malignant neoplasm of gallbladder and other parts of biliary tract
C33-C34	Malignant neoplasm of trachea, bronchus and lung
C53–C55	Malignant neoplasm of uterus
D00–D48	In situ and benign neoplasms, and neoplasms of uncertain or unknown behaviour
E10–E14	Diabetes
E86–E87	Disorders of fluid, electrolyte and acid–base balance (incl. dehydration)
F01, F03, G30	Dementia and Alzheimer disease
G20	Parkinson disease
G40-G41	Epilepsy and status epilepticus
G80–G83	Cerebral palsy and other paralytic syndromes
I10–I15	Hypertensive diseases
I20–I25	Ischaemic heart diseases
I26–I28	Pulmonary heart disease and diseases of pulmonary circulation
I34–I38	Nonrheumatic valve disorders and endocarditis
I42	Cardiomyopathy
I47–I49	Cardiac arrhythmias
I50–I51	Heart failure and complications and ill–defined heart disease
I60–I69	Cerebrovascular diseases
J00–J06, J20–J22	Acute respiratory infections other than influenza and pneumonia
J09–J18	Influenza and pneumonia
J40–J47	Chronic lower respiratory diseases
K35–K46, K56	Appendicitis, hernia and intestinal obstruction
K70–K76	Cirrhosis and other diseases of liver
N00–N39	Diseases of the urinary system
R00-R99	Symptoms, signs and ill-defined conditions

Source: Office for National Statistics – Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: technical report

Table 3: Causes of death excluded from analysis to 10 July 2020 because of an insufficient number of mentions or a large median registration delay

ICD-10 codes	Cause of death groups
A00–A09	Intestinal infectious diseases[1]
A15–A19, B90	Tuberculosis
A20, A44, A75–A79, A82–A84, A85.2, A90–A98, B50–B57	Vector–borne diseases and rabies
A33–A37, A49.2, A80, B01, B02, B05, B06, B15, B16, B17.0, B18.0, B18.1, B26, B91, G14	Vaccine-preventable diseases
A39, A87, G00–G03	Meningitis and meningococcal infection
B20–B24	Human immunodeficiency virus [HIV] disease
C23-C24	Malignant neoplasm of gallbladder and other parts of biliary tract[1]
C32	Malignant neoplasm of larynx[1]
C40–C41	Malignant neoplasms of bone and articular cartilage
D50–D53, E40–E64	Malnutrition, nutritional anaemias and other nutritional deficiencies[1]
G20	Parkinson disease1
I05–I09	Chronic rheumatic heart diseases[1]
O00–O99	Pregnancy, childbirth and the puerperium
P00–P96	Certain conditions originating in the perinatal period
V01–V89	Land transport accident
W00-W19	Accidental falls
W32–W34	Non-intentional firearm discharge
W65–W74	Accidental drowning and submersion
W75-W84	Accidental threats to breathing
X40-X49	Accidental poisoning
X60-X84, Y10-Y34	Suicide and injury/opoisoning of undetermined intent
U50.9, X85–Y09, Y87.1	Homicide and probable homicide

Source: Office for National Statistics – Analysis of death registrations not involving coronavirus (COVID-19), England and Wales: technical report

Notes

1. These causes were excluded for deaths of those aged under 65 years only.

6 . Related links

Deaths registered weekly in England and Wales, provisional
Bulletin | Updated weekly
Provisional counts of the number of deaths registered in England and Wales, including deaths involving the coronavirus (COVID-19) pandemic, by age, sex and region, in the latest weeks for which data are available.

Impact of registration delays on mortality statistics in England and Wales: 2018
Article | Released 7 February 2020
An analysis of the time taken to register deaths, by cause of death, by area of usual residence and certification type.

Comparisons of all-cause mortality between European countries and regions: January to June 2020
Article | Released 30 July 2020
Analysis of all-cause mortality patterns of selected European countries and regions, week ending 3 January (Week 1) to week ending 12 June (Week 24) 2020.